

TECHNICAL PAPER ≡

The Layman's Guide to Qualifying New Fluxes for MIL-STD-2000A or MT-0002

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The Layman's Guide to Qualifying New Fluxes for MIL-STD-2000A or MT-0002

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So, you're the poor layman who has been assigned to qualify your company's new manufacturing process for your military customers. Man, I feel for you. You have "a tough row to hoe" as the old saying goes. Not only do you have to wade through the mounds of information on the new manufacturing materials and processes, but you have to make sense out of those God-awful specifications. The specs didn't start that way. They started as fairly straight-forward documents until the standardization people and the lawyers got a hold of them. A mass of incomprehensible text was the end result. The purpose of this general paper is to get back to that original, easily understood test document and give you some practical guidance and technical pointers on how to go about demonstrating that your new process is capable of producing reliable hardware.

Important: You MUST understand that NOTHING in this paper supersedes ANYTHING!!! This paper is for guidance only. It has been reviewed by authorities in the Naval and Army technical community for accuracy and soundness, but the legal elements of the specifications, and your contractual obligations are always binding. If your military customer does not agree with the tenants of this paper, then the paper should make good kindling material for your fireplace. But, in any case, you may find some pearls of wisdom contained herein.

Who Am I?

So, who am I and why do I presume to instruct you on these matters? A fuller biography appears at the end of the paper. My name is Doug Pauls and I was, at one time, part of the technical support team for the MIL-STD-2000 committee and part of the Navy Electronic Assembly-Technology Working Group (NEQTWG). In the capacity, I helped write the basic skeletons for the text on qualifying new processes for the military, and provided technical counseling to the Category A personnel. Those skeletons later became Appendix A and C of the MT-0002 document (described later), and Appendix D and F of ANSI/J-STD-001A. I now work as Director of Research and Development for Contamination Studies Laboratories. I now work with people who are in your position, who must transition from an environmentally unacceptable process to one of the newer technologies. That work is part test services and part consulting. Many of our customers are confused by the wording of the specifications, and it has become apparent that this kind of a guide would be useful.

If the above paragraph sounds like a commercial for our services, I apologize. It is not intended as such. Neither the government nor its employees are in a position to recommend or discourage any particular lab or service. This paper should not be considered as a back-door approach to sales. The MIL-STD-2000 committee, like any specification committee, relies on industry data and informed opinions (backed by data) in order to put forth a sound document. This committee has always been ready to implement change when there was data to support such a change. It is that spirit of cooperation with the private sector which has inspired this guide. A few patriots still exist who serve their country when they can. But, enough of this disclaimer garbage. On to the important stuff!

What Are My Choices?

The answer to that question, like most engineering questions, is "It depends". First, let us separate the "Choice" into two categories: technology-related and specification-related. The technology choice relates to which flux and assembly operation you will pursue. Technology choices include:

- Rosin fluxes, but with alternative cleaners (lots to choose from)
- Water soluble fluxes with aqueous cleaning
- Low residue fluxes in an ambient air environment
- Low residue fluxes in an inert gas atmosphere
- Low residue fluxes, with or without cleaning
- Etc.

The sheer number of non-rosin fluxes is easily more than 100 at present count. Considering that all of these options will mean a capital investment of some sort for your company, the choice is not easy and has serious consequences on your bottom line, perhaps even the future of your company. But, this paper is not really about guiding you through the choice in technologies. That would be a staggering document and would probably put you to sleep before you got to page 20. To give you some help and to aid the novice, I have included a short bibliography of helpful articles and informational sources at the end of the document.

Since we are not spending time on the choosing of the technological road, we must focus on the specifications that presently exist in the military and in industry and examine how those documents treat changes in manufacturing technology.

Specifications

YOUR CUSTOMER IS DA KING! WHAT HE WANTS, HE GETS!

Pretty easy specification, huh? The point is that if your military (or commercial) customers know what they want, then your path towards acceptance is fairly clear, and the data to generate will most likely be specified. If your military contracts person tells you that, in order to use that no-clean flux technology, you must hurt a dead chicken 56 feet from a hill top under a full moon, then you had better limber up the ol' arm and find you a chicken. (Seldom happens anymore).

