

Roundtable Discussion

Process Ionic Contamination Test (PICT) Standard

Process Ionic Contamination Test (PICT) Standard Roundtable With Industry Experts

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Introduction

With standards committees set to release the first of four new test standards, I-Connect007 invited four industry experts to participate in an online discussion revolving around the process ionic contamination test (PICT) standard, which was recently approved by the IEC for publication.

Recorded on April 17, 2020, the roundtable participants included Teresa Rowe, senior director of assembly and standards technology at IPC, Graham Naisbitt, chairman and CEO of Gen3, Jason Keeping, corporate process development at Celestica, and Doug Pauls, principal materials and process engineer at Collins Aerospace.

What follows is the transcript of this audio discussion followed by a question and answer section.



Teresa Rowe
IPC



Graham Naisbitt
Gen3



Jason Keeping
Celestica



Doug Pauls
Collins Aerospace

Barry Matties: Participating in this roundtable discussion, we have IPC's Teresa Rowe, Gen3's Graham Naisbitt, Celestica's Jason Keeping, and Collins Aerospace's Doug Pauls. Welcome to all of you. Teresa, perhaps you could start with a quick overview of some of the standards work around this from IPC's point of view, please.

Teresa Rowe: Certainly. A few years ago, we were in revision for J-Standard-001. We received a comment concerning cleanliness and the cleaning section within the standard. We readily realized as a group that there was no way to make a quick decision about this. An action item was assigned, and Doug Pauls was "volun-told," as he says, that he was going to lead the effort. It took them a few years, and they came back periodically with presentations to the group to explain where they were. Changes were introduced as an amendment to Revision G. That was about a year and a half or so ago now, and that will be rolled into Revision H when it comes out by the end of the year.

Matties: Graham, you've had a big role in this. Why don't you give us a brief introduction to the new standard, including what it is, and what it's not?

Graham Naisbitt: The requirement that was put forward by Robert Bosch was to establish a pass/fail criteria that they could meet in delivering finished products to their customer base. To do that, they had already identified the only requirement was to meet this particular—I hate using the word, as Doug knows only too well—cleanliness number. For 20+ years, I have campaigned to try to remove that because the original concept of ROSE testing—as it has become commonly known—was to produce a standard of control to your manufacturing process in the context of the amount of ionic residue that might be found remaining on the surface of the assembly. That might then cause problems, long-term reliability, from an electrochemical stand-

point. We provided them with five instruments in four different countries with three operators on every machine, and we carried out an exhaustive gauge R&R test—the culmination of which was to produce an instrument that would meet not just those particular process control parameters, but actually achieved and attained cyclical verification, improvement in the process being a primary directive.

What we did then was to take that to both IPC and IEC with a view to try to get harmonization between documentation. In my humble opinion, and I'm sure that both Jason and Doug—much less Teresa—would agree that IPC has much more leverage in the marketplace than do IEC unless you live in Asia. To that extent, what happened was that events ran forward in so much as the document procedure in IEC somehow overran the document procedure that was going on in IPC. Doug and I are deeply involved in that as committee chairs, and we've been trying to get this moved forward pretty quickly. The problem, I suppose, is that—historically—due to the way in which this particular test has been employed, people have regrettably come to refer to it as a cleanliness test. That's the point that I have such heartache over because it isn't a cleanliness test. It was never intended to be a cleanliness test; it was a way to improve the evaluation of surface ionic.

Rather than using ion chromatography—which is a very long, drawn-out procedure and requires skilled operators—let us produce a simplified ion chromatograph, which is what the ROSE tester is. ROSE has become so absolutely built into everybody's psyche that I thought doing a revision of ROSE was not going to work as simply as everybody might like. Rather than that—because there's nothing wrong with the ROSE test, and PICT is pretty much exactly the same thing—I gave it a different name because I don't think I'll live long enough to see the removal of that particular expression or acronym. Now, process ionic contamination testing means what it says on the label.

It needs to be sensitive enough to be able to detect changes that are occurring in your assembly manufacturing process. By change of process material—whether it's soldering products, solder flux, wire paste, under-fills, adhesives, conformal coatings, or your cleaning technique—all of these elements are an integral part of the overall production process. All we want to do is have a method that is sensitive enough to pick it up. We were selected because we were the only manufacturing supplier capable of not only meeting their particular requirements at Robert Bosch but also to meet their Six Sigma requirement.

Matties: Graham, you're saying the ROSE and the PICT are essentially similar. What's the primary difference? Is it speed?

Naisbitt: It is sensitivity in the manufacturing, or the instrument procedure is that the efficacy of it, as the ROSE test stands today; it is the differentiation between what is referred to in that particular document as the static versus dynamic. That is a very confusing picture that is presented to a potential customer. If you talk to any engineer and say, “Would you like to buy a static tester or a dynamic tester?” the instant reaction is, “I want a dynamic tester.” It’s human nature. However, if you point out that dynamic testing is open-loop—whereas static testing is closed-loop—that decision changes completely. We want closed-loop. One of the failures of this particular test, and keep in mind that all of the instruments on the market today take their heritage from the 1970s. Doug and others were involved in much of the research that was being conducted in those days, because the U.S. military, quite understandably, wants to put a stake in the ground. We need a number.

