Cleanliness Comparison –
C3 Localized Versus Total Board Extractions

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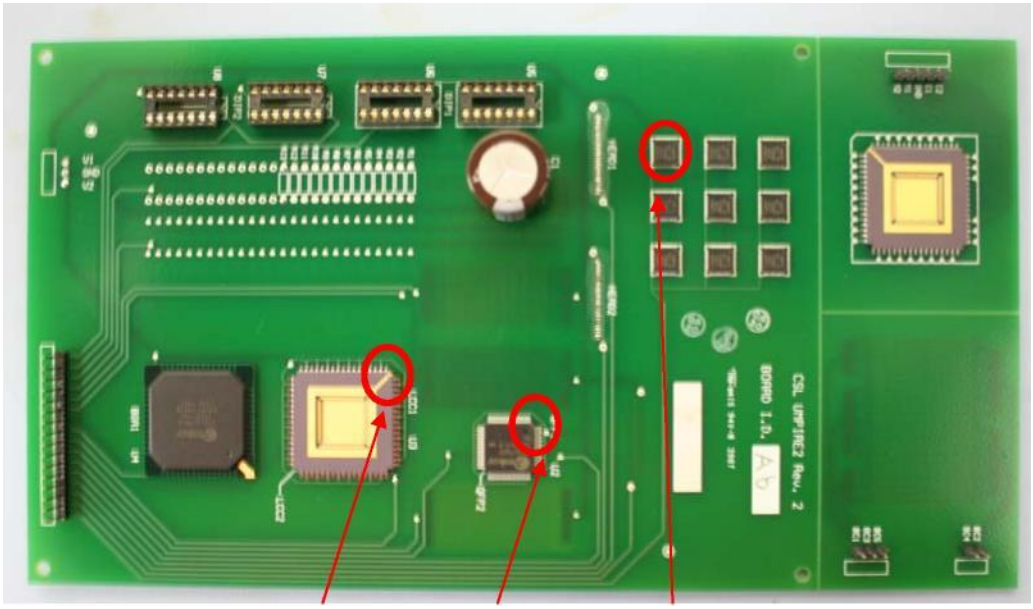
In this evaluation we will show an ionic residue comparison using Umpire 2 boards that were top and bottom surface mounted with standard reflow and selective wave soldered on the connector and B-24 comb patterns. For this evaluation, 30 boards were processed using a no clean flux with lead-based soldering parameters. Three groups were evaluated, Group A (not cleaned), Group B (water only cleaned) and Group C (saponified steam cleaned). The 30 assemblies and 3 unprocessed boards were SIR tested for electrical performance and then each assembly was C3 tested in three locations (0.1 in^2 area) and then the entire board was bag extracted.

The areas of C3 localized extraction were:
Area 1: The QFN location with the component lifted Area 2: 80 pin QFP, corner location including the via Area 3: 68 pin LCC, corner location



Area 3 Area 2 Area 1

Umpire Test Assembly Description

- A 2-layer MLB with 11 SIR test sites.
- Bottom side SMT including; 20 0805 chip and 20 1206 chip locations.
- Top side SMT BGA, QFP, QFN and LCC test patterns, with and without solder mask.
- Selective soldering of the connectors, DIPs for through hole processes and IPC B-24 test patterns with no mask, striped mask, full mask coverage.
  SIR Results Summary (1 out of 10 boards from each group)
  SIR testing was conducted using 85°C/85% RH conditions with a 100V test voltage and a 50V bias voltage. Values less than 1.0E+8 ohms are considered failures because the surface insulative resistance is below the IPC J-STD 001 limit. Failed values are in red, values of 1.0E+6 ohms indicate a hard short.

Group A No Clean	Initial	24 hrs	96 hrs	168 hrs @ 85°C	168 hrs @ 25°C
A1- QFN	5.35E+08	7.21E+06	6.14E+06	9.29E+07	1.00E+06
A1 - LCC Leads	6.89E+11	2.50E+08	5.86E+08	7.91E+08	2.13E+12
A1 - LCC Comb	1.37E+12	1.14E+09	1.65E+09	6.14E+08	2.56E+11
A1 - TQFP Leads	3.15E+11	2.18E+07	6.36E+07	6.58E+07	2.39E+08
A1 - TQFP Comb	1.90E+12	2.18E+07	2.03E+07	1.00E+06	1.00E+06
A1 - BGA	1.85E+12	5.73E+08	5.35E+08	5.33E+08	2.23E+12
A1 - DIP Y	1.02E+12	7.51E+08	6.83E+08	1.15E+09	1.77E+12
A1 - DIP Leads	1.85E+12	1.94E+09	1.94E+09	5.11E+09	2.81E+12
A1 - B-24--1	1.85E+12	1.04E+09	1.51E+08	8.28E+08	1.44E+12
A1 - B-24--2	1.09E+12	5.73E+08	2.08E+08	6.73E+08	1.94E+12
A1 - B-24--3	4.99E+11	2.87E+08	1.17E+09	6.73E+08	2.23E+12

Group B Water Cleaned	Initial	24 hrs	96 hrs	168 hrs @ 85°C	168 hrs @ 2°5C
B1- QFN	3.10E+11	4.70E+07	8.35E+07	1.15E+07	1.00E+06
B1 - LCC Leads	2.15E+11	3.48E+09	3.33E+09	4.28E+09	1.45E+12
B1 - LCC Comb	9.81E+11	5.03E+08	3.91E+08	4.92E+08	8.75E+11
B1 - TQFP Leads	7.80E+11	9.81E+08	2.20E+09	2.77E+09	1.45E+12
B1 - TQFP Comb	1.52E+11	1.52E+07	1.75E+07	2.96E+07	1.00E+06
B1 - BGA	1.00E+12	2.30E+09	1.96E+09	2.41E+09	1.35E+12
B1 - DIP Y	3.33E+11	2.15E+09	2.47E+09	3.03E+09	1.42E+12
B1 - DIP Leads	6.19E+11	2.52E+09	7.62E+09	7.98E+09	1.26E+12
B1 - B-24--1	5.27E+11	1.42E+09	1.39E+09	1.75E+09	1.26E+12
B1 - B-24--2	7.45E+11	2.47E+09	1.91E+09	2.30E+09	1.45E+12
B1 - B-24--3	4.92E+11	2.96E+08	1.67E+09	2.52E+09	1.42E+12

Group C Saponified Steam Cleaned	Initial	24 hrs	96 hrs	168 hrs @ 85°C	168 hrs @ 25°C
C1- QFN	1.87E+12	2.00E+09	6.48E+09	6.64E+09	1.49E+12
C1 - LCC Leads C1 - LCC Comb	1.87E+12	1.63E+09	5.52E+09	8.25E+09	2.10E+12
C1 - TQFP Leads	1.87E+12	1.71E+09	5.39E+09	7.05E+09	2.10E+12
C1 - TQFP Comb	1.87E+12	1.91E+09	5.52E+09	8.21E+09	4.28E+11
C1 - BGA	3.91E+12	1.87E+09	5.52E+09	7.63E+09	2.10E+12
C1 - DIP Y	3.48E+11	1.75E+09	5.39E+09	7.67E+09	5.39E+11
C1 - DIP Leads	2.64E+11	1.75E+09	5.39E+09	7.79E+09	2.10E+12
C1 - B-24--1	1.87E+12	1.15E+09	1.49E+10	5.15E+10	1.79E+12
C1 - B-24--2	1.87E+12	1.71E+09	5.65E+09	9.90E+09	2.10E+12
C1 - B-24--3	1.45E+12	1.59E+09	5.52E+09	7.49E+09	2.10E+12
	2.30E+11	1.59E+09	5.39E+09	9.59E+09	1.42E+11

SIR Results Discussion

Group A, B and C exhibited acceptable electrical results below the BGA and LCC for top side SMT, the selective wave solder areas also exhibited acceptable electrical
performance. The data indicates that areas with good thermal contact with the wave on the selective pallet and areas of reflow that see complete thermal activation have acceptable SIR performance.

The areas of the QFP with the vias open to the top side surface in the area of the selective pallet and below the component showed SIR failures and hard shorts. The
QFN in the no clean and water only clean condition showed electrical SIR failures due to trapped no clean flux.

Total Board Extraction

Total board cleanliness analysis was performed after the environmental testing (SIR was completed. This data should show the comparative differences between or among the
groups. Seven assemblies from each group were extracted in Kapak bags with 50 mls of IPA / DI water (75%/25%) for one hour at 80°C, bringing the surface residues of the assembly into solution. Using the fluid and bag to cover the entire board with solution
ionic species were extracted from the entire board surface. This represents the average ionic values per square inch of contamination.

Total Board Cleanliness Levels

	Ion Chromatography							ROSE
Sample Description	**Cl^-**	**NO2 -**	**Br^-**	**NOj**	**$PO4^{2-}$**	**$SO4^{2-}$**	**WOA**	**15 min test**
Foresite Limits No Clean	3.0	3.0	12.0	3.0	3.0	3.0	25.00	**Omega**
Foresite Limits for Cleaning	6.0	3.0	6.0	3.0	3.0	3.0	25.0	**Meter 600R**
Total Board Extraction (50 mls of IPA/DI per Extraction								
Group A - 1	1.26	0	2.36	0.89	0	1.21	21.57	
Group A - 2	1.33	0	2.51	0.94	0	1.06	22.36	
Group A - 3	1.24	0	2.33	1.21	0	1.36	20.61	
Group A - 4	1.24	0	2.85	1.06	0	1.29	24.51	
Group A - 5	1.29	0	2.10	0.85	0	1.24	21.33	
Group A - 6	1.36	0	2.39	0.74	0	1.11	18.65	
Group A - 7	1.54	0	2.45	0.99	0	1.09	19.87	
Group A - 8	Not Tested							3.5
Group A - 9	Not Tested							4.1
Group A - 10	Not Tested							3.8
Group B - 11	0.89	0	1.36	0.68	0	1.24	17.54	
Group B - 12	0.62	0	1.95	0.94	0	1.05	15.69	
Group B - 13	0.85	0	1.55	0.78	0	1.21	18.54	
Group B - 14	0.74	0	1.47	0.85	0	1.31	15.98	
Group B - 15	0.99	0	1.23	0.69	0	1.15	14.57	
Group B - 16	0.69	0	1.06	0.84	0	1.41	16.54	
Group B - 17	0.61	0	1.42	0.99	0	1.84	19.87	
Group B - 18	Not Tested							3.1
Group B - 19	Not Tested							3.9
Group B - 20	Not Tested							4.2
Group C - 21	0.24	0	0.63	0.85	0	0.24	1.05	
Group C - 22	0.15	0	0.29	0.69	0	0.26	1.63	
Group C - 23	0.36	0	0.85	0.66	0	0.15	1.24	
Group C - 24	0.25	0	0.24	0.69	0	0.35	1.51	
Group C - 25	0.19	0	0.65	0.57	0	0.24	1.95	
Group C - 26	0.35	0	0.36	0.68	0	0.22	1.24	
Group C - 27	0.47	0	0.45	0.95	0	0.19	1.32	
Group C - 28	Not Tested							2.9
Group C - 29	Not Tested							3.5
Group C - 30	Not Tested							2.8

Total Board Cleanliness Results

The general average of the total board contamination of a 5.25 x 9.5 in board (99.75 in2 total surface area) shows acceptable levels of ionic contamination. The contamination found on the surface of the total board indicates that the boards generally should perform well in a high humidity conditions, but that is not what the SIR data showed on the specific areas found around the selective solder top side components. The ROSE (Omega testing also showed similar low acceptable levels for both no clean and cleaned assemblies, again this does not correlate with the SIR performance of the QFN, and QFP locations.