The more frequent case is that your military customer may not know what testing to specify or how to interpret data packages for the various new technologies. The change in technology over the past 7-8 years has been staggering, and it is difficult for anyone to keep on top of it all, let alone those who must cope with the red tape of the Federal bureaucracy. (I was one of them and tend to get defensive on that issue.) When you throw in the fact that the technical tools used to evaluate cleanliness and circuit degradation have been called into question heavily during the past 3-4 years, you can understand why lots of people throw up their hands and say, "I have no idea". So cut them some slack. Hey, how did I get up on this soap box?!

If I were to assemble a core set of documents to start my specification education, they would be:

- MIL-F-14256F - The military standard on fluxes
- MIL-STD-2000A - The end-item specification for electronic assemblies
- MIL-STD-202 - The military standard on test methods
- Willoughby Memorandum - May 1992 Directive regarding ODC Alternatives
- NAWCADLKE-MISC-05-MT-0002 - A re-packaged form of the proposed B revision to MIL-STD-2000
- EMPF Report RR0013 - An In-Depth Look At Ionic Cleanliness Testing
- ANSI J-STD-001A - A commercial equivalent to (and eventual replacement of) MIL-STD-2000
- ANSI J-STD-004 - A commercial equivalent to (and eventual replacement of) MIL-F-14256

Gosh that's a lot of reading. Mighty liberal with your free time, aren't I? Each of these documents provides some insight on the critical issues that you must carefully consider in choosing technology. You must understand: the flux and the flux properties; where and when during an assembly process to choose samples for residue analysis; and how testing is done and why certain tests are chosen. The more information you can assemble and assimilate, the better prepared you are to make wise choices.

This paper focuses on MIL-STD-2000A and MT-0002, because they will impact you the most as a military manufacturer. But, J-STD-001A adopts the same test philosophy as MT-0002 so a review of both documents may allow you to structure your testing matrix to kill two birds with one stone (hey, maybe that's how you get the dead chickens!). The Willoughby Memorandum (a Navy document) approach has generally been superseded by the MT-0002 approach, and more recent IPC test methods are being used in many places rather than the MIL-STD-202 methods.

Before we get into the myriad details of testing the various technologies and generating data, let us examine how the two documents approach the technologies.

MIL-STD-2000A

The A revision to MIL-STD-2000 has been in place since February 14, 1991. It is the specification that most of the military manufacturers are contractually bound too. If you are manufacturing to MIL-STD-2000A, here is how you approach the various technologies:

1. If you are using rosin (R or RMA) flux, and wish to use an alternative cleaning chemistry (e.g. terpenes, semi-aqueous, saponifiers, alcohols, etc.), then you must generate data per Appendix C of the document. Appendix C covers ionic cleanliness testing. In this case, this means ionic cleanliness testing with the laboratory beaker method (not recommended) or using one of the room temperature bulk ionic cleanliness (BIC) testers, such as an Omegameter or Zero Ion.
 - MIL-STD-2000A does not restrict you to any particular cleaning chemistry or list of approved solvents.
 - Appendix C does not cover what the sample substrate for this test is. It could be a standard test board, such as an IPC-B-36, or a production board.
 - Appendix C does not specify the sample sizes needed. Theoretically, it could be done on a single sample and meet the contractual requirements of the spec.
 - The test sample ionic cleanliness must meet the traditional 10.06 ug/in² NaCl equivalence, corrected for machine type.

When I discovered this, my basic response was, "You gotta be kidding! That's NUTS!". Well, yes, it is, but that is the reality of the spec. Now, while you could legally get by with one ionics test on one sample, I would hope that you wouldn't try. Put yourself in your customer's shoes. If someone came to me and requested permission to change manufacturing methods based on one ionics sample on one board for hardware which protected MY people from bullets, missiles, Saddam Hussein, etc., my only question would be, "Where could I hide your cold, dead carcass?" We'll look at a more sound approach after the next section.