Matties: Doug, what was your role in this new standard?

Doug Pauls: As Teresa indicated, I was “volun-told.” I kind of brought it on myself. At the time that this all took place, in the 2015 timeframe, I was the general chairman of the cleaning and coating committees for IPC. That position is now held by Jason Keeping, who is also part of this panel today. With the story that Graham had told, there are many parallel ones that we could all bring up that talk about how people had relied on the ROSE test as a tool for differentiating acceptably from unacceptably dirty—acceptable from rejectable. The ROSE test is probably the most abused test in the industry, and the overall assumption from most people was that if I met this specification, then I was acceptably clean. There was a mounting degree of evidence in the industry that said this was no longer the case. As Graham had indicated, my first job in the industry as a young engineer was working with Bob DeNoon and Bill Hobson—the originators of the ROSE test at the naval avionics center in Indianapolis. They were always horrified at what the industry did with their test.

It was intended to be a process control test, but the military took it and made it a product acceptance test. Most of us who deal with the issues of ionic residues and their impact on overall reliability knew this to be a case. We knew that this test was broken, and the pass/fail criteria established in the late 1970s and early 1980s was done for a different material set, so it wasn’t valid anymore. In the IPC committees, they keep using it until something better is put in its place. Dan Foster, along with Teresa, led the J-Standard-001 committee at the time, got tired of me bellyaching about it, and turned to me in one of the meetings. They said, “Doug, you’re right. We all understand that this test is broken. It needs to be fixed.” I said, “Yes, it does.” Then he said,

“Don’t we have an IPC committee that deals with the cleanliness of electronic assemblies?” I said, “Yes, we do.”

He said, “Aren’t you the general chairman of the cleaning and coating committees?” “Yes, I am.” I could feel the noose tightening, but there wasn’t a thing I could do about it. They said, “Would you not be, then, with a lifetime of experience in this and chairman of the committees, the appropriate one to lead this A-team?” “Ugh. I guess.” That was in 2015. We got together about 15 people who dealt with the issue, or who had been dedicated to answering the two questions in the industry: how clean is clean, how do you measure cleanliness, and how clean is clean enough? How do you determine what is and is not acceptably clean? We did a lot of work. We had a lot of discussions. We met probably two or three times a month for probably two and a half to three years. It culminated in J-Standard-001 Rev G Amendment 1.

Now, a lot of people had come to me during this time and said, “If we can’t use the old number, this 1.56 value, what number do we use?” I said, “It’s not that easy.” This is a very complex thing. There is no one size fits all cleanliness standard. There are some electronics, by virtue of their density or their function, that may tolerate a lot of ionic material. There are others whose function is more critical; maybe they’re much denser and cannot take these high levels of residues. Every assembler has its own cleanliness threshold.

Matties: Doug, is this a specification that the buyer of the board is then responsible for submitting to that fabricator?

Pauls: That’s a good question. One of the questions that we frequently get into with the Rev G Amendment 1, which is presently in force, “Whose responsibility is it to generate the data?” What I have told people, and what we’re working on clarifying as well, is that the manufacturer is responsible. I have a couple of examples that may clarify whose responsibility it is to determine what the right number or numbers should be. Collins Aerospace manufactures very high-reliability aviation electronics. Let us say that I choose to use a very high-quality contract manufacturer, Celestica, for example, since I know Jason’s on the call. Now, most of the contract manufacturers are going to have their preferred sources of material. They would generate their objective evidence that they meet the current protocols. As part of that development, they will probably have done some determination of what should their new ROSE number be for process control—not product acceptance, but process control. If I choose to have a Collins Aerospace product manufactured by Celestica, I could simply accept objective evidence and say, “Here. Build my product with your material set.”

Jason provides the objective evidence, I buy off on that, and we use that. If, on the other hand, I look at that and go, “I’m not comfortable with your material sets. I would like you to use my material sets on my product,” which—of course—many of the contract manufacturers will do. At that point, in my opinion, generating objective evidence becomes a shared responsibility. It’s shared from the standpoint that I require someone to use my materials. To give me a measure of assurance that my product works, we would jointly generate the data between our two companies, share the cost. Celestica learns about a new material database. Perhaps it’s an improvement over what they’re doing. As an OEM, I get the data that says, “I have confidence that my equipment is now clean enough, and it meets my criteria.” That’s kind of an overall view of whose responsibility it is.

Matties: Jason, when you’re working with an OEM like Collins Aerospace, what’s that process like for you in terms of the testing and documentation?

Jason Keeping: Working with an OEM that understands the principles of what’s going on is much easier. When I worked with Doug, with Collins Aerospace, they already knew why things were changing. We kind of understand a little bit of the history. In the late ’70s and early ’80s, when the controls were put in place, what were they from? At that time, we were all using tin-lead solder paste alloys. We were using water wash alloys. We were using only pin through-hole components—maybe the odd QFP. A lot of that design of products and where we are today has greatly changed. That’s why when Graham’s points earlier about the old value as being a blind acceptance test, and what Doug was looking at doing, how do you have what’s acceptable now? As things transitioned into lead, lead-free, you started getting different densities, different components, and different packages.