C3 Localized Extractions and Ion Chromatography Results - Group A (No Clean)

all values are ug/in2	Ion Chromatography							C3 Tester	
Sample Description	**Cl^-**	**NO2 -**	**Br^-**	**NOj**	**$PO4^{2-}$**	**$SO4^{2-}$**	**WOA**	**Resutls**	**Time(sec)**
Foresite Limits No Clean	3.0	3.0	12.0	3.0	3.0	3.0	25.0	**Clean**	**>60**
Foresite Limits for Cleaning	6.0	3.0	6.0	3.0	3.0	3.0	25.0	**Clean**	**>60**
C3 extraction of the three areas on each Umpire 2 test assembly									
Group A - 1 QFN	0.55	0	0.26	1.21	0	1.65	89.68	Dirty	3
Group A - 2 QFN	0.62	0	0.28	1.26	0	1.27	102.65	Dirty	2
Group A - 3 QFN	0.81	0	0.11	1.05	0	1.65	96.69	Dirty	4
Group A - 4 QFN	0.65	0	0.24	0.95	0	1.54	124.77	Dirty	2
Group A - 5 QFN	0.49	0	0.36	1.17	0	1.66	151.24	Dirty	1
Group A - 6 QFN	0.63	0	0.22	0.89	0	1.51	87.94	Dirty	7
Group A - 7 QFN	0.54	0	0.21	0.91	0	1.39	103.65	Dirty	2
Group A - 8 QFN	0.66	0	0.09	1.54	0	1.24	114.24	Dirty	2
Group A - 9 QFN	0.91	0	0.24	1.69	0	1.69	123.65	Dirty	1
Group A - 10 QFN	0.37	0	0.15	1.47	0	1.54	124.36	Dirty	2
Group A - 1 QFP	0.51	0	0.12	0.68	0	1.24	74.65	Dirty	19
Group A - 2 QFP	0.36	0	0.21	0.94	0	1.05	92.36	Dirty	11
Group A - 3 QFP	0.52	0	0.26	0.78	0	1.21	71.65	Dirty	18
Group A - 4 QFP	0.24	0	0.15	0.85	0	1.31	93.26	Dirty	12
Group A - 5 QFP	0.55	0	0.16	0.69	0	1.15	81.24	Dirty	12
Group A - 6 QFP	0.62	0	0.11	0.84	0	1.41	77.25	Dirty	17
Group A - 7 QFP	0.39	0	0.15	0.99	0	1.84	69.95	Dirty	20
Group A - 8 QFP	0.57	0	0.15	0.65	0	1.63	85.64	Dirty	18
Group A - 9 QFP	0.66	0	0.17	0.66	0	1.51	78.98	Dirty	20
Group A - 10 QFP	0.51	0	0.16	0.54	0	1.36	94.21	Dirty	12
Group A - 1 LCC	0.69	0	0.21	0.85	0	1.24	12.36	Clean	180
Group A - 2 LCC	0.65	0	0.21	0.69	0	1.36	12.69	Clean	180
Group A - 3 LCC	0.54	0	0.15	0.66	0	1.15	11.24	Clean	180
Group A - 4 LCC	0.45	0	0.15	0.69	0	1.36	15.36	Clean	180
Group A - 5 LCC	0.63	0	0.17	0.57	0	1.25	14.21	Clean	180
Group A - 6 LCC	0.29	0	0.19	0.68	0	1.22	12.08	Clean	180
Group A - 7 LCC	0.65	0	0.16	0.63	0	1.19	11.96	Clean	180
Group A - 8 LCC	0.55	0	0.11	0.52	0	1.21	12.94	Clean	180
Group A - 9 LCC	0.78	0	0.18	0.61	0	1.42	12.41	Clean	180
Group A - 10 LCC	0.61	0	0.19	0.54	0	1.39	12.78	Clean	180

C3 Results of the Group A Samples

The QFN and QFP areas both show high WOA results from the SMT reflow and from the selective wave process. The QFN was high in WOA because of entrapped flux under the QFN, while the QFP was high in WOA due to the flux from the selective wave migrating up through the vias and being trapped below the component body and leads. These results correlate to the electrical performance results of the SIR testing.

C3 Localized Extractions and Ion Chromatography Results – Group B (No Clean with Water Only Cleaning)

all values in ug/in2	Ion Chromatography							C3 Testing	
Sample Description	**Cl^-**	**NO2 -**	**Br^-**	**NO3 -**	**$PO4^{2-}$**	**$SO4^{2-}$**	**WOA**	**Results**	**Time(sec)**
Foresite Limits No Clean	3.0	3.0	12.0	3.0	3.0	3.0	25.00	**Clean**	**>60**
Cleaning	6.0	3.0	6.0	3.0	3.0	3.0	25.0	**Clean**	**>60**
C3 localized extraction									
Group B - 1 QFN	0.44	0	0	0.45	0	0.98	141.36	Dirty	2
Group B - 2 QFN	0.57	0	0	0.69	0	0.92	124.51	Dirty	3
Group B - 3 QFN	0.65	0	0	0.51	0	0.65	133.62	Dirty	4
Group B - 4 QFN	0.51	0	0	0.65	0	1.05	89.74	Dirty	8
Group B - 5 QFN	0.47	0	0	0.54	0	0.69	95.68	Dirty	7
Group B - 6 QFN	0.62	0	0	0.66	0	1.24	107.54	Dirty	4
Group B - 7 QFN	0.61	0	0	0.29	0	0.74	121.36	Dirty	2
Group B - 8 QFN	0.54	0	0	0.57	0	0.84	174.35	Dirty	1
Group B - 9 QFN	0.39	0	0	0.65	0	0.99	145.62	Dirty	2
Group B - 10 QFN	0.47	0	0	0.41	0	0.87	127.14	Dirty	3
Group B - 1 QFP	0.45	0	0	0.63	0	0.69	81.54	Dirty	19
Group B - 2 QFP	0.36	0	0	0.29	0	0.87	95.64	Dirty	15
Group B - 3 QFP	0.29	0	0	0.55	0	0.95	85.64	Dirty	19
Group B - 4 QFP	0.66	0	0	0.45	0	0.87	87.88	Dirty	18
Group B - 5 QFP	0.54	0	0	0.42	0	0.99	91.24	Dirty	19
Group B - 6 QFP	0.45	0	0	0.27	0	0.79	77.14	Dirty	24
Group B - 7 QFP	0.36	0	0	0.29	0	1.02	80.69	Dirty	20
Group B - 8 QFP	0.54	0	0	0.36	0	1.05	91.24	Dirty	16
Group B - 9 QFP	0.44	0	0	0.56	0	0.94	84.54	Dirty	18
Group B - 10 QFP	0.61	0	0	0.44	0	0.81	78.98	Dirty	22
Group B - 1 LCC	0.56	0	0	0.39	0	0.92	10.32	Clean	180
Group B - 2 LCC	0.48	0	0	0.51	0	0.87	8.97	Clean	180
Group B - 3 LCC	0.65	0	0	0.27	0	0.69	9.65	Clean	180
Group B - 4 LCC	0.66	0	0	0.29	0	0.94	8.97	Clean	180
Group B - 5 LCC	0.64	0	0	0.65	0	0.85	9.65	Clean	180
Group B - 6 LCC	0.55	0	0	0.44	0	0.96	8.47	Clean	180
Group B - 7 LCC	0.29	0	0	0.42	0	0.77	8.51	Clean	180
Group B - 8 LCC	0.44	0	0	0.51	0	0.89	9.36	Clean	180
Group B - 9 LCC	0.57	0	0	0.27	0	1.01	8.97	Clean	180
Group B - 10 LCC	0.63	0	0	0.32	0	0.78	9.21	Clean	180

C3 Results of the Group B Samples

The QFN and QFP areas both show high WOA results from the SMT reflow and from the selective wave process. The QFN was high in WOA because of entrapped flux under the QFN, while the QFP was high in WOA due to the flux from the selective wave migrating up through the vias and being trapped below the component body and leads. These results again correlate with the electrical performance results of the SIR testing.

C3 Localized Extractions and Ion Chromatography Results – Group C (No Clean with Saponified Wash / Steam Cleaning)

all values are ug/in2	Ion Chromatography							C3 Tester	
Sample Description	**Cl^-**	**NO2 -**	**Br^-**	**NOj**	**$PO4^{2-}$**	**$SO4^{2-}$**	**WOA**	**Resutls**	**Time(s**
Foresite Limits No Clean	3.0	3.0	12.0	3.0	3.0	3.0	25.0	**Clean**	**>60**
Foresite Limits for Cleaning	6.0	3.0	6.0	3.0	3.0	3.0	25.0	**Clean**	**>60**
C3 extraction of the three areas on each Umpire 2 test assembly									
Group C - 1 QFN	0.24	0	0	0.24	0	0	12.32	Clean	180
Group C - 2 QFN	0.25	0	0	0.36	0	0	10.05	Clean	180
Group C - 3 QFN	0.19	0	0	0.15	0	0	9.89	Clean	180
Group C - 4 QFN	0.22	0	0	0.19	0	0	12.24	Clean	180
Group C - 5 QFN	0.14	0	0	0.24	0	0	12.00	Clean	180
Group C - 6 QFN	0.19	0	0	0.11	0	0	12.33	Clean	180
Group C - 7 QFN	0.12	0	0	0.24	0	0	11.24	Clean	180
Group C - 8 QFN	0.10	0	0	0.21	0	0	19.65	Clean	180
Group C - 9 QFN	0.13	0	0	0.26	0	0	12.04	Clean	180
Group C - 10 QFN	0.10	0	0	0.09	0	0	8.97	Clean	180
Group C - 1 QFP	0.12	0	0	0.15	0	0	5.64	Clean	180
Group C - 2 QFP	0.13	0	0	0.24	0	0	5.23	Clean	180
Group C - 3 QFP	0.14	0	0	0.13	0	0	4.65	Clean	180
Group C - 4 QFP	0.10	0	0	0.22	0	0	4.51	Clean	180
Group C - 5 QFP	0.19	0	0	0.14	0	0	4.71	Clean	180
Group C - 6 QFP	0.12	0	0	0.15	0	0	6.95	Clean	180
Group C - 7 QFP	0.08	0	0	0.22	0	0	5.85	Clean	180
Group C - 8 QFP	0.11	0	0	0.07	0	0	6.63	Clean	180
Group C - 9 QFP	0.12	0	0	0.17	0	0	7.01	Clean	180
Group C - 10 QFP	0.13	0	0	0.16	0	0	5.47	Clean	180
Group C - 1 LCC	0.09	0	0	0.11	0	0	4.35	Clean	180
Group C - 2 LCC	0.12	0	0	0.09	0	0	4.21	Clean	180
Group C - 3 LCC	0.13	0	0	0.12	0	0	3.96	Clean	180
Group C - 4 LCC	0.05	0	0	0.04	0	0	2.35	Clean	180
Group C - 5 LCC	0.12	0	0	0.07	0	0	4.05	Clean	180
Group C - 6 LCC	0.13	0	0	0.16	0	0	6.59	Clean	180
Group C - 7 LCC	0.04	0	0	0.03	0	0	4.14	Clean	180
Group C - 8 LCC	0.10	0	0	0.15	0	0	4.24	Clean	180
Group C - 9 LCC	0.06	0	0	0.11	0	0	3.96	Clean	180
Group C - 10 LCC	0.08	0	0	0.08	0	0	3.81	Clean	180

C3 Results of the Group C Samples

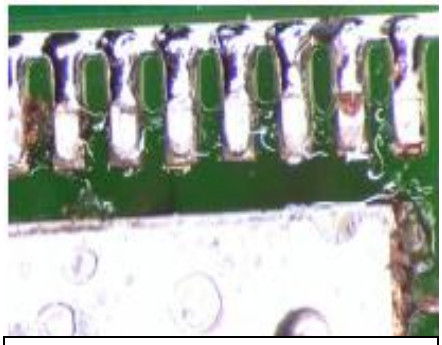
The QFN and QFP areas both show low WOA results from the SMT reflow and from the selective wave process only after cleaning. The QFN high WOA residues have been removed from the entrapped area of the flux under the QFN, while the QFP high WOA have been removed as well. These results correlate to the electrical performance results of the SIR testing.

Conclusion of the Comparison Testing – C3 Localized Extraction versus Total Board

In this study using the Umpire 2 test assembly it was shown that a mixed technology approach with selective wave pallet soldering can contaminate the top side areas of the assembly below components and leave a corrosive flux residue. This residue is not typically detectable by total board or even ROSE measurements due to the dilution effect of the large surface area and fluid normalization. The SIR results showed that these areas failed electrically, while the assembly that was cleaned with water only also failed. The saponified wash and steam cleaned assemblies showed a large reduction in the flux residue levels from the selective pallet wave soldering process and the QFN components that were cleaned with saponifier / steam cleaning passed electrical testing with acceptable SIR values.

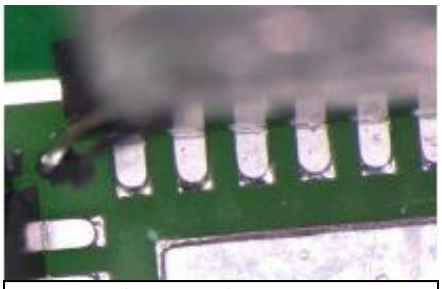
The general average of the total board contamination of a 5.25 x 9.5 in board (99.75 in2 total surface area) shows acceptable levels of ionic contamination. The contamination found on the surface of the total board indicates that the boards generally should perform well in a high humidity conditions, but that is not what the SIR data showed on the specific areas found around the selective solder top side components. The ROSE (Omega testing also showed similar low acceptable levels for both no clean and cleaned assemblies, again this does not correlate with the SIR performance of the QFN and QFP locations.

The localized C3 extraction results showed that with Groups A and B the QFN and QFP areas both show high WOA results from the SMT reflow and from the selective wave process. The QFN was high in WOA because of the entrapped flux under the QFN, while the QFP was high in WOA due to the flux from the selective wave migrating up through the vias and being trapped below the component body and leads. For Group C, the QFN and QFP areas both show low WOA results from the SMT reflow and from the selective wave process only after cleaning. The QFN high WOA residues have been removed from the entrapped area of the flux under the QFN, while the QFP high WOA have been removed as well. These results correlate to the electrical performance results of the SIR testing.



Group B after water only cleaning

These results clearly show that total board extractions only give a general level of cleanliness and only if the contamination areas are large. However, there is a better correlation to the electrical performance when using localized contamination assessment. With this system better correlation to the electrical performance can be obtained and predicted.



