THE EFFECT OF THERMAL PROFILES ON CLEANLINESS AND ELECTRICAL PERFORMANCE

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ABSTRACT
A proper reflow soldering profile is a key parameter in rendering no-clean flux residues benign which improves electrical performance and overall reliability. The level of remaining active flux residues can be directly tied to reliability of the assemblies in a normal field service environment. Another key factor the profile plays a major role in is the electrical performance during surface insulation resistance testing commonly used for initial material and process acceptance testing. This paper will demonstrate the different levels of active flux residues after multiple thermal profile variations. It will also discuss proper equipment selection and best practices for selecting locations to place thermocouples for best solder quality and fully complexed flux residues.

Key words:
Reliability, electrical leakage, thermal profile, electrochemical migration, dendrite, field failures

INTRODUCTION
The process of thermal profiling for reflow soldering is one of the most important considerations when setting assembly parameters. Knowing how to effectively profile includes choosing the proper equipment, understanding the results and being able to adjust as necessary. Consideration for some larger multi-layer assemblies and assemblies with large thermal mass components should be made to ensure that all areas of the assembly reach the minimum recommended temperature for proper solder joint formation as well as rendering no-clean flux residues benign. A review of the assembly drawing is necessary to determine if there are heavy copper layers in select areas. The heavier layers of copper will absorb heat away from the surface of the assembly. This can lead to cold and brittle solder joint defects.

Characteristics of Profile
There are four different phases or zones to analyze under the reflow curve.(See Fig.1) The first is the pre-heating slope (temperature ramp rate), then pre-heat dwell (soak time), followed by time above liquidus which will include the peak temperature, and lastly the cooling zone.

For the paste flux used in this trial the pre-heat slope should be controlled to <2.0^{o} C per second which allows for gradual evaporation of the flux and will yield a higher quality solder joint without increasing the risk of associated solder defects like solder balls, bridging, etc.

The preheat dwell phase is where the flux activators remove oxides and prep the metal surfaces for joining with the solder paste. This phase brings the entire assembly with components to a common temperature below the melting point of the solder. This temperature is typically maintained for 60-90 seconds for most paste types.

The reflow phase is when the intermetallic formation is made. The temperature is commonly anywhere between 20-40^{o}C above the melting point of the solder. Time above liquidus can vary between 30-90 seconds depending on thermal mass and other material choices.

The cooling zone helps determine the integrity of the solder joint grain structure. A quicker cool down ramp, in comparison to the pre-heat phase ramp, is normally desired but take care not to exceed the CTE of components and board surface. A common recommendation for cooling ramp rate is no more than 4^{0}C per second.

More detailed information can be found in the IPC-5730 Guideline for Temperature Profiling for Mass Soldering Process

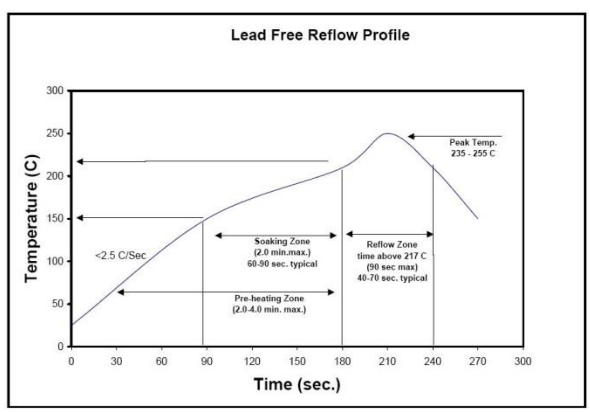


Figure 1 Example Reflow Profile Phases

Profiling Equipment
There are several choices of reflow profiling equipment available depending on need. There are profilers for either the product or the reflow oven. For this study we will

focus on only the product profiling equipment that travels with the product, thus eliminating the need for long wires that run the length of the oven. The product profiler should be capable of measuring multiple locations on the assembly. Most commercially available traveling type profilers have up to six separate thermocouples. Some have real time measurements sent to a receiver on a computer display and others use internal memory to store the data points for downloading after the product exits the reflow oven. Either type can yield the desired analysis.

Design of Experiment

Multiple thermal profiles were used for this experiment to determine what effect temperature has on cleanliness and electrical resistance measurements. Cleanliness was measured using ion chromatography and SIR testing is performed in an environment of 40^{o} C and 90% relative humidity with 5V bias with measurements made every 10 minutes. All test boards are the Umpire 2 qualification test board. See figure 2

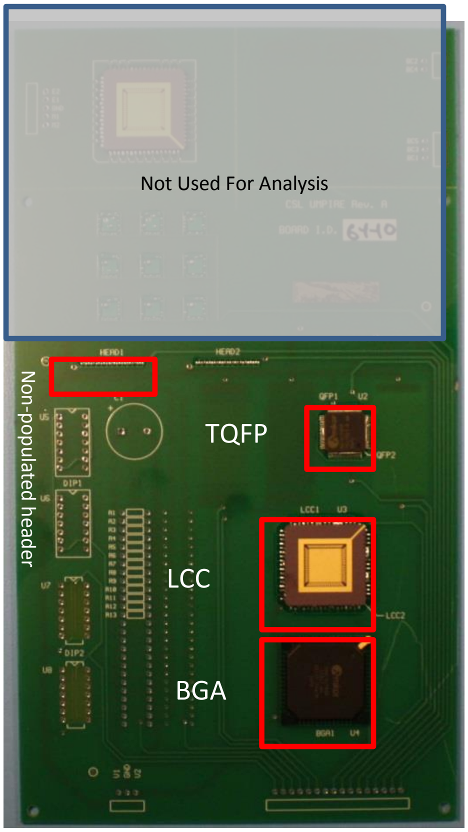


Figure 2. Umpire 2 Test Board

The first thermal profile is 20^{0} below the recommended limit

The second profile group was done at 10^{0} below the recommended limit

The third profile group was done at the manufacturers recommended profile for the solder paste. This is what is considered the minimum allowable temperature for proper solder joint formation and full flux activation.

The fourth profile was done at 10^{0} above the recommended limit.

Ten boards were processed for each profile group and of the ten five were tested with ion chromatography and the remaining five from each group were subjected to surface insulation resistance (SIR) testing. Each board was measured at four different locations including an LCC, TQFP, BGA, and a non-populated row of headers for reference.

Analysis Technique-Ion Chromatography

All testing is performed using a Dionex ICS 3000 chromatography system with Chromeleon software. The extractions were performed using an automated localized extraction technique. The parts were all mechanically removed and the samples were taken from the board level. Localized extractions are of upmost importance as they do not normalize out pockets of contamination across the full surface area of the assembly like other extraction and test methods do. A raw sample of the chosen solder paste was tested with IC to determine the main constituents of the paste activator. All samples were compared to the raw paste IC data when determining level of ionic cleanliness.

Analysis Technique-SIR

The SIR testing was performed in a standard environmental chamber capable of maintaining temperature within +/- 1^{o} C and relative humidity within 3%. A calibrated automatic switching measurement system was used for the electrical measurements taken once every 10 minutes.