You should be aware that the Appendix C requirement of 10.06 micrograms of NaCl equivalence will be very difficult to meet if you are qualifying a low solids flux. These fluxes have weak organic acid activators which, when extracted, make a solution very conductive. The BIC test response will be proportional to the amount of flux you apply to the test sample. The amount of applied flux should be representative of the amount and method of application which you intend for production assemblies.

2. If you are not pursuing rosin-based manufacturing, then you are, by default, looking at a non-rosin flux alternative. Now, some low solids fluxes have rosin as a base, but only as a very small percentage and with different flux characteristics, and so are treated as a non-rosin flux. Non-rosin fluxes refer to any flux that is not classified as an R, RMA, or RA flux per MIL-F-14256 or J-STD-004. This includes the water soluble fluxes and the low solids (no-clean) fluxes.

- A point on nomenclature - I use the term low solids fluxes rather than the more popular phrase "no-clean" flux. The no-clean term still tends to raise a lot of hackles with military types so calling it low solids is probably wise and technically more accurate, since there are also cases in which you may wish to manufacture with a low solids flux and still clean the assemblies, such as for solder ball removal. The term "no-clean" is also frequently misunderstood or misapplied.
- A point on percent solids - I have been asked, from time to time, where is the dividing line between the traditional high solids fluxes and low solids fluxes? A good question. I wish there was a definitive answer. None of the flux or assembly documents give a clear boundary. I suggest that as a rule of thumb, high solids fluxes contain 15% or more solids. Low-solids fluxes are 5% solids or less. The range from 6-14% is a gray zone, but I think you will find the 5% and 15% reasonable guides. Now, this is sure to upset the flux vendor who has a 14% RMA or a 6% low-solids flux. Introduce him to Prozac.

3. I suppose there is a possible third alternative: that you are doing a rosin-based flux and continuing to clean with an ozone-depleting compound (ODC). But, unless you choose either option 1 or 2 above, RIGHT NOW, you will be bankrupt soon and won't be in the picture.

Where was I? Oh, yes, qualifying a non-rosin flux alternative. If this is your goal, you must:

- Generate cleanliness data per Appendix C (same silly elements as in 1), with the same 10.06 ug/in² maximum.
- Generate surface insulation resistance (SIR) data per Appendix A for every combination of manufacturing alternative and conformal coating to be used on production hardware.
- The resistances must be greater than 100 megohms at all times and greater than 5000 megohms at the final ambient reading. The coating integrity must be evaluated per the visual guidelines of MIL-I-46058. In general, no degradation of the coating can be observed, like: cracking, blistering, adhesion loss, reversion, etc.

Appendix A will be the primary focus for a MIL-STD-2000A manufacturer and the greatest cost of qualification. The test substrate for Appendix A is the IPC-B-36 standard test assembly (a diagram is attached), available from a variety of sources. This test assembly is processed with four chip carriers (LCCs) mounted on the board (to provide a simulation of components and to provide a low-standoff cleaning challenge). After the test boards are manufactured with the proposed process, they are conformally coated with the candidate coating. A set of 24 B-36 boards must be processed for each coating you will be using. As an example, if I am wave soldering with Flux A, and I will be shipping product coated with either acrylic (type AR) or urethane (type UR) coatings, then I must generate a set of 24 coated with acrylic and a set of 24 coated with urethane. If I am qualifying two fluxes and two coatings, there are four total sets of 24. Uncoated boards also classify as a coating condition. Imagine the manufacturer who wants to do four fluxes and all six coating types (two words - silly and rich).

After processing, you must test the assemblies for changes in surface insulation resistance (SIR). Appendix A references MIL-I-46058 (the military conformal coating spec), which in turn references MIL-STD-202, method 106E as the test method. This test method is an exposure to cyclical temperature and humidity (25°C to 65°C, 90% RH, twice per day) for a total of ten days. Measurements are made periodically at a test voltage of 100 volts DC, 60 second electrification time. A non-measurement voltage of 100 volts is applied to all test patterns whenever measurements are not being taken.