Group C after Saponifier / Steam Cleaning

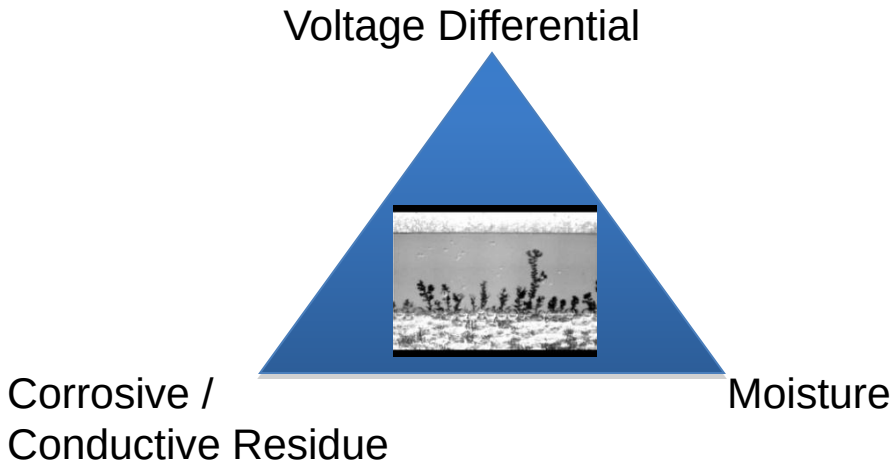
Cleanliness Comparison

C3 Localized vs. Total Board Extractions
for Ion Chromatography Analysis

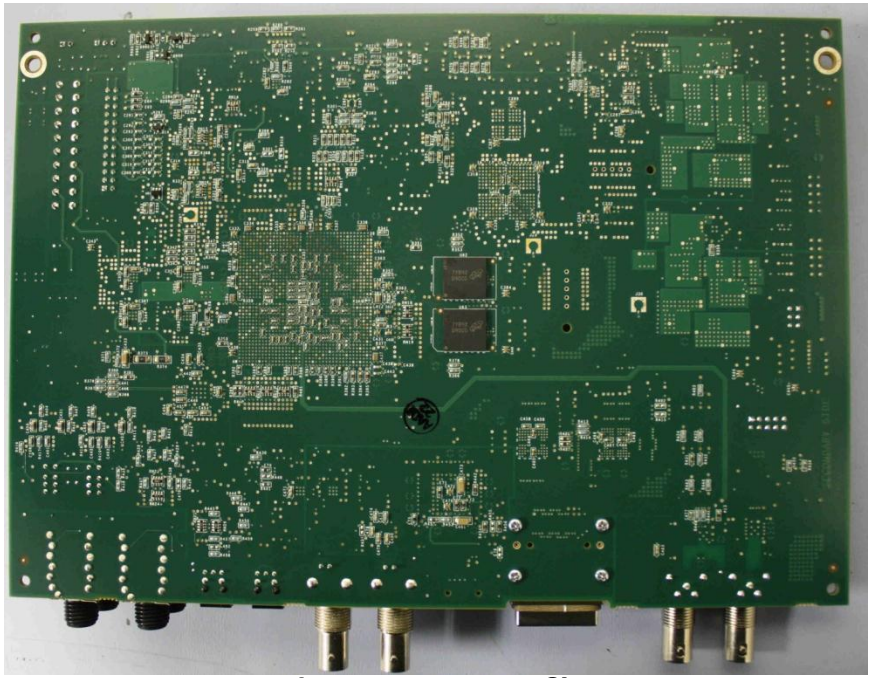
Presented by
Terry Munson of Foresite
At IPC Midwest - Sept 2011
Session S01

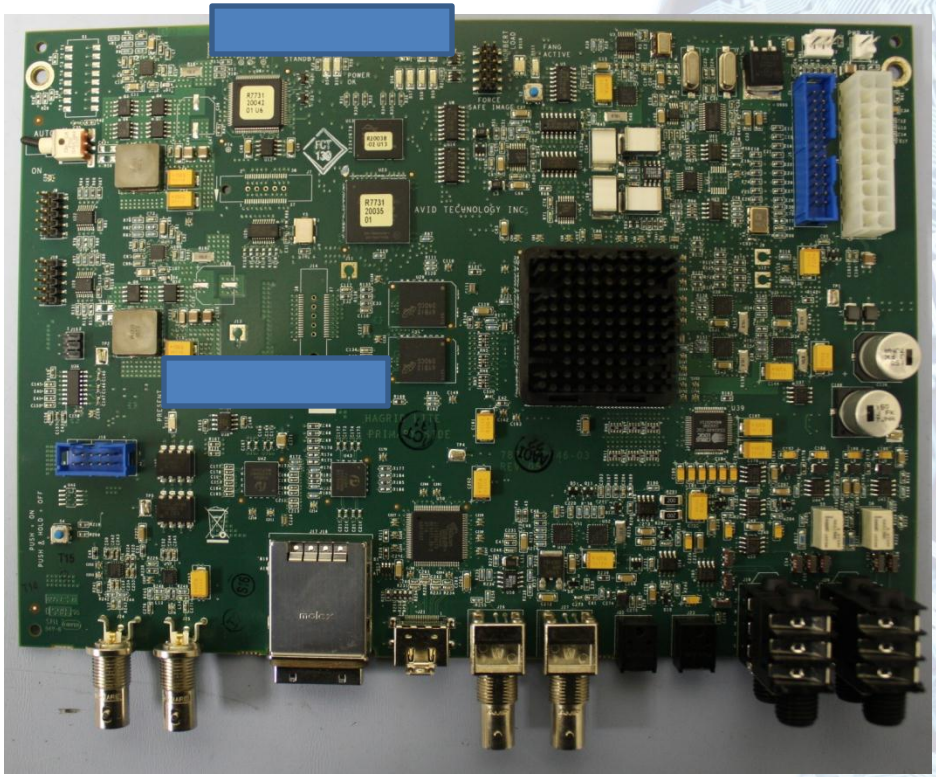
Cleanliness vs. Corrosion Cell

- When we talk about electronic cleanliness we are referring to the ability to not form a corrosion cell under normal operational conditions
- Good cleanliness means low contamination levels, minimizing the formation of a corrosion cell /or leakage path
- What are the critical parameters of the corrosion cell?



How Clean is this PCBA?

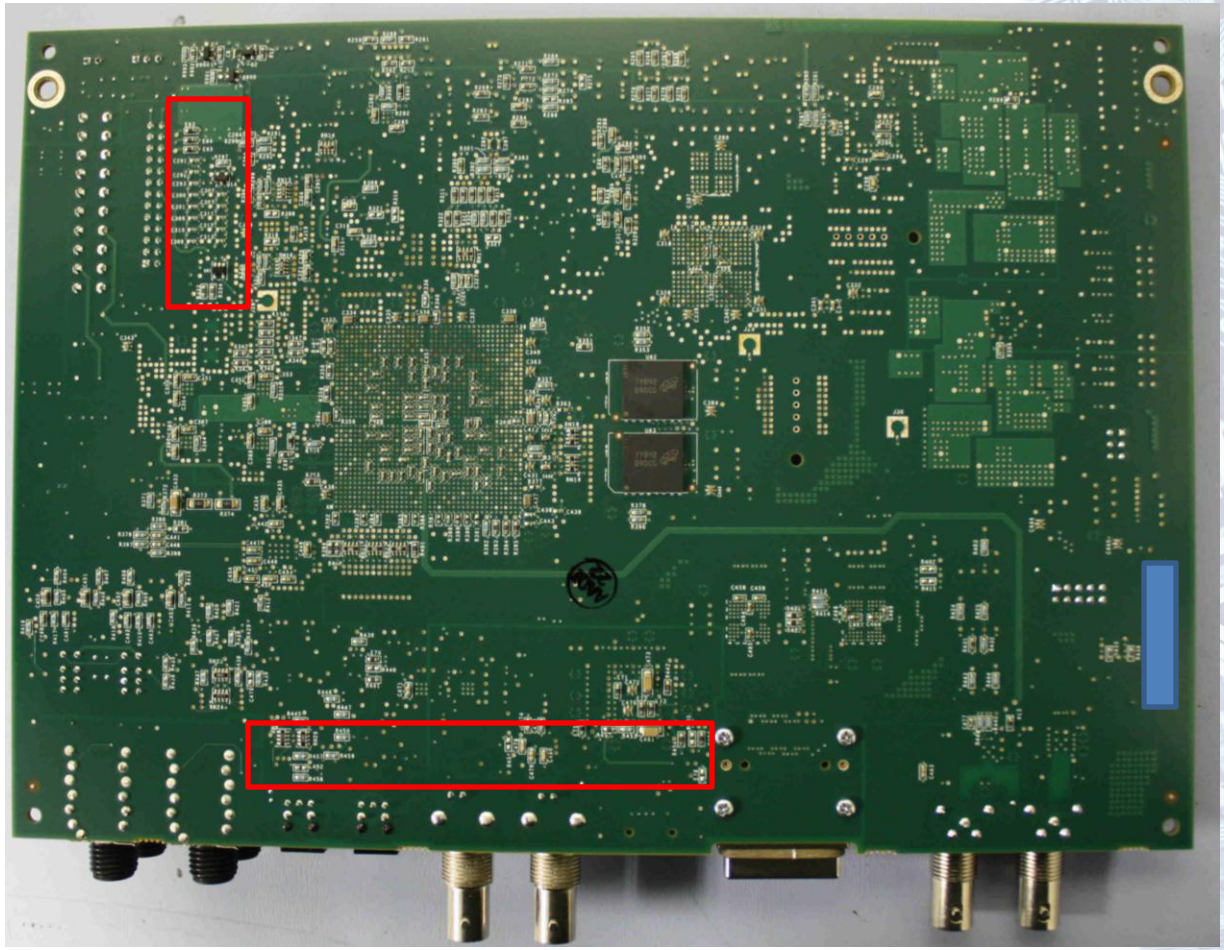




- 1st side SMT reflow
- 2nd side SMT reflow
- Selective wave
- Hand solder / touch-up

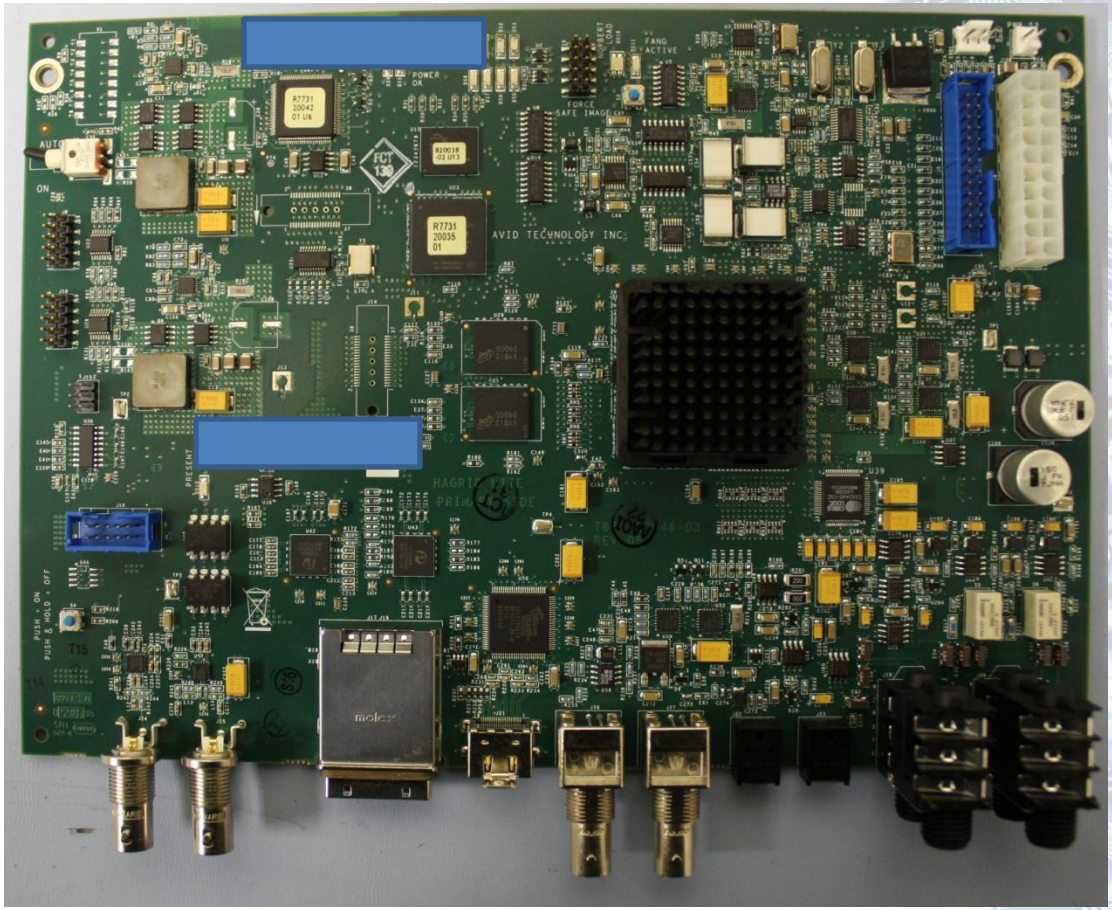
Areas that Fail on the PCBA

- SMT areas on bottom-side next to selective solder area
- BGA area (incoming cleanliness)
- Innerlayer shorts from poor resin melt and etch residue
- Microvias corroding open due to fabrication residues trapped inside via-plugged one side