Thermal Profile Group 1

The first thermal profile group was processed at a worst case temperature of 20o below what is recommended by the solder paste manufacturer. This is a profile that barely achieves liquidus state of the paste. This could be a function of multiple failing heating sources, improper recipe being used (possible a standard leaded profile) or other unknowns. See figure 3

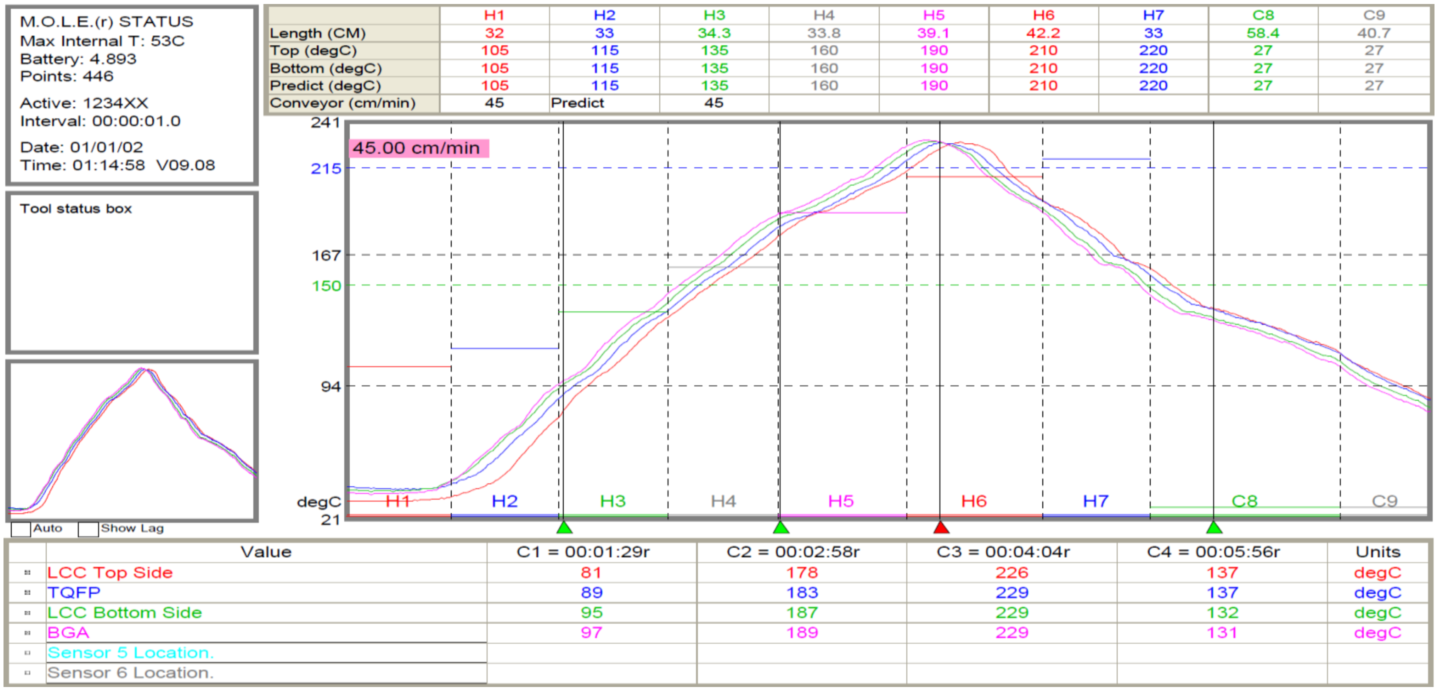


Figure 3

Analysis Results-Group #1 IC

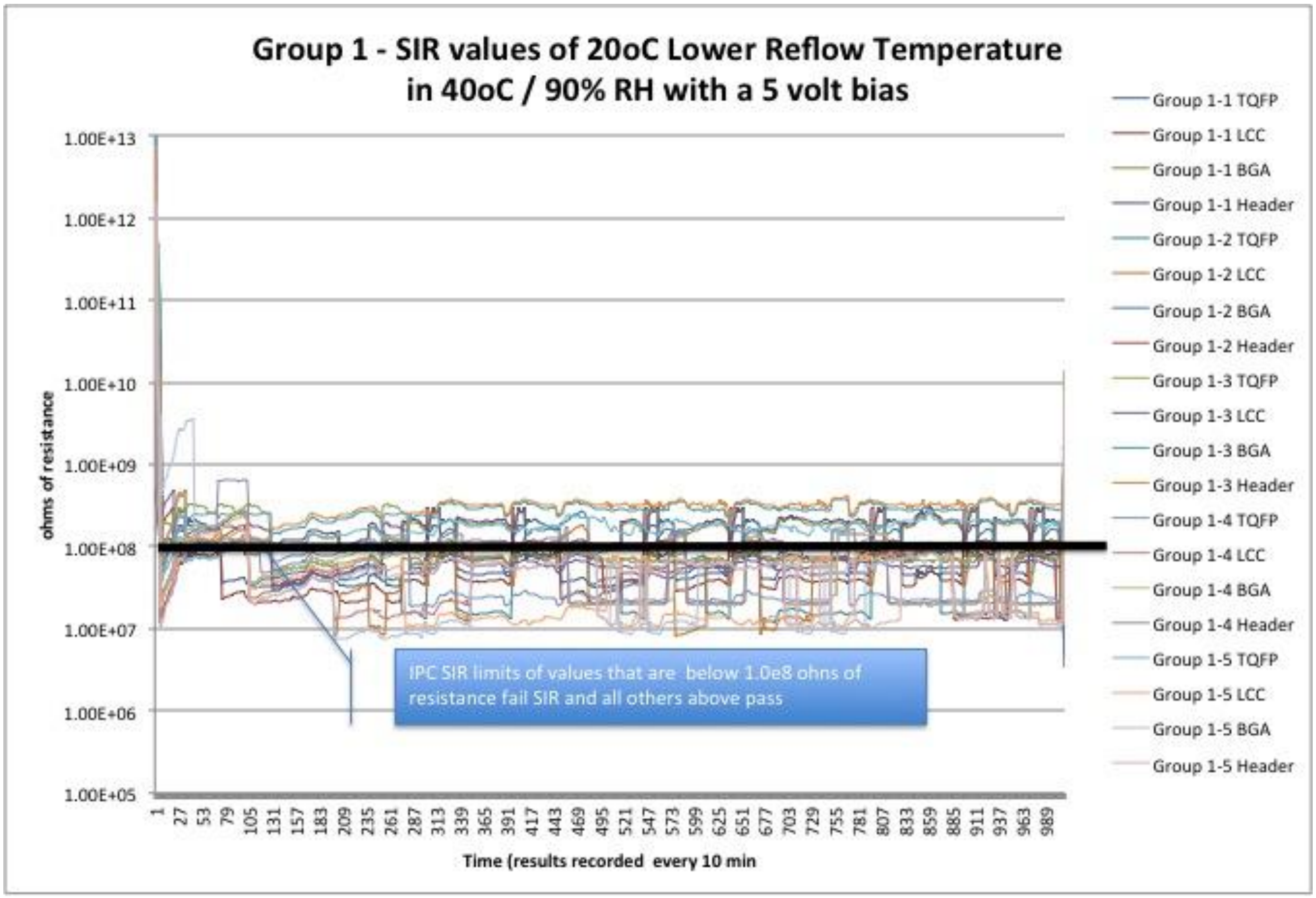
The raw paste IC sample shows that acetate, chloride, lithium, sodium, ammonium, and potassium are the ions of highest concentration and therefore also of highest concern after each reflow profile variation. This worst case profile shows highly elevated levels of acetate, chloride, lithium, and sodium. The ammonium and potassium levels depreciate greatly with this profile. See Table 1