When OEMs like Doug’s knew that these changes had occurred, they would be able to work to provide, “This is a gauntlet of testing we need to do. Find out what the chemistries look like, what does the cleaning process produce and put out? Now that we have a common number, is that common number acceptable?” Usually, there is, “Yes, it is.” Okay, we’ll use that as a process control. We’ll go forward. If there was not, then we’d work out together, why was it not? Was it a process control? Was it a materials control? What was the difference that didn’t get us to where we needed to? But having individuals that were knowledgeable on it is a lot easier to work with because then you can have those discussions. But if they don’t know the background of why we changed from a solid set number into now getting objective evidence, that discussion was usually more difficult.

Matties: Part of this whole process of testing is for you to understand your processes through the testing here. How often are you testing your process with the test coupons?

Keeping: Typically, what happens is, at the beginning of a program, you have to understand material compatibility. Based on those alloys, based on the materials, what does that all look like? Is it compatible? That's a baseline test that needs to be done for compliance. Once that's been done, then you have to have a frequency put in place. "How often now do we validate that the process is still in control?" That's where the PICT test and other test tools come in, where now they are used continuously in manufacturing to validate that that process control that's been established by technical objective data is still being met.

Matties: Is speed one of the advantages to the PICT test?

Keeping: Correct.

Pauls: A question that I get frequently is, "If we can't use our ionic cleanliness testers anymore, do we get rid of them?" My answer is no. They're still a perfectly valid process control tool. They're quick. I would say that most of the more modern ionic testers that exist are repeatable and are reproducible. There have been great improvements to that since they were introduced in the '80s and '90s. There are still a lot of very old ones out there. But the modern ones are repeatable and reproducible. The fact that almost all of us, from various contracts over the years, have one of these instruments in place, means that at least let's use the tool that we have, but let's use it properly. Let's understand what the numbers mean.

If you're an old guy like Graham and me—and you lived through the changes in the industry that came about when we went from chlorofluorocarbon cleaning and high solids RMA fluxes and were around in the early '90s when the Montreal Protocol went into effect—very few people understood their fluxes or understood cleaning. But with the moves to low solids or no-clean fluxes, water-soluble fluxes, synthetic fluxes, if you talked about aqueous cleaning, solvent cleaning, semi-aqueous cleaning, super-critical CO₂ cleaning, now everyone was forced to understand their materials. What kind of residues do we get? How do they impact my long-term performance or reliability? We're going to be going through the same thing now all over again.

Matties: I interviewed Tom Forsythe some time ago, talking about the cleaning process. He made a point that I hadn't considered, but I wanted to bring it up here, is that with the no-clean applications that we've had for many

years, that we have a generation of engineers that don't understand the cleaning process. You're talking about having people that are knowledgeable. What would you say to that? Jason let's start with you on that.

Keeping: As we start looking at the test methods, a lot of the way the testing was done was extracting a certain amount of ionics from the residues that were in the wash materials to find out, was it still good? A lot of the solder paste and solder alloy manufacturers started to think, "How can we do the alloys, but then not have those ionics, yet there was still residue on the card?" That was where what Graham had said earlier about having this blind number. You could still have visible residue on a card, but you would get this number, and it would say, "Look. I'm clean." But yet you can still physically see the residue.

That's where, if you don't understand what the cleaning is or what it does, you wouldn't know, "I should take a look at this deeper because something's not right. Something's not working correctly." That's where the comment that Tom probably said was, people that don't know to peel that onion that second level down to take a look at it. They wouldn't be aware of that issue. For me, when I start looking at conformal coatings later, those residues do cause reliability issues for the conformal coating. There's a very easy way to check. But when you have products that are not conformal coated and those residues are then shipped out in that format, it becomes a big issue.

Naisbitt: Part of the problem is that when the Montreal Protocol was put into effect, there was a huge amount of research done. One of the major culminating factors from it was, as Jason mentioned, no-clean fluxes. Dr. Wally Rubin of Multicore Solders, way back in the day, was the original inventor of no-clean fluxes. One of the problems faced by the group evaluating non-CFC cleaning was, "If we have no-clean, how do we test for it?" That led to an interesting dialogue that spread over about five years, where we tried to figure out, "If that can't tell us, why can't it tell us?" Number one, many of the additives, and today all of the additives, are largely non-ionic surfactants, used to help with either wetting or de-wetting, as the case may be. But they are contributors to failure on an electrochemical standpoint.

Therefore, what we decided in the British Collaborative CFC Elimination Program, which was headed up by Dr. Colin Lee of then the NPL, and for whom an OBE was awarded, and for everybody listening in, the definition of an OBE is other buggers' efforts. Sorry for the language, but it's a truism. Nonetheless, it's a distinction for Colin in the work that he did. The only technique that was determined suitable for this program was to measure changes to insulation resistance. Because it cares not whether it is an organic or an in-

organic. It doesn't care whether it is ionic or non-ionic. It only looks for electrochemical reliability. Ergo, if you find that you have a problem, that's when you need to go look and determine what is there that's causing the problem. For that, you are now into an awful lot more in-depth research that can extend into paying test laboratories fortunes to deal with either ion chromatography, worst case FTIR, worst case Raman spectroscopy, and who knows what else.