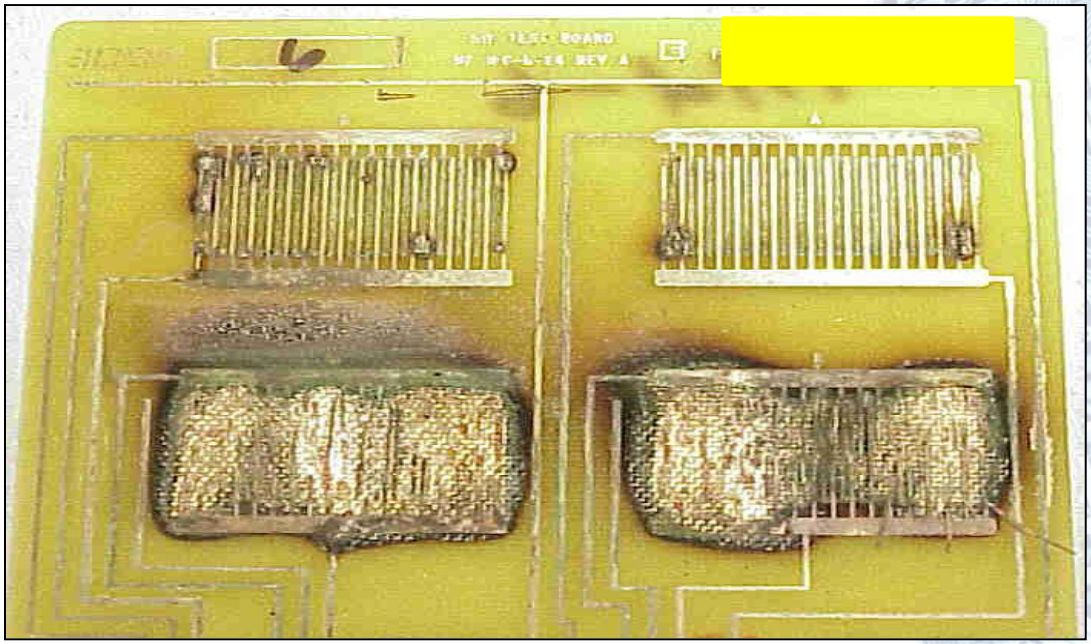
Areas that Fail on Top-Side

- Flux trapped on top-side of PCBA under the connector body
- SOT23 with flux trapped underneath from the selective solder and a via.
- Dirty BGA from WS tacky flux
- Trapped saponifier below the vented BGA lid
- Dirty component leads from nearby localized brush cleaning



The Total Board Cleanliness

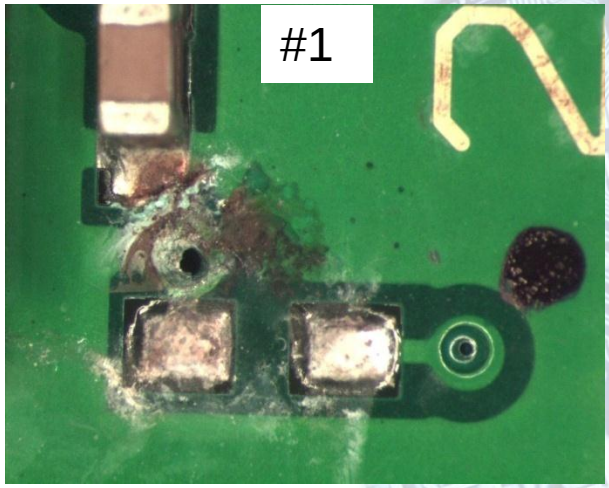
- This SIR B-24 board shows visible thermal degradation but the total cleanliness of the B-24 before SIR testing at 85C/85%RH is:
  - Chloride at 1.3μg/in^2
  - WOA at 51.8 μg/in^2

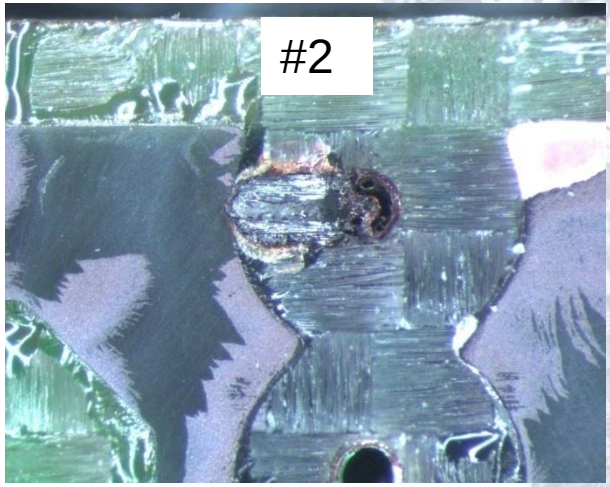


The cleanliness of the selective solder area before SIR testing shows levels of WOA at 383.9 μg/in^2

Localized Failures

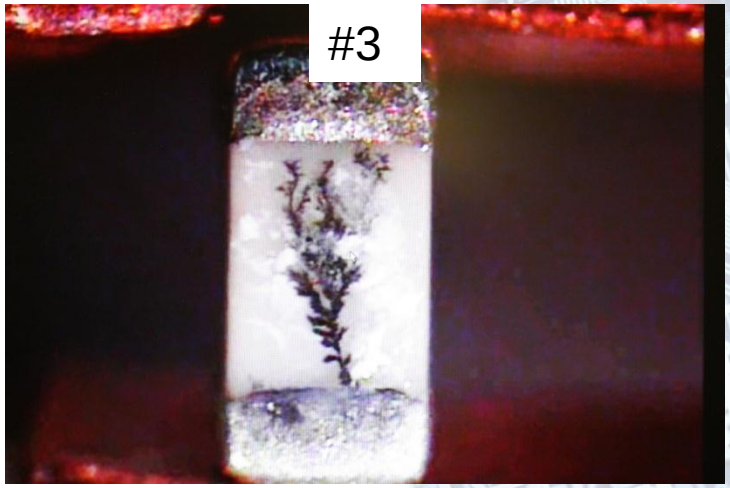
- #1, Surface failures due to residues left in the microvias or being trapped from fluxing/cleaning
  - C3 – Dirty (12s)
  - Chloride 1.21 µg/in^2
  - Sulfate 2.24 µg/in^2
  - WOA 129.39 µg/in^2
- #2, Innerlayer short causing failure
  - C3 – Dirty (9s)
  - Chloride 1.21 µg/in^2
  - Sulfate 29.54 µg/in^2
  - WOA 0.0 µg/in^2



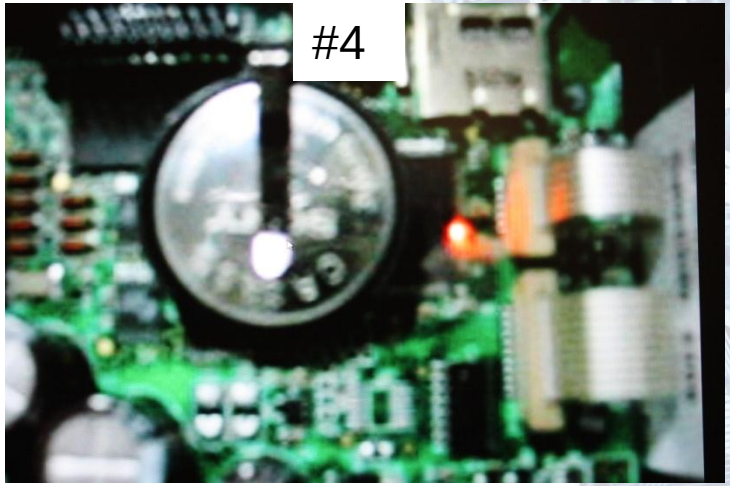


Localized Failures

- #3, Dendrite shorting on component
  - C3 – Dirty (23s)
  - Chloride 0.59 µg/in^2
  - Sulfate 11.55 µg/in^2
  - MSA 5.91 µg/in^2

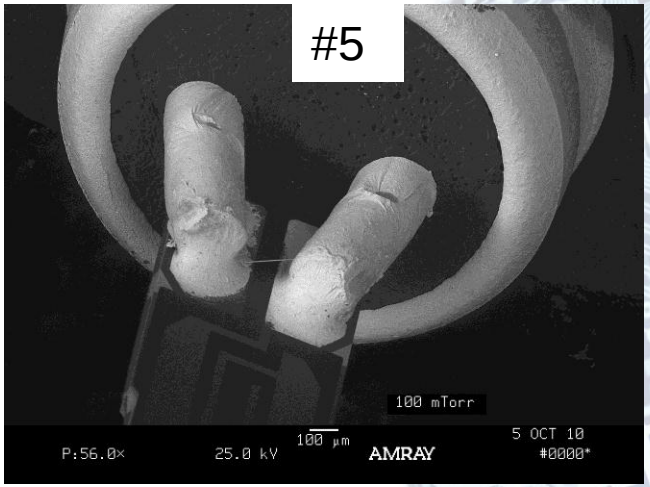


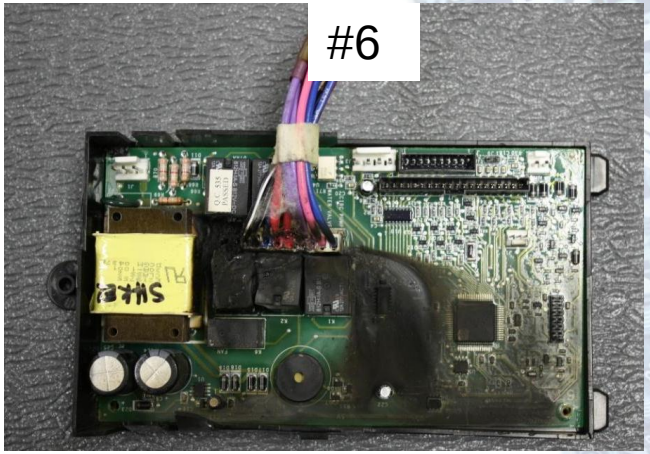
- #4, Short causing a fire with 3.3v between microprocessor leads
  - C3 – Dirty (2s)
  - Chloride 2.57 µg/in^2
  - Sulfate 1.95 µg/in^2
  - WOA 259.97 µg/in^2



Localized Failures

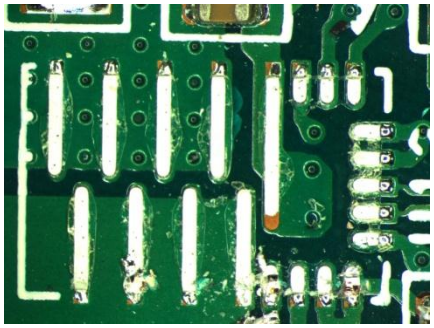
- #5, Metal whisker (lead)
  - C3 – Dirty (14s)
  - Chloride 7.59µg/in^2
  - Sulfate 9.58 µg/in^2
  - Ammonium 12.11 µg/in^2
- #6, Thermal overstress relay chatter
  - C3 – Dirty (1s)
  - Chloride 0.85 µg/in^2
  - Sulfate 2.55 µg/in^2
  - WOA 289.78 µg/in^2

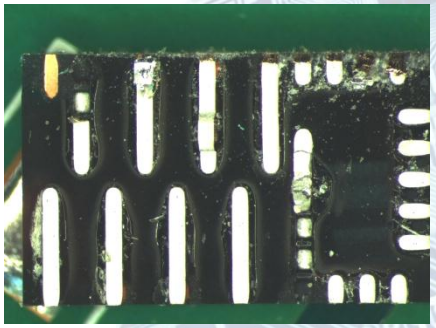


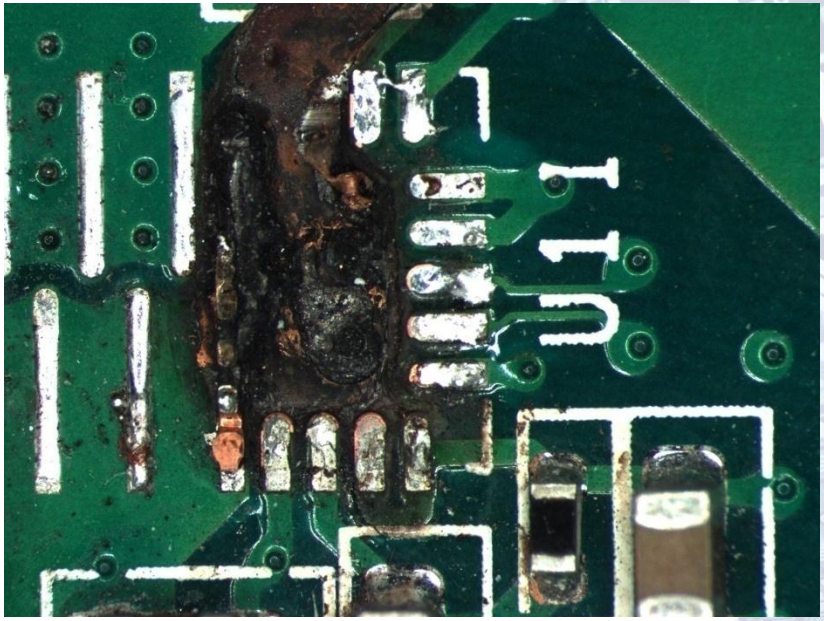


Localized Failures

- #7, Current production QFN
  - C3 – Dirty (15s)
  - Chloride 2.51 µg/in^2
  - Sulfate 2.16 µg/in^2
  - WOA 197.44 µg/in^2
  - Bromide 2.15 µg/in^2
- #8, Thermal overstress QFN
  - C3 – Dirty (1s)
  - Chloride 5.04 µg/in^2
  - Sulfate 3.76 µg/in^2
  - WOA 224.44 µg/in^2
  - Bromide 351.26 µg/in^2







What Must We Understand About PCBA Processes Related to Cleanliness?