Now, I am not a particular fan of the MIL-STD-2000A, Appendix A approach (if you have not already guessed). Here are the main arguments against:

- The temperature-humidity profile is one designed to test conformal coating adhesion and to test if a polymeric coating undergoes reversion when exposed to high humidity conditions. It does not test for electrochemical failure mechanisms, such as electrolytic corrosion or electrochemical migration (metal migration). The latter two mechanisms are what you are really concerned about when testing a new flux technology. MT-0002 makes use of the constant temperature-humidity profile (85°C/85% RH).
- There are no "controls" for either Appendix A or Appendix C. A control, in this case, is a sample of the test substrate at the start of processing. These are necessary to baseline the results. If you get readings of 15 ug/in² in an Omegameter but find you started with 6 ug/in², you have a better grasp of the true cleanliness of the process.
- The B-36 test board has a total of ten electrical test patterns. Appendix A calls for readings on only two of those ten patterns. A tremendous waste! Those two patterns specified are used for determining the effects of solder paste flux between SMT mounting pads. If you are qualifying a wave flux only, then these two patterns are not the best indication of your process and may cause a flux interaction between the wave solder flux and the flux used to attach your LCCs.
- The test is not long enough or stringent enough to show electrochemical failure effects. The cyclical temperature-humidity profile also provides plenty of opportunity for condensed water to contact the energized test patterns or the wires leading to them. SIR test experts generally agree that if liquid water condenses on the test pattern, then that pattern is invalidated.
- Appendix A gives no guidelines on the treatment of extraneous data or how to treat outliers.

Can Appendix A still yield useful data? Yes, provided you approach it in the correct manner.

Are there better ways of generating data? Absolutely. MT-0002 takes a much sounder approach, but if you are stuck with 2000A, here are some processing pointers. A recommended test matrix follows the pointers.

Processing Pointers

1. **Precleaning.** Appendix A and Appendix C are cleanliness tests. Starting out with a dirty substrate is fairly pointless. Fabricators of the test boards don't always ship them to you squeaky clean. Run them through a cleaning process. An Omegameter clean/fill cycle for about 15 minutes works well. Other possibilities could be a pass through your in-line cleaner or a cycle through your batch cleaner (you get the picture!) Don't worry about the quality of the copper or tin-lead. This is not a solderability test - it is a cleanliness test. Dry the substrates well. Store in clean aluminum foil or heat sealable polyester bags (I suggest Kapak bags from Scotchpak).

2. **Attaching the LCCs.** The test method requires you to run the qualification process with four LCCs mounted in place (a real bummer if you have no surface mount capability!) You have several choices: you can buy pre-cleaned B-36 boards with the LCCs in place; you can hand solder the LCCs to the test board yourself; you can adhere the LCCs to the boards using an adhesive; or you can apply a solder paste, mount the LCC and reflow.

2a. **Adhesives:** Of these options, I would not suggest using the adhesive. Our lab has done the 2000A test on several adhesives, and all have flowed onto the test patterns and have drastically reduced the SIR performance (i.e. caused failure) in all cases (even those adhesives designed for electronic assemblies.) I wouldn't even attempt it unless I had a robotic adhesive micro-dispenser.

2b. **Solder Paste:** If you choose to mount the LCC using solder paste, think of your final product. Will you be using a combination of RMA paste and a no-clean wave solder flux? Is the choice of paste important? I would say, "yes". In almost all cases, there is some residue left over from the paste, under the LCC, which can later react with the flux that wells up through the vias under the LCCs during wave soldering. This reaction product can lower SIR numbers for the two required patterns called out by Appendix A. Ask your flux vendor about flux compatibility issues between paste flux and wave solder

flux. If the choice of paste is not important, i.e., you do through hole only, then let your flux vendor choose the paste that will have the least chance of interaction with the wave solder flux.

2c. Soldering: The pre-assembled and pre-cleaned B-36 assemblies are your best choice if you are doing through hole only. If you have a good, qualified solderer, then you can make your own assemblies by hand soldering the LCCs to the B-36 surface. I would not recommend using additional liquid flux to aid the soldering and I would use an R-type rosin (not RMA or RA) flux cored wire solder. I suggest soldering only two points at the four corners of the LCC (8 solder connections per LCC) unless you are looking at some really high pressures in the cleaning operation. Keep in mind that the LCC is only there as a cleaning challenge. It is not functional. This is not a solderability test. By doing limited soldering, the LCCs are attached but with minimal flux residue deposited on the test boards. After attachment of the LCCs, by what ever the method, clean the assemblies again, as described before.