What happened was that the initiation of an insulation resistance test would be a useful way to try to ascertain whether or not your product, from an electrochemical standpoint, is going to be reliable in service. That is the first stage that is now a requirement for manufacturers to determine what would then be a suitable process ionic contamination test. Because SIR testing, regrettably, is not a short duration exercise. The worst condition is that it relies upon a specifically dedicated test assembly that is a replication of what is intended for the end product. But once you've established good SIR conditions, these are all written up in the IPC standards, we then have the ability to control that by having a very sensitive instrument that can carry out this check in as little as three minutes to give the producer. As Jason is there representing Celestica as well as IPC, having somebody that can give you a go, no-go answer in three minutes is one hell of a lot better than having somebody tell you, "The test got another four days to run."

This is an important and very key point because it's up to date; as an extension to that, evidence is now bouncing around the industry on a global basis that we now have some problems with no-clean fluxes, and who knows about other forms of flux because most people are buying no-clean fluxes, but they're cleanable. The issue is that there is a trigger point at approximately 500 hours into testing where failures are ramping up. The longer the duration of the test, the more concerned people are going to be. Because never lose sight of the fact that when we were writing up all of these standards back in the '70s, the test coupon that everybody around the world recognizes instantly is B-24. The separation between the conductive paths on that coupon is 500 micron, half a millimeter. But most people don't manufacture electronics like that anymore—certainly not automotive, medical, or the likes of Apple, LG, Samsung, and anybody else. There are significantly finer tracks. Therefore, the susceptibility to failure doesn't matter. If my phone fails in a year, the manufacturer of the phone says, "You're out of warranty."

If that happens on your car or airplane, that means a lot of people are going to die. All of these elements in the equation are becoming more and more of concern. That's why PICT is so important. But keep this in mind, this is the first of four new documents, test standards, that are coming out. I'm trying

to make sure as far as I possibly can as the new vice-chair of the cleaning and coating committee under the guidance of Jason, from the historical background that Doug has, to ensure that the new documents that we produce out of IPC are as bang up to date as we can possibly make them. Now, here is the dilemma. Automotive, because of electric vehicles, not such a big issue in America unless you're working for Tesla. Maybe Chrysler, maybe GM. But in Europe and the Far East, in particular, China and India, this is huge. The requirement is ultra-high voltage. We're having to deliver instruments for measuring insulation resistance at levels of greater than 1500 volts for a test duration of greater than 2,000 hours.

At every committee meeting in IPC for the last three years, I have raised this subject. The reaction around the room is, "My God. I'm not going to do that." The safety implications are incredible. Of course, my insurance to sell into America is 10 times greater than anywhere else. This is a far bigger topic than PICT on its own, as Doug has already mentioned. The big concerns for everybody are automotive, high-voltage, high-reliability, and safety-critical. Aerospace and defense are mostly lower-voltage and safety-critical. You don't want to have the guy that fired the missile ask if anybody saw where it went. Then, in the bottom end of the scale, but equally important—especially due to what's going on around the world now—medical electronics and space electronics want ultra-low voltage. They're working down to a spacing between conductors on their circuitry of 50 microns. I have customers that are asking for us to produce circuits that are at six micron separation. We're at damn near semiconductor level. We have big challenges. I speak for all three of us working with IPC; we have a lot of work to do. Never forget, every bit of information and documentation produced is produced on a volunteer basis. You don't have a vested interest.

Matties: Now, you've mentioned one of four, so we have three more to go. Teresa, when you look at a project like this where we have three more to go, what impact or what concerns would you have?

Rowe: As Graham mentioned, all of our work comes from industry through volunteers. We can't be more appreciative of those volunteers. They are developing the documentation for the industry. We're a conduit for that. It's difficult sometimes to have multiple projects going at the same time. All three of these people will tell you that time is precious, and we find that as we get stretched thinner, we don't have the time to commit to more projects. But we take them based on priority. Sometimes, we see a number of projects being worked at the same time, and they might go along a little more slowly than we had anticipated.

But—ultimately—at the end of the day, it comes down to what does the industry need? I see these moving forward and developing at a rate that Jason and Doug and Graham will be able to pace it. We depend on them to pace it based on what they have as input and what they need. We try to get those resources from them or for them as they need them. We've talked a little bit about any kind of round-robin testing funding that's needed to do things. Sometimes, they'll produce a white paper, because a white paper is ultimately faster. It doesn't need the larger committee sometimes to have the input. There are different ways that they can get their messages out there. We look to them to help us with that guidance.

Matties: There's a shift in paradigm from the ROSE test and how it's been used to process control. Doug, you've dealt with a lot of EMS. I would think process control was being measured in any case, yes? Or is this some new thinking that's going on?