1. Realize that the PCBA is a collection of chemical processes with each step contributing to the level of cleanliness over the entire surface, in some processes and in specific areas for others

2. Know that the product that goes into the field is the resultant cleanliness of all the processes, both fabrication and assembly (SMT 2x, selective solder, hand solder, cleaning or not cleaning)

3. Understand that the surface of the assembly is not the only area of contamination concern: innerlayers, under low-standoff components, inside surfaces of the housing or enclosure, and inside connectors

DOE of Umpire II SIR Test Board

Processing Conditions of Umpire II Test Coupon

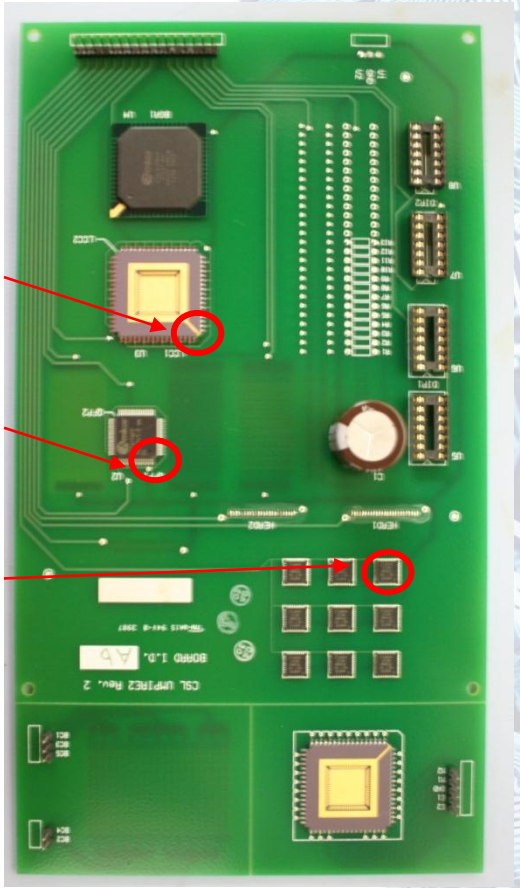
- Three groups were evaluated, Group A (not cleaned), Group B (water only cleaned) and Group C (saponified steam cleaned). The 30 assemblies and 3 unprocessed boards were SIR tested for electrical performance, each assembly was then C3 tested in three locations (0.1 in^{2}area), and then the entire board was bag extracted. All three groups used the same no clean flux. These slides will only show parts of the data focusing on the following areas:

The Areas of C3 Localized Extraction Were:

- Area 1: The QFN location with the component lifted
- Area 2: 80 pin QFP, corner location including the via
- Area 3: 68 pin LCC, corner location

Umpire II Test Assembly Description

- A 2-layer MLB with 11 SIR test sites
- Bottom side SMT including; 20 0805 chip and 20 1206 chip locations.
- Top side SMT BGA, QFP, QFN and LCC test patterns, with solder mask and via below each of the components
- Selective soldering of the connectors, DIPs for thru-hole processes and IPC B-24 test patterns with no mask, striped mask, and full mask coverage.



Total Board Cleanliness

ROSE Testing 15 minutes or Total Board 1 hour 80°C IPA/DI

	Ion Chromatography							ROSE
Sample Description	**Cl^-**	**NO_2^-**	**Br^-**	**NO_3^-**	**PO_4^{2-}**	**SO_4^{2-}**	**WOA**	**15 min test**
Foresite Limits No Clean	3.0	3.0	12.0	3.0	3.0	3.0	25.00	**Omega**
Foresite Limits for Cleaning	6.0	3.0	6.0	3.0	3.0	3.0	25.0	**Meter 600R**
Total Board Extraction (50 mls of IPA/DI per Extraction								
Group A - 1	1.26	0	2.36	0.89	0	1.21	21.57	
Group A - 2	1.33	0	2.51	0.94	0	1.06	22.36	
Group A - 3	1.24	0	2.33	1.21	0	1.36	20.61	
Group A - 4	1.24	0	2.85	1.06	0	1.29	24.51	
Group A - 5	1.29	0	2.10	0.85	0	1.24	21.33	
Group A - 6	1.36	0	2.39	0.74	0	1.11	18.65	
Group A - 7	1.54	0	2.45	0.99	0	1.09	19.87	
Group A - 8	Not Tested							3.5
Group A - 9	Not Tested							4.1
Group A - 10	Not Tested							3.8
Group B - 11	0.89	0	1.36	0.68	0	1.24	17.54	
Group B - 12	0.62	0	1.95	0.94	0	1.05	15.69	
Group B - 13	0.85	0	1.55	0.78	0	1.21	18.54	
Group B - 14	0.74	0	1.47	0.85	0	1.31	15.98	
Group B - 15	0.99	0	1.23	0.69	0	1.15	14.57	
Group B - 16	0.69	0	1.06	0.84	0	1.41	16.54	
Group B - 17	0.61	0	1.42	0.99	0	1.84	19.87	
Group B - 18	Not Tested							3.1
Group B - 19	Not Tested							3.9
Group B - 20	Not Tested							4.2
Group C - 21	0.24	0	0.63	0.85	0	0.24	1.05	
Group C - 22	0.15	0	0.29	0.69	0	0.26	1.63	
Group C - 23	0.36	0	0.85	0.66	0	0.15	1.24	
Group C - 24	0.25	0	0.24	0.69	0	0.35	1.51	
Group C - 25	0.19	0	0.65	0.57	0	0.24	1.95	
Group C - 26	0.35	0	0.36	0.68	0	0.22	1.24	
Group C - 27	0.47	0	0.45	0.95	0	0.19	1.32	
Group C - 28	Not Tested							2.9
Group C - 29	Not Tested							3.5
Group C - 30	Not Tested							2.8

Group C – Sap/Steam Cleaning - SIR Results (Board C1)

all SIR values (ohms of resistance)

Group C Saponified Steam Cleaned	Initial	24 hrs	96 hrs	168 hrs @ 85°C	168 hrs @ 25°C
C1- QFN	1.87E+12	2.00E+09	6.48E+09	6.64E+09	1.49E+12
C1 - LCC Leads	1.87E+12	1.63E+09	5.52E+09	8.25E+09	2.10E+12
C1 - LCC Comb	1.87E+12	1.71E+09	5.39E+09	7.05E+09	2.10E+12
C1 - TQFP Leads	1.87E+12	1.91E+09	5.52E+09	8.21E+09	4.28E+11
C1 - TQFP Comb	3.91E+12	1.87E+09	5.52E+09	7.63E+09	2.10E+12
C1 - BGA	3.48E+11	1.75E+09	5.39E+09	7.67E+09	5.39E+11
C1 - DIP Y	2.64E+11	1.75E+09	5.39E+09	7.79E+09	2.10E+12
C1 - DIP Leads	1.87E+12	1.15E+09	1.49E+10	5.15E+10	1.79E+12
C1 - B-24--1	1.87E+12	1.71E+09	5.65E+09	9.90E+09	2.10E+12
C1 - B-24--2	1.45E+12	1.59E+09	5.52E+09	7.49E+09	2.10E+12
C1 - B-24--3	2.30E+11	1.59E+09	5.39E+09	9.59E+09	1.42E+11

Group A - No Clean- SIR Results (Board 1)

all SIR values (ohms of resistance)

Group A No Clean	Initial	24 hrs	96 hrs	168 hrs @ 85ºC	168 hrs @ 25ºC
A1- QFN	5.35E+08	7.21E+06	6.14E+06	9.29E+07	1.00E+06
A1 - LCC Leads	6.89E+11	2.50E+08	5.86E+08	7.91E+08	2.13E+12
A1 - LCC Comb	1.37E+12	1.14E+09	1.65E+09	6.14E+08	2.56E+11
A1 - TQFP Leads	3.15E+11	2.18E+07	6.36E+07	6.58E+07	2.39E+08
A1 - TQFP Comb	1.90E+12	2.18E+07	2.03E+07	1.00E+06	1.00E+06
A1 - BGA	1.85E+12	5.73E+08	5.35E+08	5.33E+08	2.23E+12
A1 - DIP Y	1.02E+12	7.51E+08	6.83E+08	1.15E+09	1.77E+12
A1 - DIP Leads	1.85E+12	1.94E+09	1.94E+09	5.11E+09	2.81E+12
A1 - B-24--1	1.85E+12	1.04E+09	1.51E+08	8.28E+08	1.44E+12
A1 - B-24--2	1.09E+12	5.73E+08	2.08E+08	6.73E+08	1.94E+12
A1 - B-24--3	4.99E+11	2.87E+08	1.17E+09	6.73E+08	2.23E+12

Group B - Water Only Cleaning - SIR Results (Board 13)

all SIR values (ohms of resistance)

Group B Water Cleaned	Initial Ambient (20C/ 42%RH)	24 hrs Ambient (85C/ 85%RH)	96 hrs (85C/ 85%RH)	168 hrs (85C/ 85%RH)	168 hrs Ambient (20C/ 42%RH)
B13- QFN	3.10E+11	4.70E+07	8.35E+07	1.15E+07	1.00E+06
B13 - LCC Leads	2.15E+11	3.48E+09	3.33E+09	4.28E+09	1.45E+12
B13 - LCC Comb	9.81E+11	5.03E+08	3.91E+08	4.92E+08	8.75E+11
B13 - TQFP Leads	7.80E+11	9.81E+08	2.20E+09	2.77E+09	1.45E+12
B13 - TQFP Comb	1.52E+11	1.52E+07	1.75E+07	2.96E+07	1.00E+06
B13 – BGA	1.00E+12	2.30E+09	1.96E+09	2.41E+09	1.35E+12
B13 - DIP Y	3.33E+11	2.15E+09	2.47E+09	3.03E+09	1.42E+12
B13 - DIP Leads	6.19E+11	2.52E+09	7.62E+09	7.98E+09	1.26E+12
B13 - B-24—1	5.27E+11	1.42E+09	1.39E+09	1.75E+09	1.26E+12
B13 - B-24—2	7.45E+11	2.47E+09	1.91E+09	2.30E+09	1.45E+12
B13 - B-24--3	4.92E+11	2.96E+08	1.67E+09	2.52E+09	1.42E+12

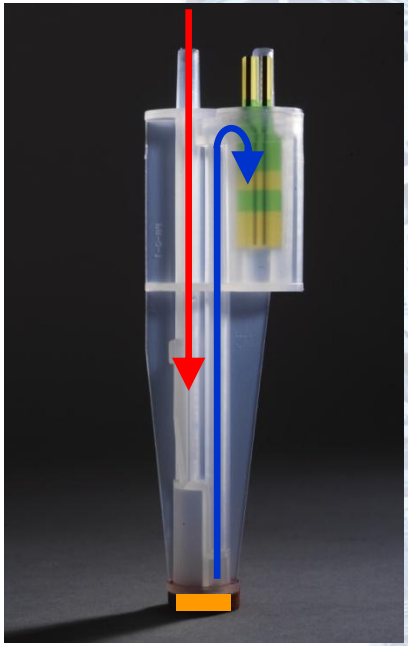
Group B - Water Only Cleaning - SIR Results (Board 17)

all SIR values (ohms of resistance)

Group B Water Cleaned	Initial Ambient (20C/ 42%RH)	24 hrs Ambient (85C/ 85%RH)	96 hrs (85C/ 85%RH)	168 hrs (85C/ 85%RH)	168 hrs Ambient (20C/ 42%RH)
B17- QFN	2.50E+11	3.55E+07	1.24E+07	1.00E+06	1.00E+06
B17 - LCC Leads	2.75E+11	4.24E+09	5.24E+09	6.85E+09	2.14E+12
B17 - LCC Comb	8.44E+12	4.14E+09	5.99E+09	5.81E+09	9.65E+11
B17 - TQFP Leads	6.34E+11	3.69E+09	4.11E+09	3.87E+09	6.52E+11
B17 - TQFP Comb	6.25E+11	3.52E+07	1.04E+07	9.81E+06	1.00E+06
B17 - BGA	5.14E+12	3.63E+09	5.24E+09	1.54E+10	2.55E+12
B17 - DIP Y	4.11E+11	1.24E+09	3.66E+09	4.14E+09	3.69E+11
B17 - DIP Leads	1.07E+12	1.47E+09	5.24E+09	8.74E+09	2.14E+12
B17 - B-24--1	1.55E+11	1.58E+09	3.66E+09	5.96E+10	2.07E+11
B17 - B-24--2	1.69E+12	3.05E+09	2.74E+09	8.97E+10	1.63E+12
B17 - B-24--3	2.85E+11	1.77E+08	3.07E+09	5.76E+10	2.05E+11