Table 1 Ion Chromatography Data for Group 1

all values in µg/in²		Ion Chromatography (Dionex ICS 3000 at Foresite) n/a = not applicable															
		F^-	$C_2H_2O_2$	CH_2O_2	Cl^-	NO_2^-	Br^-	NO_3^-	PO_4^{3-}	SO_4^{2-}	WOA	MSA	Li^+	Na^+	NH_4^+	K^+	Ca^{2+}
Foresite recommended limits for PCBA (no clean)		1	3	3	3.00	3	6.0	3	3	3.0	150	1	3	3	3	3	n/a
Group #	Board #																
Raw Solder Paste		0.61	273.44	39.06	61.02	0.81	0.24	0.86	0	4.77	4.48	0	248.49	10.26	23.57	64.65	15.47
G1-B1	TQFP	0.58	12.54	2.61	3.47	0.14	0.30	0.75	0	2.74	2.55	0	30.40	6.18	1.06	1.84	8.66
G1-B1	LCC	0.76	13.99	5.21	4.35	0.98	0.22	0.15	0	2.56	0.85	0	28.98	6.12	1.33	0.50	9.39
G1-B1	BGA	0.28	10.84	3.17	16.30	0.12	0.13	0.44	0	3.06	0.63	0	31.32	3.77	0.88	0.84	9.71
G1-B1	Header	0.11	9.54	2.52	1.74	0.96	0.18	0.51	0	3.31	0.52	0	30.22	7.86	1.34	1.36	5.98
G1-B2	TQFP	0.88	14.57	2.95	3.24	0.36	0.31	0.40	0	3.68	0.73	0	32.77	7.26	1.91	1.29	7.35
G1-B2	LCC	1.00	12.07	3.62	1.80	0.57	0.35	0.16	0	3.82	3.74	0	35.23	3.65	1.79	0.71	3.53
G1-B2	BGA	1.05	11.55	3.59	1.56	0.47	0.24	0.18	0	3.98	0.30	0	33.83	4.31	1.36	1.01	10.43
G1-B2	Header	0.05	6.79	3.18	1.37	0.84	0.41	0.16	0	2.67	n.a.	0	41.15	7.28	0.97	0.66	3.15
G1-B3	TQFP	0.82	13.39	2.22	3.10	0.34	0.32	0.12	0	3.53	0.71	0	34.37	6.91	1.25	1.03	5.49
G1-B3	LCC	1.02	16.52	3.89	4.28	0.32	0.70	0.21	0	3.77	1.95	0	34.85	4.64	3.30	1.07	10.22
G1-B3	BGA	0.70	12.62	3.23	4.62	0.79	0.41	0.49	0	4.41	0.57	0	33.91	3.02	1.03	1.18	12.47
G1-B3	Header	0.23	6.75	2.60	3.93	1.07	0.33	0.10	0	3.12	1.02	0	41.38	5.94	0.81	0.14	0.71
G1-B4	TQFP	0.90	11.43	3.01	2.82	0.28	0.37	0.29	0	4.10	2.15	0	27.71	3.90	1.54	1.54	11.06
G1-B4	LCC	0.71	13.51	5.82	1.55	0.47	0.52	0.23	0	3.54	2.70	0	27.48	5.11	1.43	0.49	9.84
G1-B4	BGA	0.84	10.05	3.05	14.83	0.51	0.78	0.37	0	3.96	0.46	0	34.64	3.23	0.79	1.09	12.59
G1-B4	Header	0.02	10.55	2.82	5.87	0.66	0.68	0.15	0	2.96	2.40	0	30.38	6.33	1.05	1.51	7.06
G1-B5	TQFP	0.23	11.98	2.98	1.63	0.93	0.30	0.16	0	4.21	2.08	0	32.24	5.80	1.38	1.26	5.93
G1-B5	LCC	0.13	14.94	3.34	1.94	0.67	0.21	0.09	0	3.06	1.66	0	34.12	3.41	1.61	0.91	5.80
G1-B5	BGA	0.14	15.86	4.30	2.13	0.17	0.35	0.09	0	4.30	2.74	0	40.22	4.20	1.30	1.55	13.68
G1-B5	Header	0.02	12.68	1.94	1.47	0.56	0.13	0.13	0	2.27	1.05	0	53.61	4.71	1.64	0.31	0.78

Analysis Results-Group #1 SIR
Group #1 SIR results show that all samples fail the IPC limits of 1.0e8 ohms of resistance. See Table 2

Table 2 Group #1 SIR Results



Thermal Profile Group 2
Group 2 is a much more realistic profile than group 1 that shows the effect of the flux residues left behind on the analysis when the temperatures are only 10 degrees below the recommended limits. 10 degree variability is not out of the question for larger thermal mass boards and components and emphasizes the importance of profiling the assembly as well as the equipment. The equipment must also be tested to ensure that all heating elements are functioning properly. See figure 4 for thermal profile, table 3 for IC data, and table 4 for SIR data.