2d. An additional note on the LCCs. Topline Components manufactures lines of dummy test components, of which the LCC is one. It is important that the LCC have NO functional circuitry inside it. The resistances contained in a circuit die would give odd SIR results. You want an empty LCC. Those little chips are expensive though. For your process development work, use the plastic LCC (PLCC) version. You get the same function and footprint, but at 25% of the price. Save the LCCs for the optimization work and the qualification test samples. The military does require the LCCs rather than the PLCCs because it represents a greater cleaning challenge. You should also be aware that there are two standoff heights for LCCs and PLCCs. The LCC standoff is about 0.8 mils by itself. Add this to the 2 mils from the copper circuitry and the 2 mils from the B-36 solder mask standoffs and you get roughly a 5 mil (over the laminate surface) standoff. The PLCC standoff is 10 mils over the copper surface due to the construction of the leads (J-leads), and therefore is not as hard to clean under. So practice with the PLCCs, but optimize the process using LCCs.

3. Post assembly drying. If you are qualifying a process which contains an aqueous cleaning process or washing step, be sure to incorporate a drying step prior to testing or prior to conformal coating. The LCCs tend to trap solvents and moisture under them. The 5-mil standoff of the LCC makes it very difficult to clean under or to dry under. We have yet to see an in-line or batch cleaner with sufficient drying power to get the moisture out from under the LCCs. A vacuum bake step works very well. If the moisture is not removed, you have quasi-shorts on all test patterns which are covered by an LCC (8 out of 10). It makes for ambiguous test results.

4. Conformal coating. Unless you want to really upset your test labs personnel, mask off the contact fingers of the B-36 board prior to conformal coating. Whether your test lab uses edge card connectors (as I do) or whether they hard wire to the contact finger, the presence of a coating on the contact fingers is a phenomenal pain. I have been asked whether the adhesives from the tape can degrade SIR performance. I have not seen this to be the case. If you use a Kapton tape, usually used for wave soldering, then the adhesive is very light and little residue remains. The use of duct tape would be another matter entirely. Black electrical tape is also discouraged. If you do use a tape, a light wiping with isopropanol over the contact fingers is in order to remove any tape residue.

5. Final Ambient Measurements. When taking the final ambient measurements at the end of the SIR test, you are allowed to make the measurements anytime between one hour after return to ambient and 24 hours after return to ambient. You will generally get higher results at 24 hours than you will at one hour because your assemblies have a chance to dry out. So delay the final readings as long as possible, but document the time the readings were taken. Be smart, not underhanded.

6. Current limiting resistors. If your SIR bias and / or data acquisition system does not make use of a current limiting resistor in each circuit pathway, you will be placing 100 volts across a 6-mil pattern, which may not be coated (such as under the LCCs). There is a term for this. It's called arc-welding. By placing a current-limiting resistor in each path, you protect your equipment and the test boards from current surges. The values of the resistors should not be below 100 kilohm and should not exceed 2 megohms. One megohm seems to be typical for the industry.

Suggested Test Matrix

Here is what I would suggest as a test matrix for a company stuck with 2000A but desiring to generate a good data package for their customers

Process	Bulk Ionics	IC	SIR
Precleaned Control	3	3	3
Present Process	3	3	3
Proposed Process	3	3	3

Table 1. Proposed Matrix - Alternative Cleaners Only

Process	Bulk Ionics	IC	SIR
Precleaned Control	3	3	3
Present Process	3	3	3
Proposed Process - Coating 1	3	3	24
Proposed Process - Coating 2	3	3	24
Etc.			

Table 2. Suggested Test Matrix for Non-Rosin Fluxes

These matrices use three test methods to generate residue characterization data. Bulk ionics refers to Omegameter-type testing at room temperature. This gives data which can be compared (although not always accurately) to the historical database for rosin chemistry. IC refers to ion chromatography which is a more precise method of measuring ionic contamination (more on this testing later). SIR testing is a required test.