Pauls: I look at a lot of this as the development of a toolbox. A lot of the things that we're doing for IPC is to develop new tools for determining, is the residue level that we have acceptable or unacceptable? Under what conditions are they acceptable or unacceptable? From the standpoint of process control, our industry has relied on the ROSE for decades to be our lone process control tool for determining, can I ship products? It's going to take quite a bit of education to get away from that. There have been tools that have been used quite effectively. Ion chromatography is part of it. SIR is part of it. There are many different ways in which you can control a manufacturing process. But unfortunately, the only tool that everyone knows and uses has been the ROSE test. Now, in the past, prior to my coming to Collins Aerospace 20 years ago, I was the technical director of Contamination Studies Laboratories, which is now Foresite.

As a company back then and to this day, many of them use ion chromatography to determine where possibly hotspots are in the manufacturing process. Properly understood, this is a new tool. The problem being is that, as Graham indicated earlier, ion chromatography is not a quick test. It takes an hour-long extraction, and then it takes rather sophisticated equipment. You're looking at probably a \$75,000 to \$100,000 investment. Then, you need someone who can set up the methods and set up the interpretation. It's not cheap. I have both IC and SIR. I use it daily. Both of them are worth their weight in gold. I use them as tools all the time, but they're not common. A lot of what our committee is doing is trying to educate people on how to look at process control with a more modern view. How do we determine if we can't use the 1.56 value, what should we be using, and how do we use it as a process control tool?

Teresa mentioned white papers earlier. Our particular A-team that developed what became Rev G's Amendment 1, we developed an explanatory white paper, WP-19A, that was to go along with it. That would educate the people on what exactly this new cleaning protocol, what this new tool, what this new wrench did. It's had very good reviews so far. As J-Standard-001 goes into Revision H, which I expect would be finished at some point later this year, that white paper is or will be revised to answer a lot of the questions that have come up.

Matties: Coming over to Jason to follow that thought, with the new testing paradigm, Jason, have you improved process performance and capability? In other words, what are the benefits that you've seen so far?

Keeping: As Doug and both Graham noted, it's not like I've seen more benefits for us. Because a lot of the times, our processes were already in control. It's more a lot of education. A lot more information, and a lot of our even OEMs and Collins Aerospace are very knowledgeable on it, but a lot of others are not. When we come back to them, and we say, "This value is no longer a valid test point. We need to do some other process control." They're like, "What do you mean?" Even though they own their own products, this is still a transition right now that this information still needs to get to all the different OEMs as well.

Matties: It's helping position you as a thought leader and educating your customer base.

Keeping: Correct. When we can go through showing our manufacturing process controls about the way we do handling, the way the equipment is put together, the gauge R&Rs to make sure everything is repeatable, that it's always given the same process, showing all that data with the objective evidence with the customer on the new things of how to get a new process control point, then they'd understand what that means. Now, that's when they clean. When they don't clean, and then they try using this number, it's a much different discussion point, and it's a lot more complicated. Right now, this has been a guideline that cleanliness, as Graham noted earlier, it's not what it meant.

That they thought, "If I do this testing and my product meets 1.56, then my product is cleanliness assessment as good." A lot of people have taken that to heart as stone as, "It doesn't matter what I do—if I clean or I don't clean. If I reach that value, my board is acceptable ionically." Now, we the changes from tin-lead to lead-free, different densities from the pin through-holes

now to QFNs, that knowledge some OEMs are not aware of. To get them to understand that and to show them the objective evidence, why that number is no longer valid, is much more complicated.

Matties: They would be motivated, I would think, by the number of failures 500 hours down the road.

Keeping: Yes. But then it goes back to, what is the market? Is it a product that only lasts 100 hours? Is it a product that lasts a couple of weeks? Then you have to look at it. Sometimes, they also look at it from a cost point of view. If I add in a cleaning process, it is going to be an extra value of cost. Then you have to start looking at them when you talk to them as, “Okay, but don’t look at it at the cost point. Look at it from a total cost of ownership point of view. You’re going to add a little cost now. But over the long run and lifespan, you save all these failures, reliability warranties, and the overall total cost of ownership goes down.” It’s about more of an education from a whole point of view.

Matties: You’re not even getting into the litigious side of things, where product liability comes back to them. The cost could be astronomical.

Keeping: Exactly.

Matties: We’re coming up on an hour. This has been interesting. Why don’t we walk through and ask if there’s anything that we haven’t talked about that you feel like we should include in this conversation? Teresa, why don’t we start with you?

Rowe: We’ve covered the majority of it. I would encourage the listeners who have additional questions to reach out to any one of us for further discussion, for further explanation. As Doug mentioned, and I’ll reiterate, we recognized even when this topic was introduced to the 001 task group at large, after the A-team had worked on it for a while, we had a lot of skeptical people. We had some inquisitive people, and we had some scrunched eyebrows and foreheads. It even took education at that level to begin to have a conversation. I’d be interested to see if any one of the three of them disagrees with me. But over the course of the three years that they worked on this, even the task group members became more educated on the finer points of this. That’s why they were adamant, and so was the A-team, that this white paper that Doug talked about accompanying the amendment. That it had to be part of the education process so that the industry at large could put the information to use and put it to use properly. That’s a huge takeaway for this.

