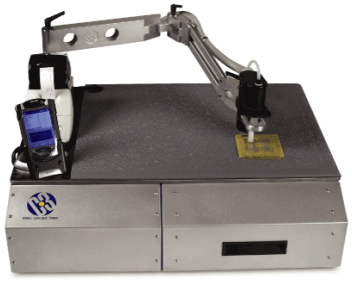
How Clean is this Spot?

C3 is a Localized Cleanliness Tester and Extraction Tool for Ion Chromatography Analysis

Electronic assemblies are experiencing more residue related problems today than ever before. Increased circuit sensitivity, closer spacing, greater portability, more rework and repair, and harsher operating environmental conditions are contributing to poorer field performance for products used by all industries. The problem of how clean is clean enough for reliable operating performance is an ongoing issue for higher reliability assemblies. Using the different assembly techniques, such as no-clean or water soluble flux and water cleaning, has shown greater field performance trouble than the previous rosin assembly. We see electromigration problems and increases in no trouble found (NTF) returns due to bare board, component, assembly, and rework cleanliness issues.

Due to all of the recent advances in electronic assemblies, it is now necessary to understand whether a residue in a critical area is corrosive or insulative, and this should be done on the production floor for immediate response to problems. If the residue extracted from this specific area is corrosive, then we must be able to analyze this sample with laboratory support analytical tools, such as ion chromatography, to identify the type and level of each of the contaminants that were removed from that spot. Board fabrication residues or poorly cleaned flux residues are invisible at the levels that cause problems, but still able to cause electromigration or leakage problems.

A new process control tool has been developed to work on the production floor and in the laboratory for assessing a residue in a specific area (0.1 in^2) using nondestructive extraction and testing techniques. This tool is the C3, (Critical Cleanliness Control), developed by Foresite to create an automated, faster, localized extraction and cleanliness test for the production floor. This tester can be used to automate the extraction protocol for ion chromatography analysis. It can also be placed on the production floor and used to assess incoming material cleanliness and to monitor assembly and repair processes. The production floor samples from the C3 can be used in conjunction with ion chromatography, FTIR or SEM/EDX to identify the type and level of residue that created a corrosive event on the test electrode.



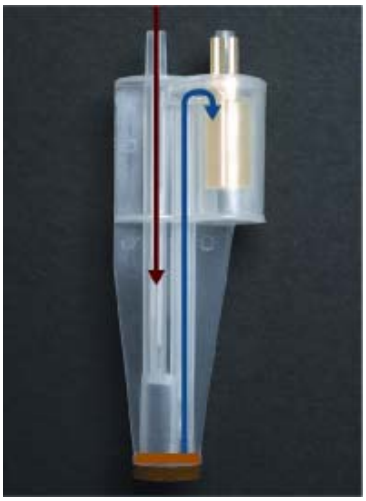
An example of a C3 application: One medical manufacturer is currently using the C3 to check bare board, component and assembly cleanliness levels. They are also using the C3 after repairs to show rework operators the effects of using a small amount of extra no clean flux and not heating it adequately near where the flux spreads from the solder joint. The C3 has repeatedly indicated that the remaining flux was conductive in high humidity environments, which corresponded to a problem the manufacturer had been experiencing. As a result of this

Contact Nick Bauer at
P: 317.569.1775
www.finepointinc.com

production floor information they have implemented a second, controlled, heating process to ensure that the no clean flux saw the proper amount of heat to complex completely and leave the intended benign residue on the board surface.

C3 Principles of Operation

Extraction



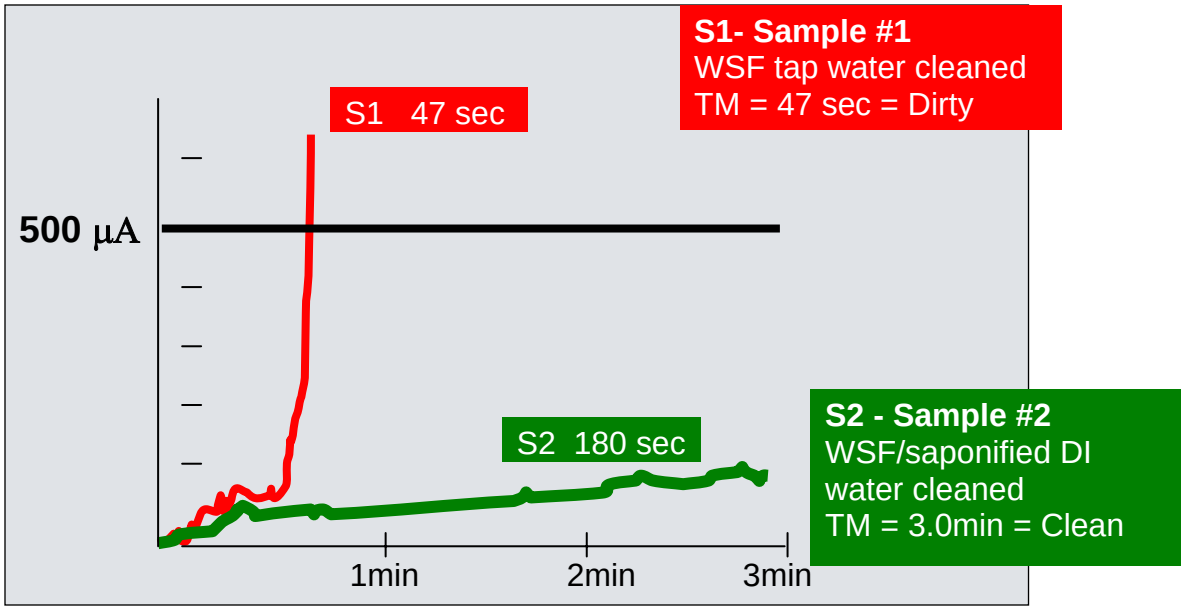
Any production floor or analytical test for cleanliness is only as good as the technique to remove the residue from the surface of the assembly. Process cleanliness relates to the type and level of residues that are able to be brought into solution in critical areas, such as pad to pad or hole to hole on a functioning assembly. It is these residues that the C3 has been designed to assess. The extraction process has been designed to achieve effective ionic residue removal using a heated delivery system consisting of 3 stages:

1. Solution heating/delivery to the extraction site
2. Soak and ionization time
3. Aspiration of solution to collection cell

This cycle is repeated 9 times to effectively remove the surface residues from a 0.1 in^2 area, generating approximately 2.0 ml of extraction solution to be used during the testing and afterwards for any desired additional testing.

Electrical Testing

Using a sacrificial Y-pattern electrode immersed in the extraction solution, a 10 volt bias is applied to the electrode and an internal timer is started to measure the time it takes to achieve a leakage event. The system measures the leakage across the electrode generated by the extraction solution plus the residues extracted from the board surface. A threshold of 500 µA has been set to identify when a current leakage event has occurred. This threshold has been established using a combination of SIR and ion chromatography data from 12 years of research by Foresite. The electrical measurement is determined by assessing the time it takes for the extraction solution and the 10 volt biased electrode to reach a 500 µA event. The system works under the theory that the more corrosive or conductive the residue the faster it will achieve this event. The less corrosive or conductive the residue the longer it will take.



Data Interpretation

The output from the C3 is recorded in seconds (+/-0.1) and typical run times are up to 180 seconds. Since corrosive residues will create short run times and benign, insulative residues take longer, the challenge was to determine the limit between clean and dirty. After repeated testing and correlation between SIR and ion chromatography, a division line has been set at 60 seconds. Electrical tests that run are less than 60 seconds are identified as dirty samples. Sample runs greater than 60 seconds are identified as clean. Some examples of dirty and clean samples are as follows:

Sample	***C3 test time***	***Interpretation***
HASL Bare Board Vendor	37 sec	Dirty
HASL Bare Board Vendor SA after remedial cleaning	171 sec	Clean
0805 Capacitor Vendor A	180 sec	Clean
0805 Capacitor Vendor B	45 sec	Dirty
Assembly No Clean 0805 Capacitor area Vendor B	28 sec	Dirty
Assembly No Clean top side near rework area	21 sec	Dirty
Assembly No clean top side rework after 2nd heating	180 sec	Clean

Contact Nick Bauer at
P: 317.569.1775
www.finepointinc.com

Ion Chromatography Testing of Extraction Solution

Using ion chromatography to assess the extracted residue will determine which type and level of contamination is present to cause the measured electrical effect. The ion chromatography analysis is conducted using IPC TM 650 2.3.28 test method. The following are test results using both the standard one (1) hour 80° C extraction and the C3:

		Ion Chromatography				C3	
		Cl	Br	SO4	WOA	**Test**	**Time**
Sample 1	C3 extraction #1	1.28	1.89	0	24.12	**Pass**	**2.14**
Sample 2	C3 extraction #2	0.24	0.41	0	3.16	**Pass**	**2.99**
Sample 3	C3 extraction #3	0.11	0.14	0	5.12	**Pass**	**3**
Sample 4	C3 extraction #4	0.06	0.08	0	0	**Pass**	**3**
Sample 5	C3 extraction #5	0.04	0.07	0	0	**Pass**	**3**
Sample 6	Standard Extraction Site #2 Cut from board next to Site #1	1.56	1.97	0	29.91	**N/A**	**N/A**
Sample 7	Standard Extraction Site #2 Cut from board next to Site #2	0.33	0. 63	0	3.33	**N/A**	**N/A**
Sample 8	Standard Extraction Site #2 Cut from board next to Site #3	0.18	0.64	0	5.15	**N/A**	**N/A**
Sample 9	Standard Extraction Site #2 Cut from board next to Site #4	0.15	0.57	0	0.21	**N/A**	**N/A**
Sample 10	Standard Extraction Site #2 Cut from board next to Site #5	0.11	0.59	0	0.65	**N/A**	**N/A**

Conclusions

With the C3 extraction we see similar levels of ionic removal in the three (3) minute time as the one (1) hour 80° C standard extraction. We also have the information from the C3 indicating whether the area of interest on the board surface contains residues that are corrosive or benign. Using a localized extraction we are able to quickly and efficiently assess various individual areas on any circuit board assembly, bare board, component or material to identify if corrosive residues are present. This tool puts process cleanliness control of invisible and complex residues from today's manufacturing processes in the hands of the manufacturing and quality engineers.

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