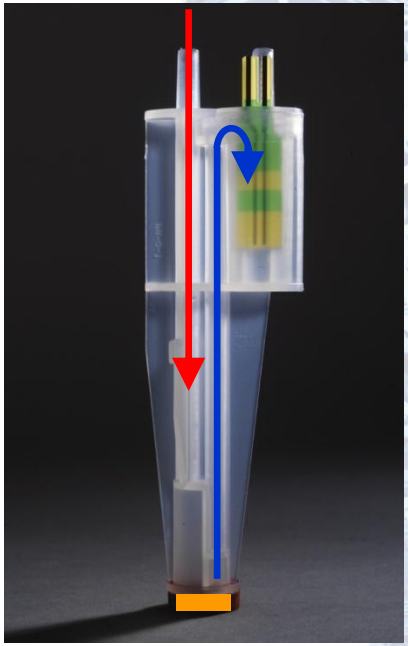
Group A - Localized Extractions

all values are ug/in2	Ion Chromatography							C3 Tester	
Sample Description	**Cl^-**	**NO_2^-**	**Br^-**	**NO_3^-**	**PO_4^{2-}**	**SO_4^{2-}**	**WOA**	**Resutls**	**Time(sec)**
Foresite Limits No Clean	3.0	3.0	12.0	3.0	3.0	3.0	25.0	**Clean**	**>60**
Foresite Limits for Cleaning	6.0	3.0	6.0	3.0	3.0	3.0	25.0	**Clean**	**>60**
C3 extraction of the three areas on each Umpire 2 test assembly									
Group A - 1 QFN	0.55	0	0.26	1.21	0	1.65	89.68	Dirty	3
Group A - 2 QFN	0.62	0	0.28	1.26	0	1.27	102.65	Dirty	2
Group A - 3 QFN	0.81	0	0.11	1.05	0	1.65	96.69	Dirty	4
Group A - 4 QFN	0.65	0	0.24	0.95	0	1.54	124.77	Dirty	2
Group A - 5 QFN	0.49	0	0.36	1.17	0	1.66	151.24	Dirty	1
Group A - 6 QFN	0.63	0	0.22	0.89	0	1.51	87.94	Dirty	7
Group A - 7 QFN	0.54	0	0.21	0.91	0	1.39	103.65	Dirty	2
Group A - 8 QFN	0.66	0	0.09	1.54	0	1.24	114.24	Dirty	2
Group A - 9 QFN	0.91	0	0.24	1.69	0	1.69	123.65	Dirty	1
Group A - 10 QFN	0.37	0	0.15	1.47	0	1.54	124.36	Dirty	2
Group A - 1 QFP	0.51	0	0.12	0.68	0	1.24	74.65	Dirty	19
Group A - 2 QFP	0.36	0	0.21	0.94	0	1.05	92.36	Dirty	11
Group A - 3 QFP	0.52	0	0.26	0.78	0	1.21	71.65	Dirty	18
Group A - 4 QFP	0.24	0	0.15	0.85	0	1.31	93.26	Dirty	12
Group A - 5 QFP	0.55	0	0.16	0.69	0	1.15	81.24	Dirty	12
Group A - 6 QFP	0.62	0	0.11	0.84	0	1.41	77.25	Dirty	17
Group A - 7 QFP	0.39	0	0.15	0.99	0	1.84	69.95	Dirty	20
Group A - 8 QFP	0.57	0	0.15	0.65	0	1.63	85.64	Dirty	18
Group A - 9 QFP	0.66	0	0.17	0.66	0	1.51	78.98	Dirty	20
Group A - 10 QFP	0.51	0	0.16	0.54	0	1.36	94.21	Dirty	12
Group A - 1 LCC	0.69	0	0.21	0.85	0	1.24	12.36	Clean	180
Group A - 2 LCC	0.65	0	0.21	0.69	0	1.36	12.69	Clean	180
Group A - 3 LCC	0.54	0	0.15	0.66	0	1.15	11.24	Clean	180
Group A - 4 LCC	0.45	0	0.15	0.69	0	1.36	15.36	Clean	180
Group A - 5 LCC	0.63	0	0.17	0.57	0	1.25	14.21	Clean	180
Group A - 6 LCC	0.29	0	0.19	0.68	0	1.22	12.08	Clean	180
Group A - 7 LCC	0.65	0	0.16	0.63	0	1.19	11.96	Clean	180
Group A - 8 LCC	0.55	0	0.11	0.52	0	1.21	12.94	Clean	180
Group A - 9 LCC	0.78	0	0.18	0.61	0	1.42	12.41	Clean	180
Group A - 10 LCC	0.61	0	0.19	0.54	0	1.39	12.78	Clean	180



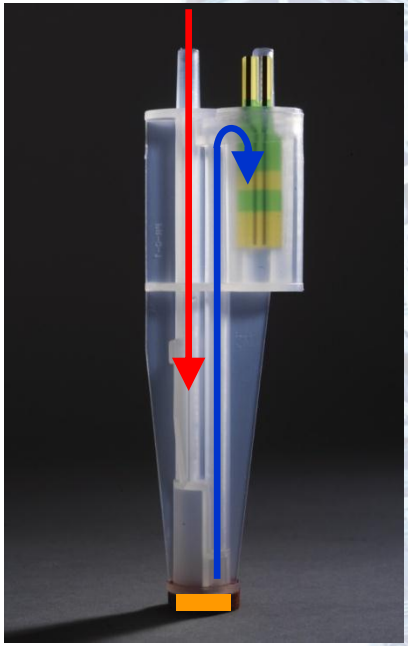
Group B - Localized Extractions

all values in ug/in2	Ion Chromatography							C3 Testing	
Sample Description	**Cl^-**	**NO_2^-**	**Br^-**	**NO_3^-**	**PO_4^{2-}**	**SO_4^{2-}**	**WOA**	**Results**	**Time(sec)**
Foresite Limits No Clean	3.0	3.0	12.0	3.0	3.0	3.0	25.00	**Clean**	**>60**
Foresite Limits for Cleaning	6.0	3.0	6.0	3.0	3.0	3.0	25.0	**Clean**	**>60**
C3 localized extraction									
Group B - 1 QFN	0.44	0	0	0.45	0	0.98	141.36	Dirty	2
Group B - 2 QFN	0.57	0	0	0.69	0	0.92	124.51	Dirty	3
Group B - 3 QFN	0.65	0	0	0.51	0	0.65	133.62	Dirty	4
Group B - 4 QFN	0.51	0	0	0.65	0	1.05	89.74	Dirty	8
Group B - 5 QFN	0.47	0	0	0.54	0	0.69	95.68	Dirty	7
Group B - 6 QFN	0.62	0	0	0.66	0	1.24	107.54	Dirty	4
Group B - 7 QFN	0.61	0	0	0.29	0	0.74	121.36	Dirty	2
Group B - 8 QFN	0.54	0	0	0.57	0	0.84	174.35	Dirty	1
Group B - 9 QFN	0.39	0	0	0.65	0	0.99	145.62	Dirty	2
Group B - 10 QFN	0.47	0	0	0.41	0	0.87	127.14	Dirty	3
Group B - 1 QFP	0.45	0	0	0.63	0	0.69	81.54	Dirty	19
Group B - 2 QFP	0.36	0	0	0.29	0	0.87	95.64	Dirty	15
Group B - 3 QFP	0.29	0	0	0.55	0	0.95	85.64	Dirty	19
Group B - 4 QFP	0.66	0	0	0.45	0	0.87	87.88	Dirty	18
Group B - 5 QFP	0.54	0	0	0.42	0	0.99	91.24	Dirty	19
Group B - 6 QFP	0.45	0	0	0.27	0	0.79	77.14	Dirty	24
Group B - 7 QFP	0.36	0	0	0.29	0	1.02	80.69	Dirty	20
Group B - 8 QFP	0.54	0	0	0.36	0	1.05	91.24	Dirty	16
Group B - 9 QFP	0.44	0	0	0.56	0	0.94	84.54	Dirty	18
Group B - 10 QFP	0.61	0	0	0.44	0	0.81	78.98	Dirty	22
Group B - 1 LCC	0.56	0	0	0.39	0	0.92	10.32	Clean	180
Group B - 2 LCC	0.48	0	0	0.51	0	0.87	8.97	Clean	180
Group B - 3 LCC	0.65	0	0	0.27	0	0.69	9.65	Clean	180
Group B - 4 LCC	0.66	0	0	0.29	0	0.94	8.97	Clean	180
Group B - 5 LCC	0.64	0	0	0.65	0	0.85	9.65	Clean	180
Group B - 6 LCC	0.55	0	0	0.44	0	0.96	8.47	Clean	180
Group B - 7 LCC	0.29	0	0	0.42	0	0.77	8.51	Clean	180
Group B - 8 LCC	0.44	0	0	0.51	0	0.89	9.36	Clean	180
Group B - 9 LCC	0.57	0	0	0.27	0	1.01	8.97	Clean	180
Group B - 10 LCC	0.63	0	0	0.32	0	0.78	9.21	Clean	180



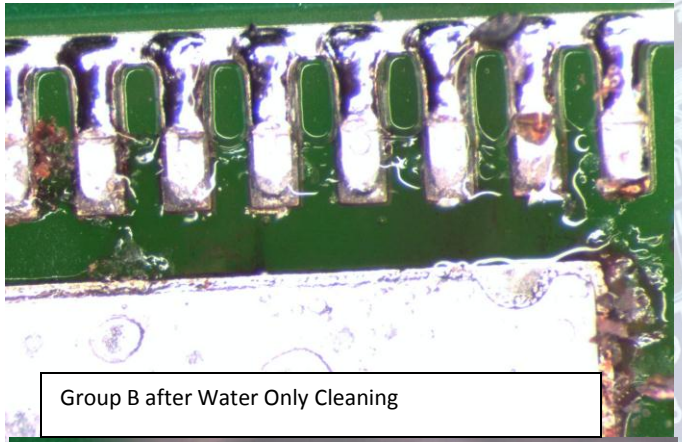
Group C - Localized Extractions

all values are ug/in2	Ion Chromatography							C3 Tester	
Sample Description	**Cl^-**	**NO_2^-**	**Br^-**	**NO_3^-**	**PO_4^{2-}**	**SO_4^{2-}**	**WOA**	**Resutls**	**Time(sec)**
Foresite Limits No Clean	3.0	3.0	12.0	3.0	3.0	3.0	25.0	**Clean**	**>60**
Foresite Limits for Cleaning	6.0	3.0	6.0	3.0	3.0	3.0	25.0	**Clean**	**>60**
C3 extraction of the three areas on each Umpire 2 test assembly									
Group C - 1 QFN	0.24	0	0	0.24	0	0	12.32	Clean	180
Group C - 2 QFN	0.25	0	0	0.36	0	0	10.05	Clean	180
Group C - 3 QFN	0.19	0	0	0.15	0	0	9.89	Clean	180
Group C - 4 QFN	0.22	0	0	0.19	0	0	12.24	Clean	180
Group C - 5 QFN	0.14	0	0	0.24	0	0	12.00	Clean	180
Group C - 6 QFN	0.19	0	0	0.11	0	0	12.33	Clean	180
Group C - 7 QFN	0.12	0	0	0.24	0	0	11.24	Clean	180
Group C - 8 QFN	0.10	0	0	0.21	0	0	19.65	Clean	180
Group C - 9 QFN	0.13	0	0	0.26	0	0	12.04	Clean	180
Group C - 10 QFN	0.10	0	0	0.09	0	0	8.97	Clean	180
Group C - 1 QFP	0.12	0	0	0.15	0	0	5.64	Clean	180
Group C - 2 QFP	0.13	0	0	0.24	0	0	5.23	Clean	180
Group C - 3 QFP	0.14	0	0	0.13	0	0	4.65	Clean	180
Group C - 4 QFP	0.10	0	0	0.22	0	0	4.51	Clean	180
Group C - 5 QFP	0.19	0	0	0.14	0	0	4.71	Clean	180
Group C - 6 QFP	0.12	0	0	0.15	0	0	6.95	Clean	180
Group C - 7 QFP	0.08	0	0	0.22	0	0	5.85	Clean	180
Group C - 8 QFP	0.11	0	0	0.07	0	0	6.63	Clean	180
Group C - 9 QFP	0.12	0	0	0.17	0	0	7.01	Clean	180
Group C - 10 QFP	0.13	0	0	0.16	0	0	5.47	Clean	180
Group C - 1 LCC	0.09	0	0	0.11	0	0	4.35	Clean	180
Group C - 2 LCC	0.12	0	0	0.09	0	0	4.21	Clean	180
Group C - 3 LCC	0.13	0	0	0.12	0	0	3.96	Clean	180
Group C - 4 LCC	0.05	0	0	0.04	0	0	2.35	Clean	180
Group C - 5 LCC	0.12	0	0	0.07	0	0	4.05	Clean	180
Group C - 6 LCC	0.13	0	0	0.16	0	0	6.59	Clean	180
Group C - 7 LCC	0.04	0	0	0.03	0	0	4.14	Clean	180
Group C - 8 LCC	0.10	0	0	0.15	0	0	4.24	Clean	180
Group C - 9 LCC	0.06	0	0	0.11	0	0	3.96	Clean	180
Group C - 10 LCC	0.08	0	0	0.08	0	0	3.81	Clean	180

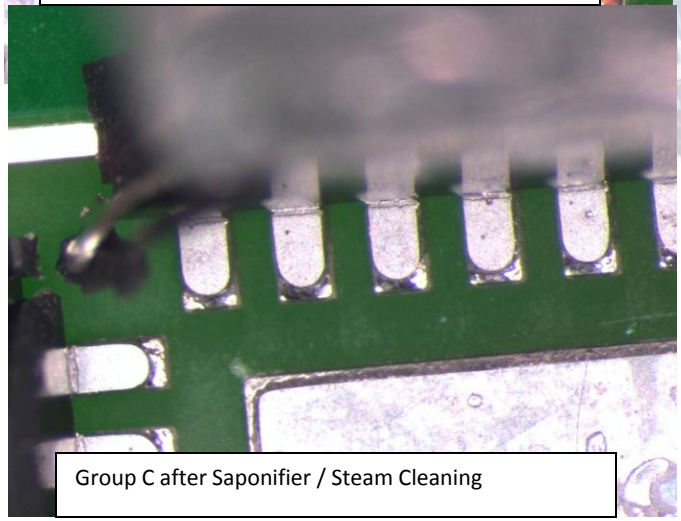


QFN Failures – Why?