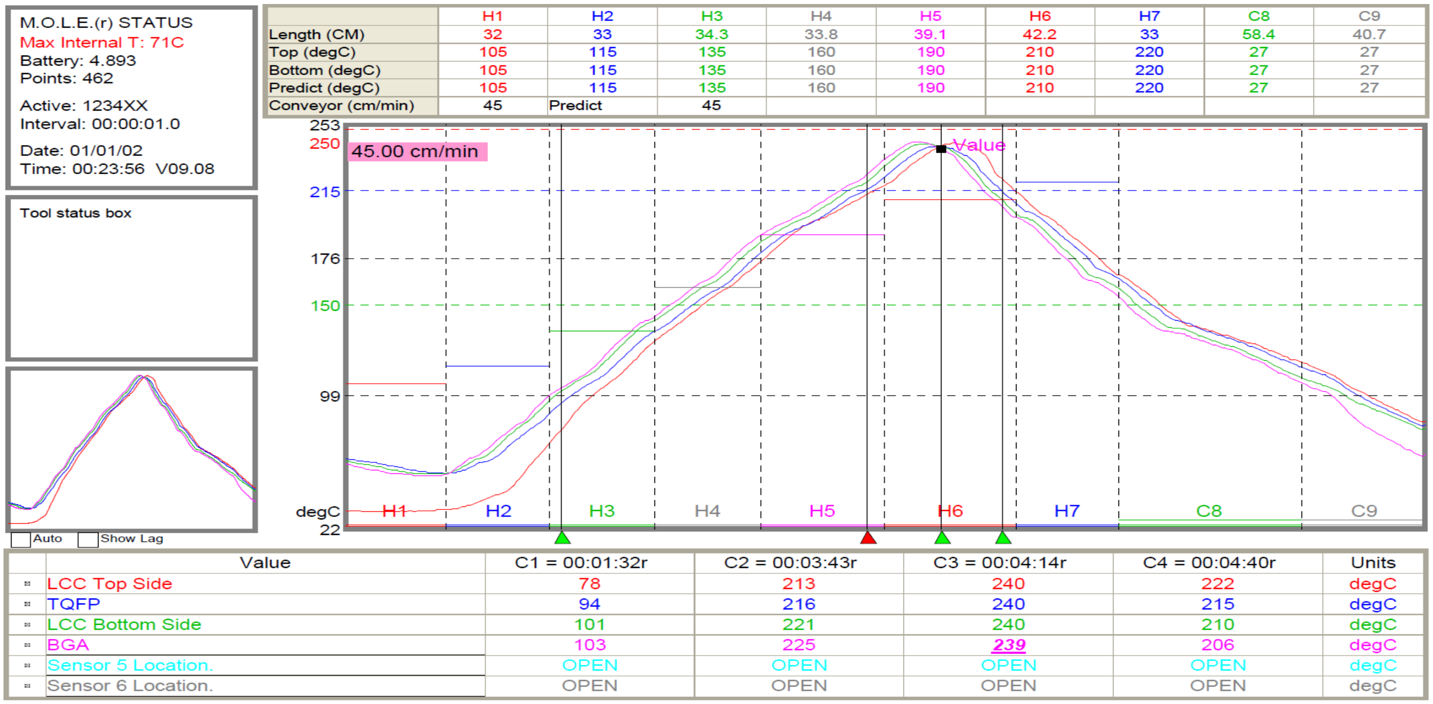


Figure 4 Group #2 Thermal Profile

Analysis Results-Group #2 IC

The IC results for group 2 shows lower levels of most ionics but most are still above the recommended limits. In particular the acetate, lithium, and sodium ions are still at a level that will increase the risk of failure in a normal field service environment.

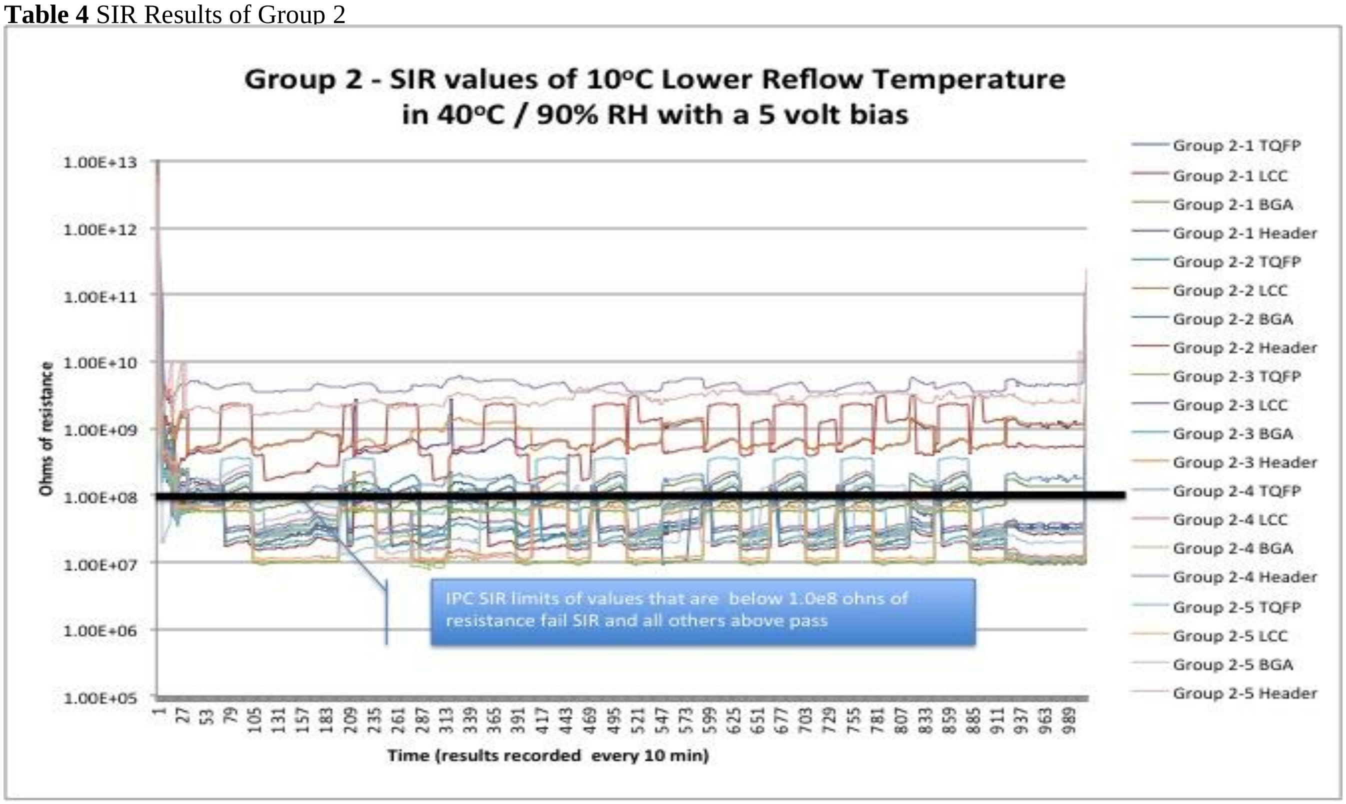
Table 3 Ion Chromatography Data for Group 2