Matties: Great. Thank you, Teresa. Graham, do you have any thoughts?

Naisbitt: As everybody has pointed out, education is the key issue. We have a transient workforce in our industry. They come on board, work with the company for two or three years, learn something, and go onto another posting somewhere else. Increasingly, what we have is that the industry, especially in China, and I mention that very specifically because developmental work in the context of getting a reliable product happens at a pace in China that the West cannot hope to keep up with. They had so many people thrown at it. It's quite scary. Something that's being discussed at great length in years gone by, IPC ran a fantastic technical forum called the TechNet. Doug, Jason, and myself have been members of the TechNet pretty much from its inception. That goes back, believe it or not, Doug, over 20 years. Some of the conversations that have taken place are, "This whole move toward lead-free doesn't make any sense."

But the biggest problem for humanity is the world is full of an awful lot of people. At some point, there's going to be an incident that brings everything back to some scary realization effect. Sadly to report, we are now, all of us, living that nightmare because of this virus. I've had conversations with our partners in India, and the prime minister of India is proposing to extend the lockdown to the 3rd of November. What's happening elsewhere in the world varies gigantically. But make no mistake, handling this, reducing the electronic equipment and materials to deal with the massive boom in medical electronics that's happening, requires some very fast thinking, and it needs an awful lot of very clever people to get a handle on this to move this forward. We cannot rely on what we did 20, 30 years ago, or more. It doesn't apply anymore. God save us all.

Matties: Good point. Doug, how about you? Any final thoughts?

Pauls: I would build a little bit upon what Graham had indicated. It's kind of interesting. We look at what's going on with the pandemic, and my background in looking at the effects of residues, I am now on our company's disinfecting team. We can't get all of the disinfectants we used to get, because everyone's buying them. Which ones can be used? There are very few people out there who can determine the effects of these residues on electronics. I happen to be one of them. Graham had talked about the value of education. I wouldn't be able to be in the position that I'm in had it not been for the education that I have learned from IPC throughout the years.

There's a lot of work that's going on to better characterize materials, to better characterize the effects of residues on assembly performance. Graham talked about TechNet, an excellent tool to be used. But I would say participation in the IPC's technical committees is an educational arena that cannot

be matched anywhere. A lot of the work that went into J-Standard-001 Rev G Amendment 1, which was done by this A-team—or, as we called it, the rhino team—is now being formalized as an IPC committee. The question that I get from people a lot is, “Doug, I need to master this learning curve very rapidly for my company. How would I do that?” Part of that is becoming more educated, being involved with IPC. IPC has a lot of educational materials that are with it. But participation is our best investment.

Matties: Let’s move to you, Jason. Any final thoughts from your point of view?

Keeping: I’d probably re-elaborate what was said by Teresa earlier, in that a lot of the industry groups are volunteers. But then, as Doug mentioned, we had the rhino team or the subject-matter expert group. It’s not that we were all very good at what we did, but by being all together, the synergies by listening to different experts of technologies, we were able to learn how to put all that together for the industry for the best solution of what needed to happen. You can always have a whole group of people that are all chemistry, but they don’t know the equipment, they don’t know the process, and they don’t know the incoming. By having that group and team of different areas of expertise was phenomenal. That was why we were able to put together what we did.

Going back to some of the stuff that Doug invited me into, and now by being part of, we started every two years having a conference on assembly cleaning and conformal coating. Doug and I did a lot of the workshops at the beginning of the course. Between the group of us, including Graham, there are over 50 for sure and close to 100 years of experience that’s in that content. When you start looking at how to educate people that are new to the subject, by being able to attend these events, by being there, the amount you can absorb by listening to other experts is phenomenal. Being relevant and present is the best thing.

Matties: You bring up a great point that you’ve connected a supply chain in developing this new standard. Those viewpoints probably made that process so much better overall as an end result. Well done.

Keeping: Yes, because we only looked at it from the cleaning agent point of view only, or an OEM point of view, or the equipment or the manufacturer. You would get different levels of expertise and different requirements. Having everyone together, we figured out, how did those aspects work? How did they interrelate, and what needed to happen to move all of it forward? Which is what was done.

Matties: Doug, you're the OEM in the room here. What advice would you give to other OEMs regarding this new standard, and the approach?

Pauls: OEMs as a group have a tendency to take the standpoint, "Be reasonable. Do it my way." A lot of OEMs would say, "I want you to use my material sets, but I want you to pay for it." This needs to be a shared responsibility. That needs to be understood by everyone who's out there right now. This is not something you can't take all the burden and put it on your contract manufacturer. You can't even put it on your own manufacturing lines. There's a lot of new information that needs to be done. People need to be open to generating new data sets. The one point that I would say is there is no one-size-fits-all cleanliness requirement anymore. That horse has left the barn. You have to determine what is acceptable or unacceptable for your product, and that is most often done collaboratively with whoever's doing the manufacturing.