- Typically, the flux from the ground and thermal vent pad is trapped under the QFN, leaving gooey, wet flux between the back of the pad and ground plane when the component is less than 3 mils off the board surface



Group B after Water Only Cleaning



Group C after Saponifier / Steam Cleaning

Localized Extraction vs. Total Board

- The QFN and QFP areas both show high WOA results from the SMT reflow and from the selective wave process when using the C3/IC and **not** when utilizing ROSE or total board extraction.

- The QFN was high in WOA because of entrapped flux under the QFN, while the QFP was high in WOA due to the flux from the selective wave migrating up through the vias and being trapped under the component body and leads.

- The LCC area showed good low levels of flux residues (WOA) using C3/IC, with good SIR performance

- These C3 results correlate with the electrical performance results of the SIR testing per the J-STD 001 testing protocol. C3/IC is more sensitive than the ROSE and total board analysis techniques.

- ROSE testing and total board Ion Chromatography were not able to target the pockets of contamination on the Umpire II Board and did not correlate with SIR on specific components.

Why Didn't We Ever Worry About These Critical Parameters Before?

- From 1950 to 1990 circuit designs and miniaturization were slowly evolving, while from 1990 to present day – Wow!!!
- The use of Rosin based fluxes and solvent cleaning, during these times, sealed in bare board contaminants and flux activators in a thin clear coat varnish layer that was left after the solvent cleaning – Rosin sealed these corrosive residues in and kept out the moisture from our active circuits
- Mixed technology boards were top-side SMT (reflow), bottom-side SMT (glue) and Wave
- Since 1990 the fluxes contain 0% Rosin and are not cleaned. For 70% of the industry, the cumulative contaminants are what go into the field; while 25% that clean, will do so with RO / DI water only

How Do We Test for Cleanliness?

- We use a two stage approach to answer the cleanliness question

1. Extract the dry residues from the surface and sub-surface with a non-destructive, minimally-diluting, steam system to isolate the specific PCB area on which we want to understand the cleanliness

2. Analyze the extracted solution with an optimized column separation and techniques that have low PPB sensitivity and minimal extraction volume dilution effects to determine the amount of contamination present as individual ions and organics

C3 Extraction and Test System

- How does the C3 work?
  - Extractions are isolated, by the test cell, to the specific area with a Cell, A = 0.1 in^2
  - Extraction solution is optimized for the C3 test system with minimal residues and dilution effects
  - Use of the C3 standard parameters that remove 98% of the ionizable, extractable residues
  - Proper steam dispense, soak and aspiration to extract the residues
  - Electrically understand the corrosivity of the residue from a specific location through electrical testing, using a copper electrode in the solution to see if and when a short circuit occurs

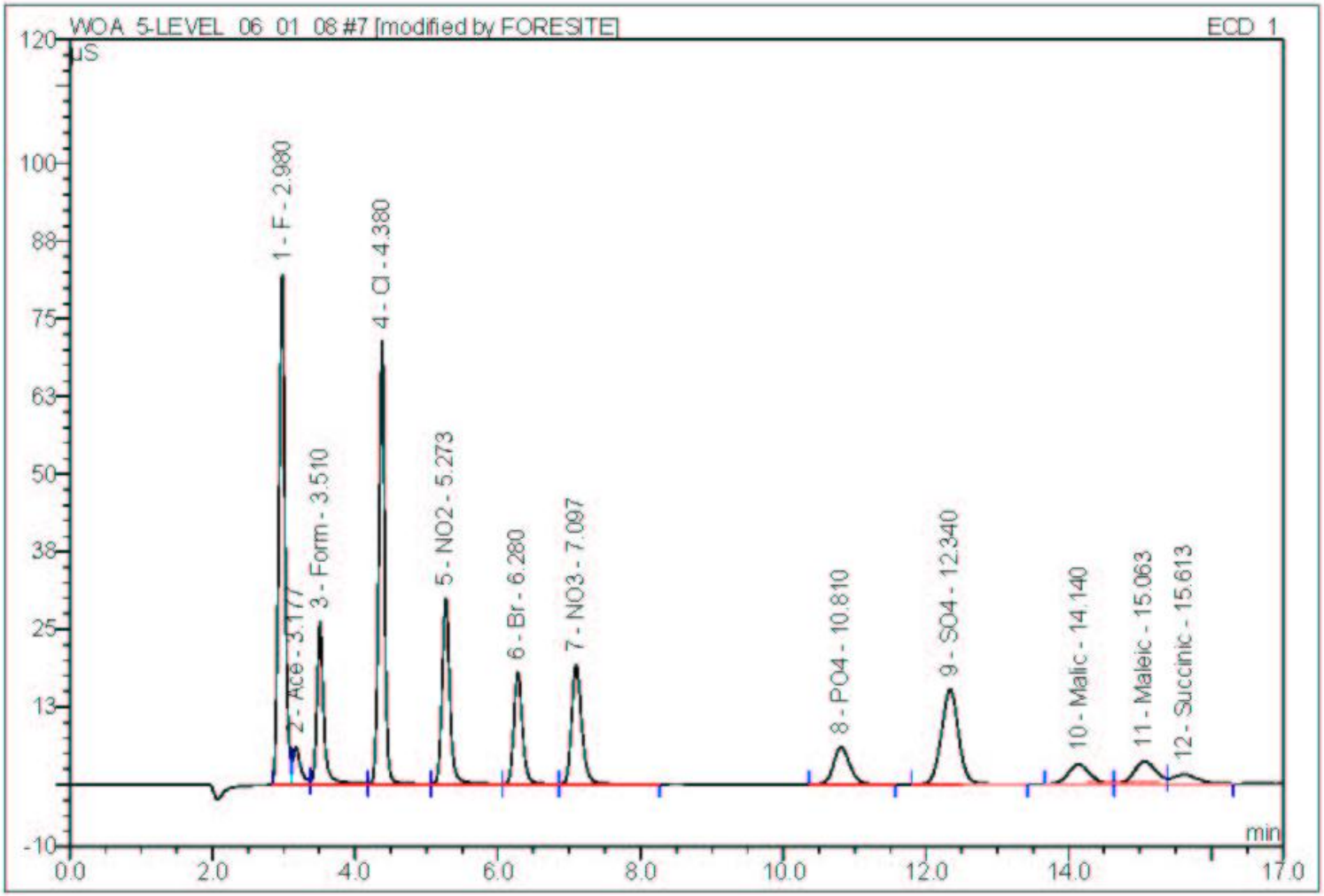
Ion Chromatography

- Foresite has optimized the separation of the AS22 column to create a 17 minute run that eliminates the problems with other columns (co-elution of sulfate and WOA, separation of the WOAs into separate organic acids, short run-time, low PPB sensitivity)
  - Anions:

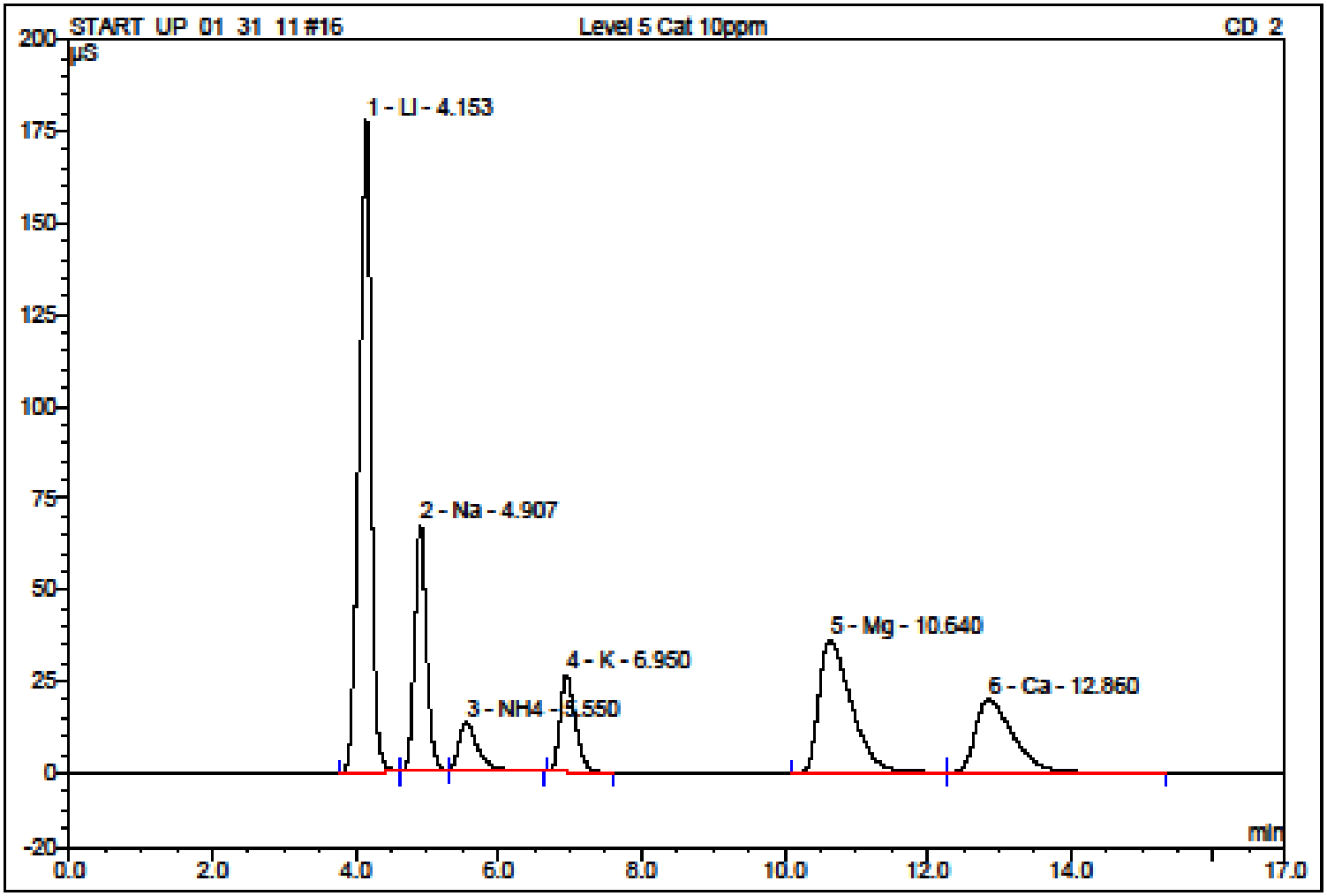
    Dionex AS22 modified isocratic eluent with chemical suppression
    - Fluoride, acetate, formate, MSA (Methane Sulfonic Acid), chloride, chlorate, nitrite, nitrate, phosphate, sulfate, succinic, malic, maleic, glutaric, adipic, propanoic and abieatic acids
  - Cations:

    Dionex CS12A modified isocratic eluent with chemical suppression)
    - Lithium, sodium, ammonium, potassium, calcium, and magnesium

AS22 Anion Chromatogram



CS12A Cation Chromatogram



How Clean is Clean Enough?