all values in µg/in²		Ion Chromatography (Dionex ICS 3000 at Foresite) n/a = not applicable														
		F^-	$C_2H_2O_2$	CH_2O_2	Cl^-	NO_2^-	Br^-	NO_3^-	PO_4^{3-}	SO_4^{2-}	WOA	MSA	Li^+	Na^+	NH_4^+	K^+	Ca^{2+}
Foresite recommended limits for PCBA (no clean)		1	3	3	3.00	3	6.0	3	3	3.0	150	1	3	3	3	3	n/a
Group # Board #																	
Raw Solder Paste		0.61	273.44	39.06	61.02	0.81	0.24	0.86	0	4.77	4.48	0	248.49	10.26	23.57	64.65	15.47
G2-B1	TQFP	0.07	7.79	3.12	1.10	0.13	0.25	0.36	0	0.56	1.14	0	14.87	2.44	7.91	1.84	8.66
G2-B1	LCC	0.34	5.20	4.19	1.51	0.09	0.03	0.65	0	0.84	2.40	0	10.70	9.87	12.55	0.50	9.39
G2-B1	BGA	0.65	7.61	2.58	1.16	0.12	0.20	0.47	0	1.21	1.34	0	10.13	5.67	4.50	0.84	9.71
G2-B1	Header	0.97	1.18	1.16	0.62	n.a.	0.11	0.20	0	0.38	1.01	0	2.86	0.63	1.88	1.36	2.98
G2-B2	TQFP	0.96	8.57	3.64	2.03	0.18	0.04	0.85	0	0.51	2.63	0	12.18	2.89	5.83	1.29	7.35
G2-B2	LCC	0.63	11.75	3.59	2.37	0.09	0.30	0.33	0	0.27	1.31	0	11.01	7.44	8.53	0.71	3.53
G2-B2	BGA	0.66	12.71	3.13	0.87	0.10	0.10	0.05	0	0.69	2.55	0	11.06	5.34	8.81	1.01	10.43
G2-B2	Header	0.56	0.66	1.24	0.92	0.14	0.05	0.02	0	0.12	1.50	0	2.12	1.31	2.32	0.66	1.15
G2-B3	TQFP	0.82	10.08	2.89	1.38	0.08	0.13	0.13	0	0.94	2.38	0	10.86	1.07	3.76	1.03	5.49
G2-B3	LCC	0.59	9.86	3.11	2.56	0.22	0.13	0.89	0	1.11	1.39	0	10.96	8.71	10.11	1.07	10.22
G2-B3	BGA	0.50	7.88	2.41	1.27	0.21	0.08	0.36	0	1.05	1.95	0	11.40	5.55	4.70	1.18	12.47
G2-B3	Header	0.41	1.13	1.45	1.19	0.23	0.14	0.13	0	0.54	1.04	0	1.61	0.83	2.58	0.14	0.71
G2-B4	TQFP	0.19	10.67	1.13	1.40	0.24	0.60	0.35	0	0.62	1.86	0	12.58	1.83	5.98	1.54	11.06
G2-B4	LCC	0.10	12.53	2.99	2.08	0.11	0.21	0.14	0	0.42	1.24	0	11.85	2.87	4.21	1.32	6.32
G2-B4	BGA	0.31	11.83	3.84	3.26	0.26	0.07	0.24	0	0.33	1.59	0	12.96	3.15	4.65	2.01	5.54
G2-B4	Header	0.39	1.02	0.95	0.91	0.19	0.06	0.10	0	0.19	0.98	0	2.01	1.29	2.77	0.54	2.01
G2-B5	TQFP	0.22	8.44	2.16	4.01	0.14	0.11	0.18	0	0.27	2.20	0	13.10	2.98	3.96	1.22	3.67
G2-B5	LCC	0.44	9.61	3.02	3.25	0.22	0.27	0.07	0	0.28	3.01	0	12.43	3.01	4.02	1.63	4.21
G2-B5	BGA	0.38	9.74	4.01	3.64	0.34	0.30	0.11	0	0.30	2.57	0	12.22	2.57	3.65	1.25	3.96
G2-B5	Header	0.27	0.98	1.29	1.01	0.09	0.14	0.12	0	0.16	1.13	0	1.45	1.03	1.43	0.91	2.14

Analysis Results-Group #2 SIR

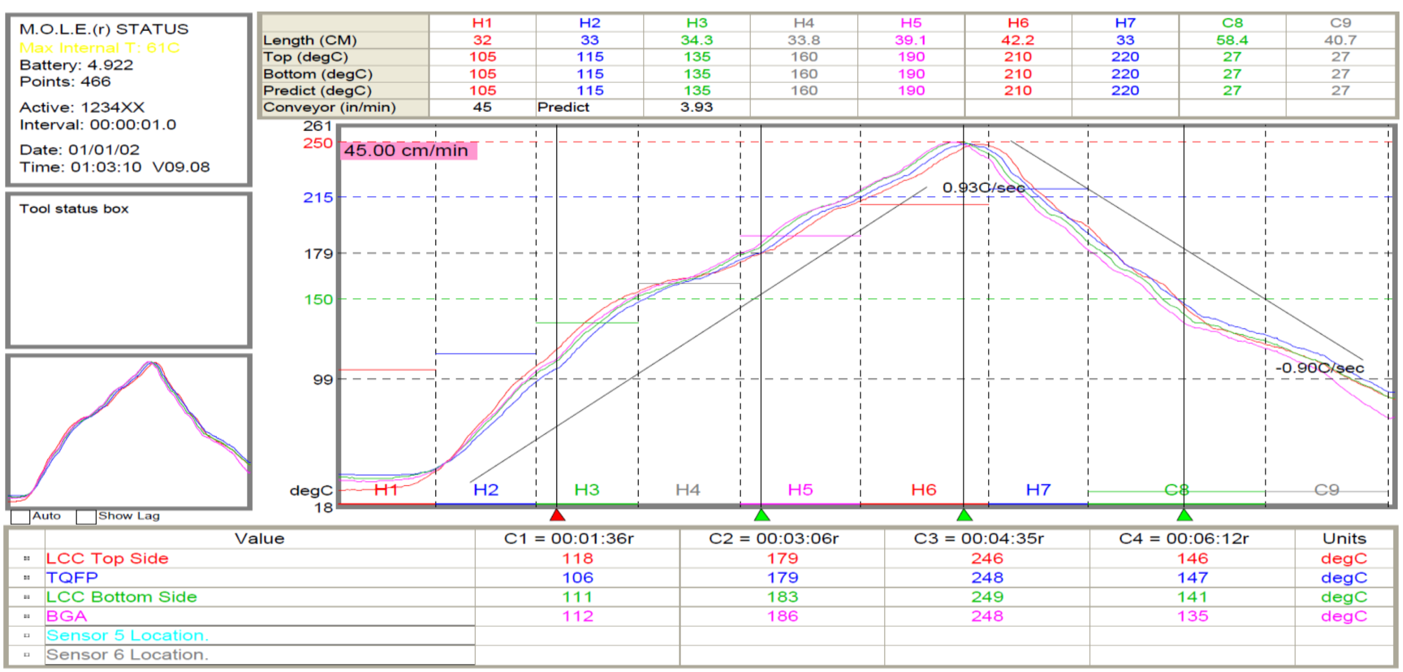
All locations with components failed both the SIR criteria as well as the recommended ion chromatography limits. The header (non-populated) area did pass both SIR and IC testing due to the lack of thermal mass

Table 4 SIR Results of Group 2



Thermal Profile Group 3

The manufacturer recommends a maximum ramp of <2^{o} per second with a dwell time of between 30-90 seconds at peak temperature. For this study a peak temp of 250^{0} and a dwell time of ~60 seconds was chosen. The profile is seen in figure 5, IC results in table 5, and SIR results in table 6



Analysis Results-Group #3 IC

The manufacturers recommended profile renders all of the flux activators benign in the areas tested with and without components. Looking at the profile for group #3 all of the areas reached at least 246^{o} C which is within the recommended range of 25-45 degrees above melting point of the solder.