Matties: I would think, listening to you and Jason talk, that that relationship between the customer and supplier has to be incredibly strong because of the way you are interlocked in this process.

Pauls: It works a lot better if the contract manufacturer and the OEM are willing to work together. I have seen cases where, in essence, it is an adversarial relationship. It does not work there very well.

Matties: Thank you all for taking the time out today to help educate the industry about this new process. We appreciate the years of dedication you've put into generating this.

Pauls: I'm glad to be of service.

Rowe: Thank you.

Keeping: Thanks, everyone.

Naisbitt: I appreciate it.

PICT Roundtable Discussion Q&A

What if the reflow process does not work?

If you put something to cook into a cold oven, it won't be fit to eat. The same answer applies with respect to electronic circuits. However, I am assuming that the reader is referring to some incorrect reflow where the solder paste is insufficiently reacted. This would mean excess unreacted residues, and yes, a PICT tester will detect this.

Is the equipment safe to operate and maintain?

As with a ROSE tester, this is a simple, easy-to-operate instrument. To maintain optimum performance, the de-ionising resin filter will require periodic replacement. The period of use is influenced by the amount of ionic "dirt" being removed. Keep in mind that it is not designed to be used as a cleaner.

Should PICT testing not be applied throughout the whole process all the way to client final box build? Testing only shows a reading for that day, not forever.

That is entirely dependent upon the manufacturing process and where such testing would be desirable. However, the instrument is only required to detect measurable levels of ionic matter that could compromise the end-product reliability of the circuit assembly at the completion of its assembly process. Every individual production line will have differing levels of ionic contamination. This level will also be sensitive to its environmental location.

Establishing the user upper control limit for each process line is determined from a process characterisation test using surface insulation resistance (SIR) testing.

Refining the assembly process to maintain acceptable production controls will determine, case-by-case, the test frequency that is required. High-volume producers might determine that a sampling level of one assembly per month is acceptable. Others might determine one test per assembly is necessary.

Can PICT testing be carried out economically?

Yes. The test instrument requires unskilled operators. The test solution is an inexpensive mixture of IPA and de-ionised water. The mixed resin filter is readily available from water treatment suppliers.

Are there issues with the ICT?

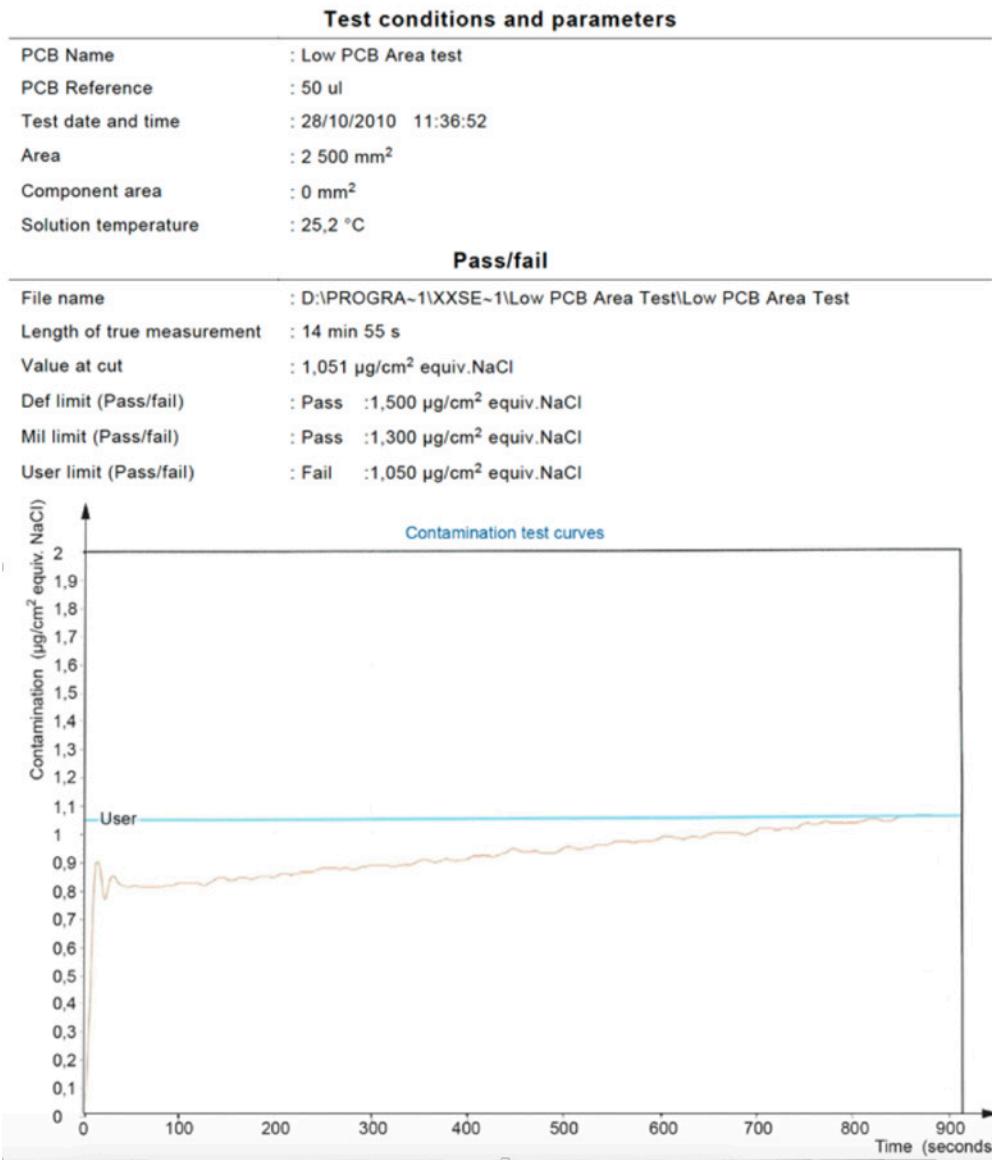
No, as long as any tested assembly has been thoroughly dried following the test.