Testing a pre-cleaned control allows you to baseline any cleanliness testing against the starting values. It can also help explain poor performance in other tests. The addition of test samples from your presently accepted manufacturing process allows you to baseline your results against what you are doing now.

For Table 2, you have more tests and larger sample sizes than required in Appendix C, but a stronger, more widely accepted data package is generated. Three samples per cell is a recommended minimum. Increasing to 5 samples per cell size gives you more statistical confidence in the process and a better idea of the process variability but also increases the testing cost. Your call, but don't go less than 3.

Since Appendix A calls for conformally coated samples, I should point out that only the SIR samples are conformally coated for testing. Yes, I know it should be obvious, but the coating of samples for the other testing has occurred. The pre-cleaned controls and the present process samples should also be conformally coated for SIR testing. This gives you a better basis of comparison. The direct comparison of SIR numbers for coated vs. uncoated boards is generally a questionable practice.

Summary of How to Approach MIL-STD-2000A

So, to wrap up all of the last chapter on qualifying processes for MIL-STD-2000A; if I were in your shoes, this is how I would approach it.

1. Get the concurrence of my military customer, FIRST.
2. If I were only doing an alternative cleaner, I would generate the data per the matrix in Table 1. I could then use the alternative cleaner if I met the guidelines.
3. If I were transitioning to a non-rosin flux, I would first try REALLY hard to convince my military customer to accept MT-0002 qualification in lieu of MIL-STD-2000A qualification.
4. Failing #3, do not get too upset with the military customer. They are under some incredibly shortsighted directives from DoD and often have no latitude to make intelligent decisions.
5. Failing #3, do the testing as outlined in Table 2.

If you are doing all the testing in house, congratulations. You have a fine analytical base and are probably already ten steps ahead of this document. But, most readers of this document will be using an outside test lab for at least some of the testing. I cannot really advise you on selecting a test lab because I have an inherent conflict of interest, but any lab you pick should function as a partner in your qualification effort: counseling you in what tests make the most sense to run, telling you what the generated numbers are and what they mean, etc. If you keep these salient points in mind, common sense will help you choose the right lab.

Testing For Residues

Before discussing MT-0002, let us talk for a few minutes on residues and test methods for measuring residues. Both of these specifications are asking the same basic questions:

- What residues are your new processes leaving on the board?
- What effects do these residues have?

The original basis of the ionic cleanliness test was the known fact that high levels of activated rosin flux led to electrochemical failures like metal migration and electrolytic corrosion. When the test was first developed at the Naval Avionics Center, it was developed specifically as a process control tool, not as an analytical tool. The original tests were crude in nature and soon an entire industry sprang up around this concept, offering high degrees of precision for a crude measurement (much to the amusement of the original researchers). There is neither time nor space to fully examine the history of ionic cleanliness testing, but the reports (MRR 3-72 and MRR 3-78) are available from NAWC Indianapolis.

Bulk Ionic Cleanliness (BIC) Testing

What the original cleanliness tests measured was the amount of residual amine hydrochloride or amine hydrobromide activator materials in the RMA fluxes. These halide materials made a solution conductive as the residual rosin flux dissolved from the board surface and went into solution. To this day, no one can determine with any precision the exact quantitative relationship between ionics and circuit degradation, but as a process control tool it functioned well. If I had a reading of 8.0 all last week and all this week, but today it went up to 15.0, something changed, and I better find out what. The original tests at NAC showed a gross correlation between contamination and a degradation in SIR reading. A value of 10.06 ug /in² was the line drawn in the sand as a tentative pass/fail limit. Over time, and with the incorporation of this value into military specifications, this line in the sand became cast in concrete.

The IPC Ionic Cleanliness Task Group was dedicated to examining the test methods, the test equipment, and what ionic cleanliness really means, especially in light of the newer flux chemistries. An in-depth research effort was designed and implemented at the Electronics Manufacturing Productivity Facility (EMPF), culminating in a 200 page report (RR0013) titled "An In-Depth Look At Ionic Cleanliness Testing". The reader is encouraged to obtain a copy of this report to fully understand both the limitations and the applications where such testing is still valid. In essence, the report confirmed what many people already knew: that the BIC testers were not adequate analytical tools for non-rosin fluxes, but can function adequately as process monitoring tools, provided you understand what the responses of the BIC instruments are indicating.