1. We must understand how clean each of the critical parameters are:
   - A. Incoming bare boards (surface and innerlayer cleanliness, and mask porosity)
   - B. Incoming sensitive components
   - C. After 1st reflow (look at critical low stand off components (QFN, SOT23 and BGA)
   - D. After 2nd reflow
   - E. After selective soldering
     (look at contact area of wave and just next to it, and top side vias)
   - F. After repair/rework/ touch-up
   - G. After cleaning (batch or in-line)
   - H. After bench top brush cleaning
   - I. After conformal coating or potting
     (corrosive residues under coating / potting still corrode)
   - J. Inside housing , enclosure, foam, RTV level of cure

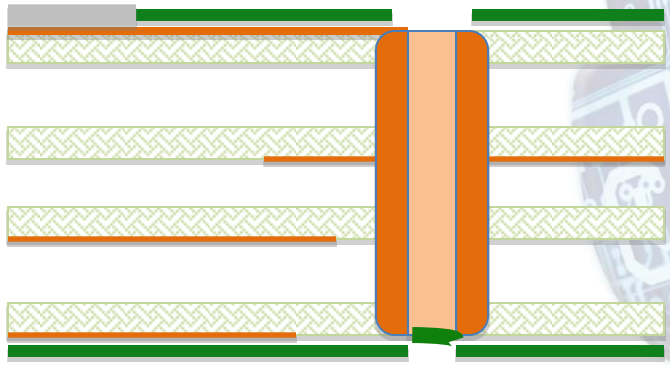
2. This is a lot to understand about the process, why should we???
   - A. When we ignore the changing critical parameters, quality and reliability suffers

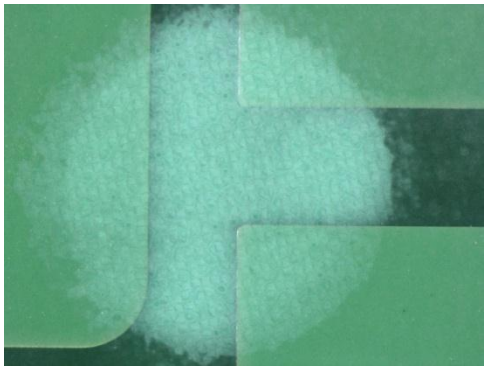
Questions

Bare Board Cleanliness Limits

ION NAME	CHEM ID	Bare Board
Foresite Cleanliness Limits for Class 1, 2, and 3		PCB prior mask Via or PTH Soldermask Area Pad Area Innerlayer
Acetate	$C_2H_2O_2$	2.5
Formate	CH_2O_2	2.5
Bromide	Br-	2.5
Chloride	Cl-	2
Fluoride	F-	2.5
Nitrate	NO_3^-	2.5
Nitrite	NO_2^-	2.5
Sulfate	SO_4^{2-}	3
Phosphate	PO_4^{2-}	2.5
MSA	methane sulfonic acid	0.5
WOA	SMT / hand/Selective	NA
WOA	Wave (direct contact)	NA
Lithium	Li+	2
Sodium	Na+	2
Potassium	K+	2
Ammonium	NH_4+	2.5
Calcium	Ca^2+	NA
Magnesium	Mg^2+	NA
C3	time/uA	>60s / 500 uA

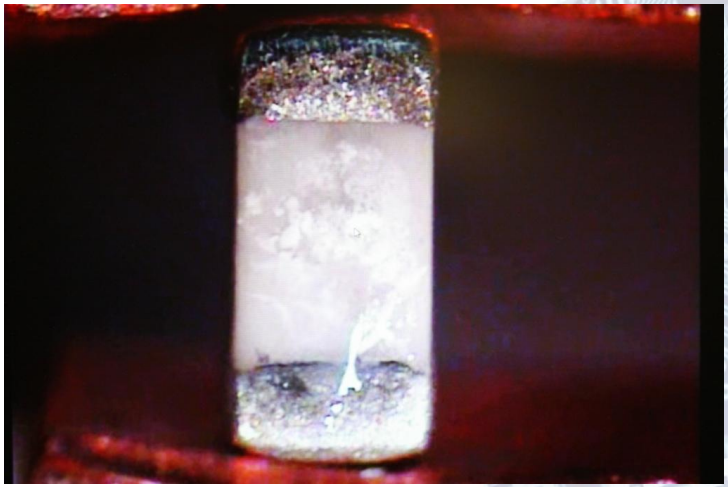
Bare board exploded cross-sectional view of via and innerlayers

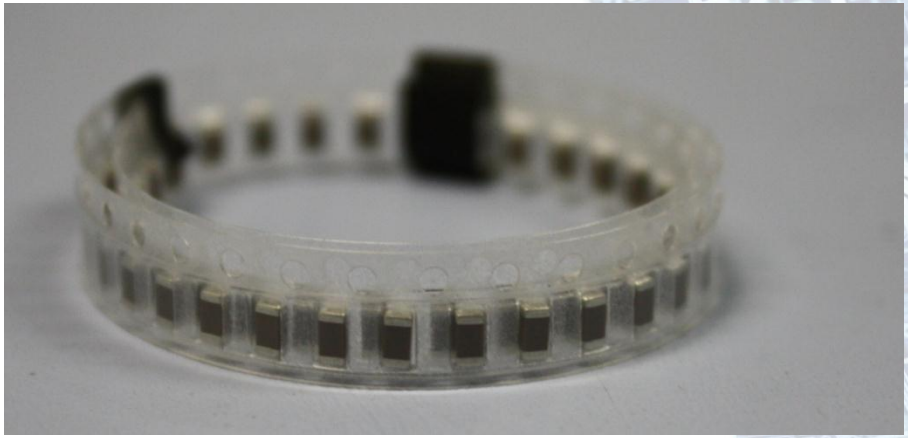




Component Cleanliness

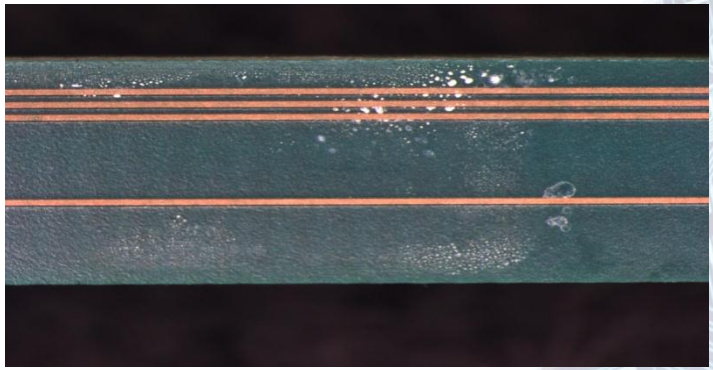
ION NAME	CHEM ID	Component
Foresite Cleanliness Limits for Class 1, 2, and 3		BGA Reballed BGA Tinned Incoming Tape / Reel Trayed component
Acetate	$C_2H_2O_2$	3
Formate	CH_2O_2	1
Bromide	Br-	6
Chloride	Cl-	1
Fluoride	F-	1
Nitrate	NO_3^-	2
Nitrite	NO_2^-	2
Sulfate	SO_4^{2-}	1
Phosphate	PO_4^{2-}	2
MSA	methane sulfonic acid	1
WOA	SMT / hand/Selective	25
WOA	Wave (direct contact)	NA
Lithium	Li+	1
Sodium	Na+	2
Potassium	K+	2
Ammonium	NH_4+	2.5
Calcium	$Ca^{2}+$	NA
Magnesium	$Mg^{2}+$	NA
C3	time/uA	>60s / 500 uA

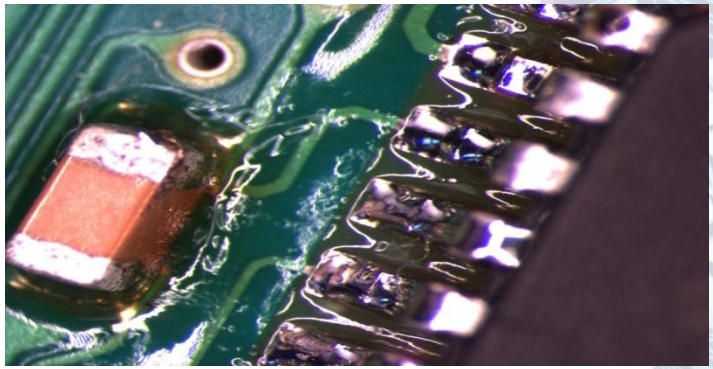


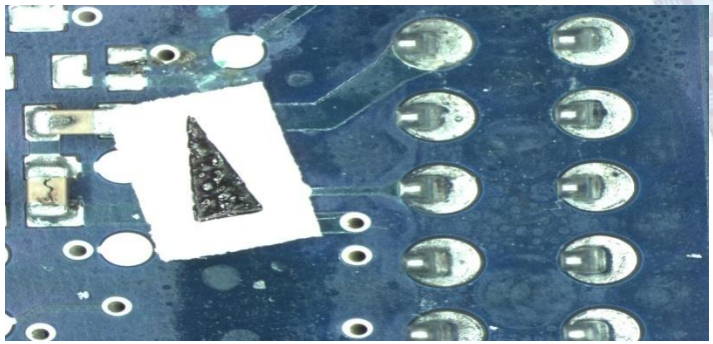


No Clean Cleanliness Limits

ION NAME	CHEM ID	PCBA (No Clean)
Foresite Cleanliness Limits for Class 1, 2, and 3		NC top via NC Selective NC SMT NC Wave Rework Area
Acetate	$C_2H_2O_2$	3
Formate	CH_2O_2	3
Bromide	Br-	6
Chloride	Cl-	3
Fluoride	F-	1
Nitrate	NO_3^-	3
Nitrite	NO_2^-	3
Sulfate	SO_4^{2-}	3
Phosphate	PO_4^{2-}	3
MSA	methane sulfonic acid	1
WOA	SMT / hand/Selective	25
WOA	Wave (direct contact)	150
Lithium	Li+	3
Sodium	Na+	3
Potassium	K+	3
Ammonium	NH_4+	3
Calcium	Ca^{2}+	NA
Magnesium	Mg^{2}+	NA
C3	time/uA	>60s / 500 uA

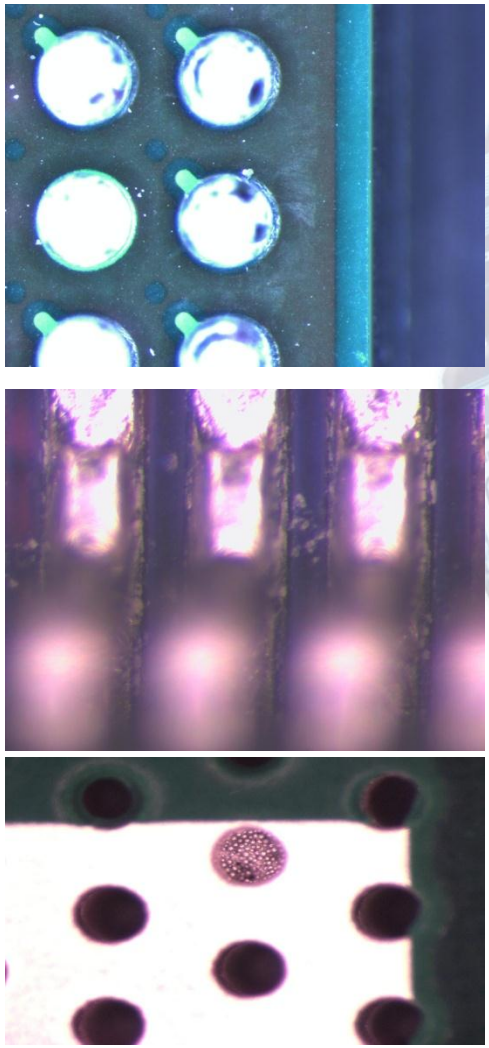






Cleaning Limits (WSF and NC)

ION NAME	CHEM ID	PCBA (Cleaned)
Foresite Cleanliness Limits for Class 1, 2, and 3		NC / WSF top via NC / WSF Selective NC / WSF SMT NC / WSF Wave Reworked / Misprint SMT
Acetate	$C_2H_2O_2$	3
Formate	CH_2O_2	3
Bromide	Br-	6
Chloride	Cl-	6
Fluoride	F-	1
Nitrate	NO_3^-	3
Nitrite	NO_2^-	3
Sulfate	SO_4^{2-}	3
Phosphate	PO_4^{2-}	3
MSA	methane sulfonic acid	1
WOA	SMT / hand/Selective	25
WOA	Wave (direct contact)	25
Lithium	Li+	3
Sodium	Na+	3
Potassium	K+	3
Ammonium	NH_4+	3
Calcium	$Ca^{2}+$	NA
Magnesium	$Mg^{2}+$	NA
C3	time/uA	>120s / 500 uA



Housing / Enclosure Cleanliness Limits

ION NAME	CHEM ID	Support
Foresite Cleanliness Limits for Class 1, 2, and 3		Heat Sink Housing Thermal Material Thermal Pad Battery housing
Acetate	$C_2H_2O_2$	3
Formate	CH_2O_2	3
Bromide	Br-	6
Chloride	Cl-	2
Fluoride	F-	1
Nitrate	NO_3^-	3
Nitrite	NO_2^-	3
Sulfate	SO_4^{2-}	3
Phosphate	PO_4^{2-}	3
MSA	methane sulfonic acid	1
WOA	SMT / hand/Selective	NA
WOA	Wave (direct contact)	NA
Lithium	Li+	1
Sodium	Na+	1
Potassium	K+	3
Ammonium	NH_4+	2
Calcium	Ca^{2+}	NA
Magnesium	Mg^{2+}	NA
C3	time/uA	>60s / 500 uA