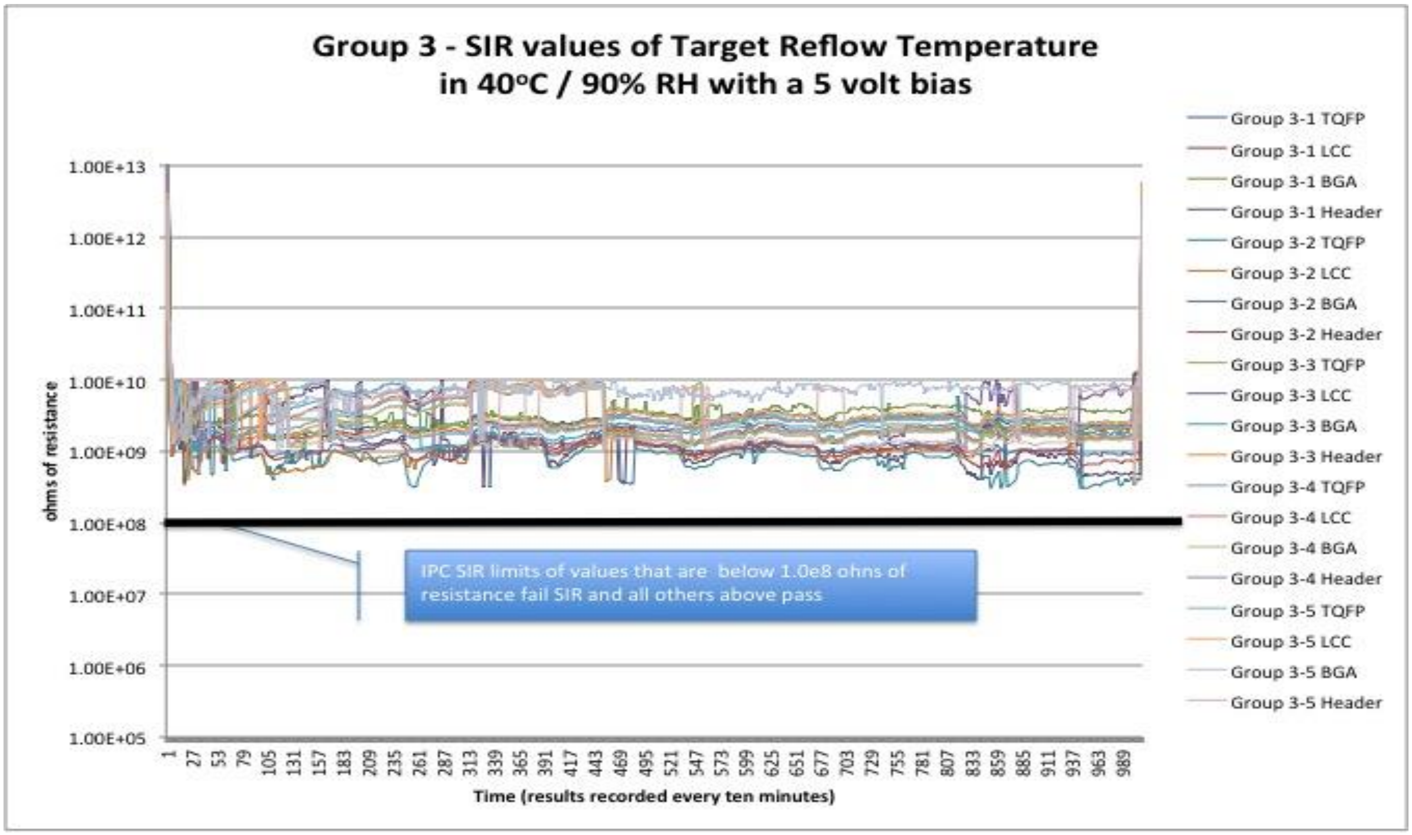
Table 5 Ion Chromatography Results of Group 3

all values in $\mu g/in^2$		Ion Chromatography (Dionex ICS 3000 at Foresite) n/a = not applicable															
		F^-	$C_2H_2O_2$	CH_2O_2	Cl^-	NO_2^-	Br^-	NO_3^-	PO_4^{3-}	SO_4^{2-}	WOA	MSA	Li^+	Na^+	NH_4^+	K^+	Ca^{2+}
Foresite recommended limits for PCBA (no clean)		1	3	3	3.00	3	6.0	3	3	3.0	150	1	3	3	3	3	n/a
Group # Board #																	
Raw Solder Paste		0.61	273.44	39.06	61.02	0.81	0.24	0.86	0	4.77	4.48	0	248.49	10.26	23.57	64.65	15.47
G3-B1	TQFP	0	2.58	2.45	1.97	0.37	1.33	0.08	0	2.59	0.39	0	1.91	1.60	1.41	0.91	1.53
G3-B1	LCC	0	1.88	2.16	1.41	0.32	1.53	0.05	0	1.46	0.40	0	2.84	1.55	2.89	2.03	3.29
G3-B1	BGA	0	2.46	2.24	1.41	0.42	1.06	0.04	0	1.22	2.78	0	2.06	1.38	1.34	1.53	2.38
G3-B1	Header	0	0.13	1.15	0.44	0.56	0.43	0.02	0	1.61	1.88	0	1.16	1.13	1.10	0.86	2.56
G3-B2	TQFP	0	1.31	2.28	2.00	0.43	1.30	0.28	0	2.28	2.02	0	2.24	0.79	1.89	2.33	2.30
G3-B2	LCC	0	1.33	1.98	0.93	0.31	1.28	0.03	0	2.23	1.47	0	2.99	0.81	0.96	2.80	2.29
G3-B2	BGA	0	1.63	1.94	1.04	0.66	0.88	0.01	0	2.68	1.24	0	1.16	0.92	0.96	1.74	3.02
G3-B2	Header	0	0.24	0.39	0.54	0.04	0.71	0.05	0	1.10	2.24	0	0.77	0.45	0.79	0.70	2.03
G3-B3	TQFP	0	2.08	2.38	1.39	0.41	1.23	0.15	0	2.24	2.25	0	1.69	1.76	1.15	0.24	0.67
G3-B3	LCC	0	1.41	2.73	1.07	0.53	1.49	0.04	0	2.56	2.08	0	1.88	1.71	1.09	1.99	2.43
G3-B3	BGA	0	1.88	2.02	1.25	0.19	1.54	0.09	0	2.53	1.91	0	2.05	1.57	0.90	2.23	1.47
G3-B3	Header	0	0.80	0.74	0.87	0.49	0.90	0.30	0	1.41	0.29	0	0.79	1.22	1.23	1.05	2.28
G3-B4	TQFP	0	1.34	3.06	1.28	0.28	1.27	0.16	0	2.91	1.59	0	1.19	2.32	0.98	1.96	3.29
G3-B4	LCC	0	0.98	2.43	1.06	0.23	1.84	0.05	0	2.64	3.06	0	2.01	2.08	0.90	2.40	2.58
G3-B4	BGA	0	1.67	2.55	0.36	0.27	1.18	0.14	0	1.58	2.43	0	2.39	1.68	0.95	2.35	1.96
G3-B4	Header	0	0.87	1.05	0.93	0.17	1.29	0.16	0	1.08	1.99	0	0.56	0.66	1.12	1.01	1.44
G3-B5	TQFP	0	1.34	3.06	0.75	0.26	1.42	0.11	0	2.66	2.72	0	1.31	2.63	0.76	1.16	3.83
G3-B5	LCC	0	1.52	2.30	1.53	0.48	2.78	0.17	0	1.57	2.37	0	2.92	3.04	1.06	1.71	1.64
G3-B5	BGA	0	1.74	1.31	1.25	0.29	1.34	0.11	0	2.42	3.38	0	1.31	1.51	1.26	1.93	1.31
G3-B5	Header	0	1.01	0.93	1.21	0.12	1.12	0.19	0	0.98	1.22	0	0.41	0.69	0.98	1.22	0.60