So, if BIC testers are so worthless as analytical tools, why are 2000A and MT-0002 using this testing as an evaluation tool for new processes? There are basically three reasons:

- At the time of the drafting of these methods, no better (or more accurate) ionic cleanliness measurement was accepted by either the military or commercial worlds.
- Virtually everyone who manufactured for the military had a BIC tester in house so some gross measure of ionics, even if not totally accurate, was available to almost everyone.
- For those methods which are envisioned to eventually replace BIC testers, such as ion chromatography, no generally accepted pass/fail limits had been established.



Essentially, the most important reason was: we'll use this until something better comes along. Fortunately something has, although it is not as widely available as BIC testers and is not as amenable to production monitoring as a BIC tester. It is called ion chromatography (see below).

There are two primary shortcomings of the BIC testers which ion chromatography improves upon: a relatively mild extraction method and only a gross measure of solution conductivity.

1. The extraction time has generally been 10-15 minutes at room temperature using a static 75%/25% isopropanol / water solution. Some of the more current BIC models incorporate heated solutions and jet spray agitation, but no equivalency factors have been established for these machines. An educated guess for these machines would be around 25. The test times were based on the solubility parameters of rosin flux. If a material is less soluble than rosin flux, then less of the material will enter solution in the same amount of time. The room temperature solution may also not be aggressive enough to solubilize the residues.
2. You only get a measure of solution conductivity and generally don't know what material or materials are causing the solution to become conductive. You know something is there but not what. Not all materials which make a solution electrically conductive are detrimental to circuits. As an example, dry-film solder masks, if not properly cured, can break down in IPA/water solution and will leach a carboxylic acid breakdown product into solution. You get a corresponding high value for solution conductivity, but carboxylic acid is not a material which will cause long term failure in the assembly. If I had a dime for every time this phenomena caused mass hysteria on a manufacturing floor, I'd be rich, and someone else would be writing this document.

Ion Chromatography

Ion chromatography has now been entered as a standard IPC test method: TM-650, method 2.3.28. This is also an extraction type of analytical test using the same 75% / 25% IPA / water solution, but the extract time is 60 minutes, and the extraction temperature is 80°C.

These extraction conditions tend to cause a full extraction of any surface material which is soluble in IPA or water and some of the contamination which may be trapped in the subsurface layers of the laminate. The solution is then analyzed in an ion chromatograph. The instrument separates the unknown solution into it's various pure elements, determines what those elements are, and tells you how much of each element is present. One limitation is that the elements you wish to detect must be electrically conductive in solution, so non-conductive organic materials cannot be directly determined by ion chromatography. Fortunately, the same extract solution can be used for high pressure liquid chromatography (HPLC) (IPC-TM-650, method 2.3.27.1) which can determine some of the non-conductive elements present. The two methods are highly similar, varying primarily in the detector used at the end of the separation column. Ion chromatography uses a sensitive conductivity cell; HPLC uses a photodiode array. A typical ion chromatography analysis will tell you that you have X.X ug/in² of chloride, Y.Y ug/in² of bromide, Z.Z ug/in² of weak organic acids, etc., provided you have some general standards to relate the unknowns to. In both cases, you may detect the presence of a conductive (or UV fluorescent for HPLC) material, but may not know exactly what that material is.

IC gives a better overall picture of what your ionic contamination is, which elements are benign, and which elements are harmful. As an example, bromide usually comes from the laminate material. Bromide is the fire retardant in most FR-4 epoxy glass laminates. It is a conductive material in solution but is not harmful to long term circuit reliability. Weak organic acids are another example. All present industry research indicates that WOAs are benign and tend to polymerize or self-encapsulate themselves on a board surface. They do not promote corrosion or metal migration but are greatly conductive in solution. A "no-clean" assembly with high amounts of WOAs will generally exceed the meter capability of a BIC, but is not a cause for concern. Chlorides are among the worst materials and must be closely watched.