Analysis Results-Group #3 SIR

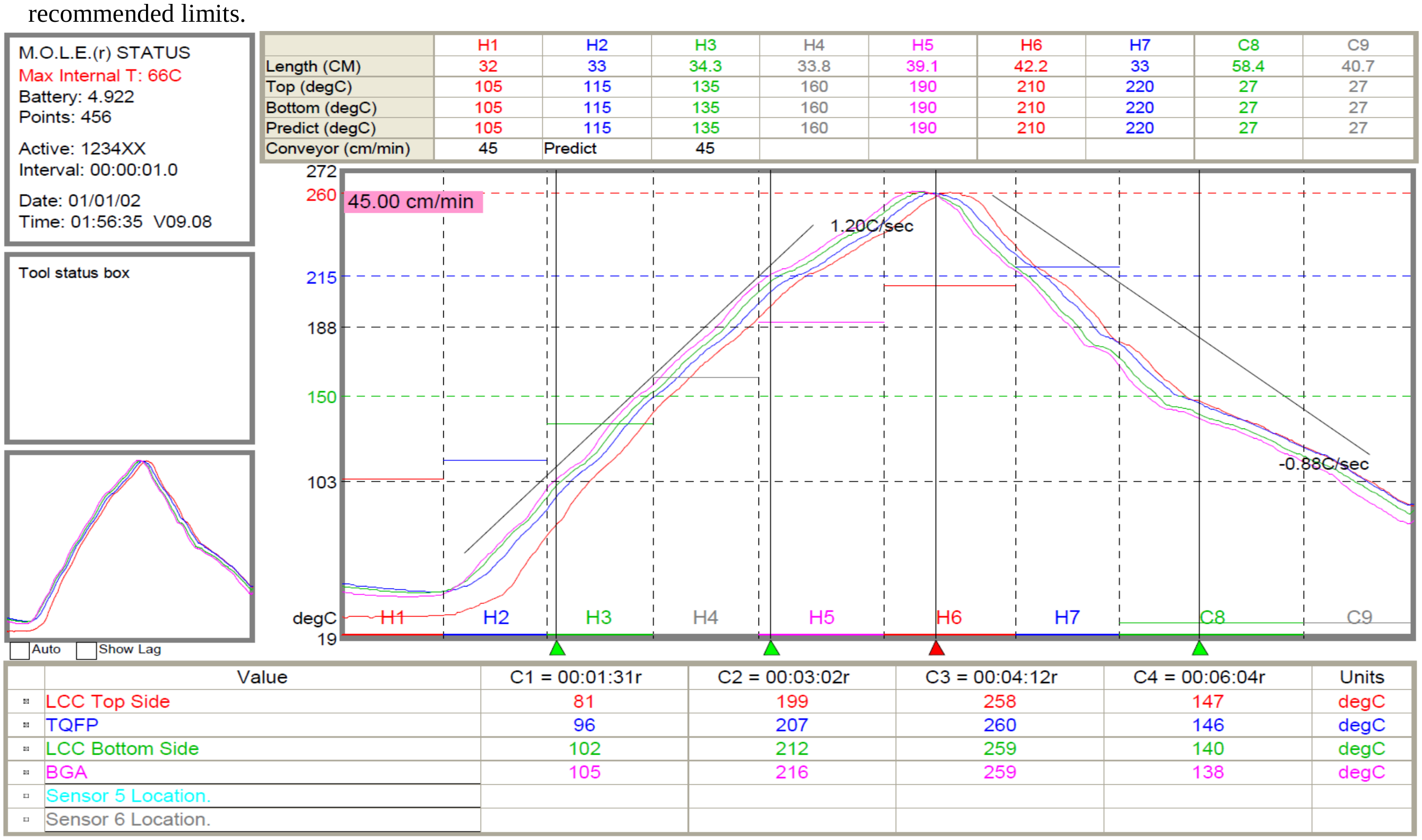
All locations with and without components passed the acceptance criteria. The data in table 6 shows that at no time did the resistance measurement dip below the 1.0e8 ohms of resistance. This indicates that in a normal field service environment without excessive available atmospheric moisture the product should not fail when voltage is applied.

Table 6 SIR Results of Group 3



Thermal Profile Group 4

The final group was processed at a peak temperature of 260° C to determine what if any effect additional thermal energy has in relation to cleanliness and SIR performance. The preheat and cooling ramp are still within the recommended limits.



Analysis Results-Group #4 IC

The additional thermal energy did not significantly reduce the level of ionics beyond the peak temperature of 250° C. Adding thermal energy can actually be detrimental and induce damage in certain types of components. The data in table 7 shows similar levels to that of group #3

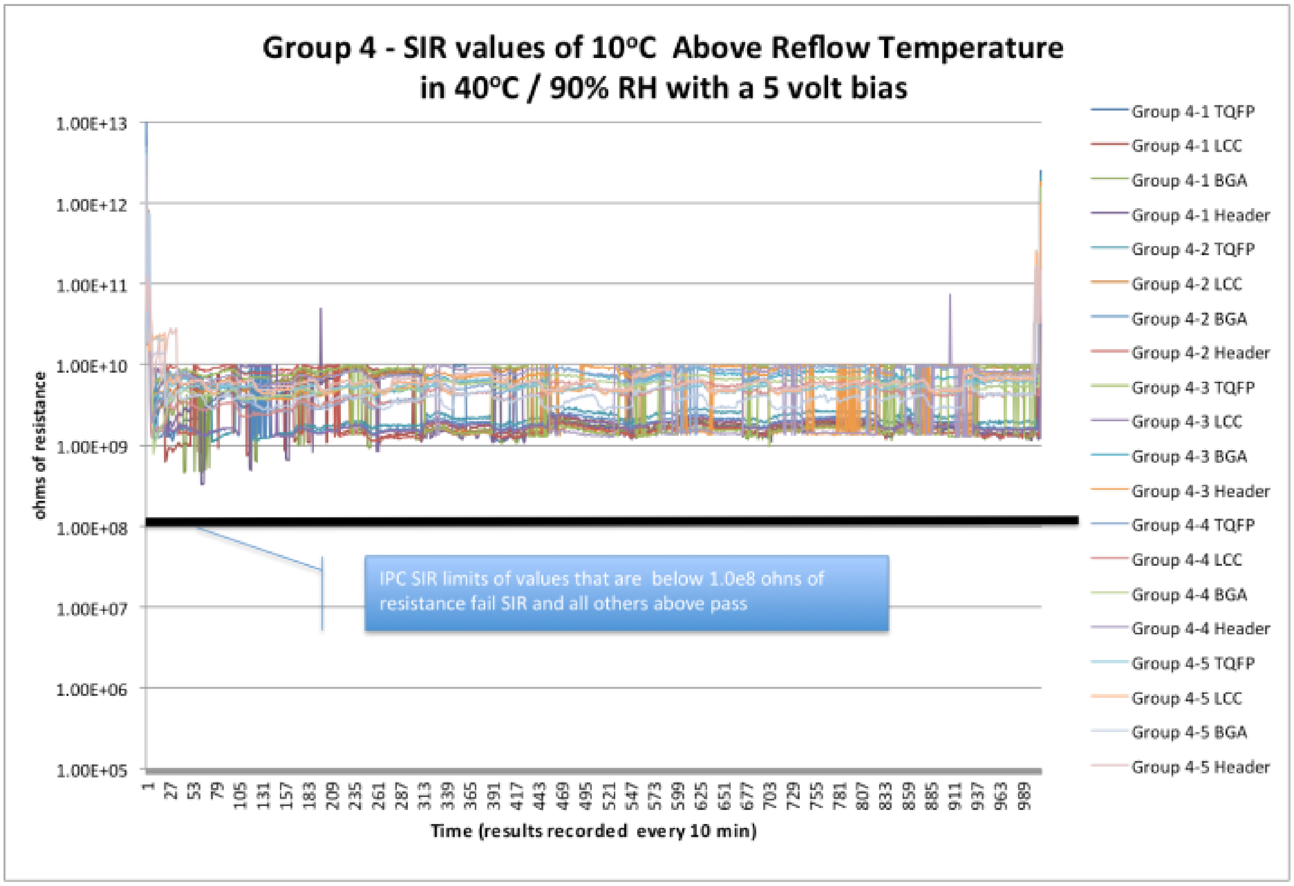
Table 7 Ion Chromatography Results of Group 4

all values in µg/in²		Ion Chromatography (Dionex ICS 3000 at Foresite) n/a = not applicable															
		F^-	$C_2H_2O_2$	CH_2O_2	Cl^-	NO_2^-	Br^-	NO_3^-	PO_4^{3-}	SO_4^{2-}	WOA	MSA	Li^+	Na^+	NH_4^+	K^+	Ca^{2+}
Foresite recommended limits for PCBA (no clean)		1	3	3	3.00	3	6.0	3	3	3.0	150	1	3	3	3	3	n/a
Group #	Board #																
Raw Solder Paste		0.61	273.44	39.06	61.02	0.81	0.24	0.86	0	4.77	4.48	0	248.49	10.26	23.57	64.65	15.47
G4-B1	TQFP	0	1.27	2.02	1.84	0.18	0.13	0.10	0	1.87	0.41	0	1.18	0.96	1.52	1.24	2.03
G4-B1	LCC	0	1.25	1.54	0.96	0.52	0.33	0.07	0	2.01	0.33	0	1.54.	1.21	2.01	1.49	1.11
G4-B1	BGA	0	2.21	2.87	1.21	0.33	0.15	0.11	0	1.02	1.24	0	1.54	1.32	0.94	0.96	1.98
G4-B1	Header	0	0.22	1.06	0.58	0.35	0.42	0.06	0	0.88	0.74	0	0.93	0.98	0.95	1.41	1.85
G4-B2	TQFP	0	2.01	2.61	1.63	0.14	0.31	0.19	0	1.29	2.06	0	1.05	1.02	1.12	1.62	2.64
G4-B2	LCC	0	1.27	1.22	0.81	0.19	0.26	0.17	0	1.14	1.27	0	1.34	1.13	0.88	1.10	1.18
G4-B2	BGA	0	1.24	0.89	2.11	0.54	0.74	0.11	0	2.51	0.94	0	0.79	0.89	0.87	1.83	2.31
G4-B2	Header	0	0.36	0.21	0.74	0.29	0.59	0.04	0	0.94	2.01	0	1.18	0.32	0.17	0.62	0.57
G4-B3	TQFP	0	1.54	2.41	1.22	0.78	0.35	0.27	0	1.09	2.31	0	0.83	0.88	1.54	0.49	0.89
G4-B3	LCC	0	2.17	1.76	2.09	0.07	0.51	0.33	0	1.99	1.97	0	1.15	0.95	1.33	1.17	1.87
G4-B3	BGA	0	1.47	1.15	2.27	0.36	1.01	0.02	0	2.02	1.86	0	1.09	1.17	1.02	0.98	1.54
G4-B3	Header	0	0.44	0.88	0.48	0.51	0.08	0.21	0	0.84	0.31	0	0.53	0.44	0.57	0.16	1.02
G4-B4	TQFP	0	1.05	2.86	1.92	0.14	0.87	0.18	0	1.19	1.02	0	0.87	1.18	0.68	1.82	2.31
G4-B4	LCC	0	1.46	1.83	0.88	0.37	0.93	0.16	0	1.64	2.41	0	1.24	1.54	0.89	1.87	1.82
G4-B4	BGA	0	1.75	2.12	0.67	0.55	0.57	0.13	0	1.47	1.03	0	2.01	1.22	1.21	1.52	1.47
G4-B4	Header	0	0.91	0.94	0.37	0.06	0.93	0.08	0	1.65	0.54	0	0.47	0.33	0.41	0.85	0.97
G4-B5	TQFP	0	1.86	2.71	1.17	0.44	0.25	0.26	0	2.22	1.86	0	1.24	1.15	1.28	0.62	1.41
G4-B5	LCC	0	1.88	2.18	1.77	0.37	0.64	0.14	0	1.67	2.03	0	1.14	2.12	0.57	0.81	0.93
G4-B5	BGA	0	1.63	0.99	1.14	0.28	0.49	0.31	0	1.24	2.14	0	0.95	0.96	1.85	0.94	1.22
G4-B5	Header	0	0.82	1.01	0.55	0.19	0.07	0.05	0	0.77	0.42	0	0.15	0.47	0.66	0.78	0.51

Analysis Results-Group #4 SIR

All locations with and without components passed the acceptance criteria, much as with group #3. The data in table 8 shows that at no time did the resistance measurement dip below the 1.0e8 ohms of resistance. This indicates that in a normal field service environment without excessive available atmospheric moisture the product should not fail when voltage is applied.

Table 8 SIR Results of Group 4



Conclusions

The final reliability of an assembly relies heavily on the thermal profile used for soldering. When the peak temperature is too low excess amounts of active flux residues are left behind and when ample moisture is available from a normal operating atmosphere or from condensing moisture anomalies there is a greatly increased risk of failure due to electrical leakage and/or electrochemical migration. Active no-clean flux residues are conductive in general and when moisture is absorbed into the residue across non-common conductors voltage easily flows between the two. When processing assemblies with a water soluble flux, or when cleaning no-clean flux, there is a failsafe for removing the conductive residues. Processing with no-clean flux types does not allow for any excess of contamination from any of the selected materials such as PCB's and components. One of the few things that can be controlled in an effort to reduce overall cleanliness and quality is the reflow process.

Future Work

With the myriad of different no-clean flux formulas a larger study that includes more types is in order to determine the effect of thermal energy on different types of chemistry used as flux activators.