Can an existing ROSE tester be retrofitted or upgraded to perform PICT testing?

It depends. To use the instrument to its performance optimum, it needs high sensitivity, an efficient test solution circulation/flow rate, and be capable of delivering reliable and repeatable test results. The ability to achieve 6 Sigma, as required by most high-volume manufacturers, is the ultimate expression of capability.

Any de-ionised solution hates being in that condition and will aggressively attempt to scavenge ionic matter wherever it can. This applies to CO₂ in the air above the tank (test chamber). Chemically, the de-ionised water and alcohol test solution—whether 75:25 or 50:50—will exchange with CO₂ and convert itself, over time, to carbonic acid. This is why the surface area of the tank and keeping a lid on it is essential.

The diagram below shows the influence of CO₂ over time:



If existing equipment can be upgraded, who can provide parts and perform the upgrade?

The user needs to determine whether their existing instrument is capable of meeting their process requirements.

What are the process equipment/purchasing options?

No additional process equipment is required unless the intention is to automatically divert a sample for test from the production line. Most commonly, this is simply a manual pick from the line.

The most important purchasing option is to determine the correct tank size for the instrument. To help with this, it is important to determine tank size by using the ratio of 10 ml per cm² to be individually tested.

This might mean having more than one instrument. By example, a back-plane circuit of say 250 mm x 500 mm (10" x 20") might suggest a tank containing >20 litres of test solution, whereas the majority of assemblies might only measure 100 mm x 150 mm (4" x 6") and require a tank containing <10 litres.

Some testers can switch use between 75% or 50% IPA/DI water mix. Where would you use the lower 50% mix?

A closed-loop tester (static) is a better option than an open-loop tester (dynamic.)

Extracted from the IEC 61189-5-504 PICT Test:

- Ionic soils can be dissociated in water, and the conductance measured to give an indication of the contaminate level. The test solution, however, is more than just water; it contains propan-2-ol (IPA), a non-polar liquid that aids the dissolution of the soil and, as a non-ionic hydrophilic solvent, its presence does not influence the reading except insofar as it "dilutes" the water bearing the dissociated ions.
- The test employs a test solution that comprises a specific ratio of 50% V/V propan-2-ol and 50% V/V de-ionised water or 75% V/V propan-2-ol and 25% V/V de-ionised water.
- The 50:50 mixed solution is an optimal compromise between the sensitivity and the solvency when using immersion test methods.
- The 75:25 mixed solution with the higher alcohol content will reduce sensitivity but increase solvency and vice versa with respect to water.

Is PICT testing realistic, and can the result really reflect the reliability of an assembly as an indicator?

It depends. The user is expected to know the maximum upper ionic contamination level permitted to be left on the individual circuit assembly surface. Clearly, if that level is exceeded, then the risk of electrochemical failure increases. That needs to be determined by the manufacturer.

Are there issues with the AOI?

No. This is a test conducted offline.

What are the environmental impact and safety procedures?

PICT and ROSE testers have been in use since the 1970s. They use a mixture of IPA and de-ionised water.

If the upgrade path is not available, how costly is a new machine? \$10K - \$50K - \$100K?

Responding as the manufacturer of the Contaminometer, aka CM Series instruments, the start price of the CM11+ is ~USD10K, the price of our CM33L+ is ~USD25K. Our top of the range CM60 instrument, widely used by the space industry, employs a volumetric measurement cell, which is ~USD50K.

Confidence in the repeatability of the testing is an important factor in choosing a measuring process. How would this be verified?



The Contaminometer CM Series instruments uniquely meet 6 Sigma criteria as determined by Robert Bosch of Germany. A full explanation of what was done to achieve this is shown in the free micro eBook, [*The Printed Circuit Assembler's Guide to... Process Verification*](#). It is also available as a technical paper that was presented jointly by Robert Bosch and GEN3 at IPC APEX EXPO in 2017.

Can PICT testing be carried out in series production on reference modules (test coupons), or does it refer explicitly to the individual electronics module?

Sampling is to be done on the product itself—not representative coupons.

Meet the Participants



Teresa Rowe, IPC's Sr. Director of Assembly & Standards Technology, has over twenty-five years working for a defense contractor with responsibilities in quality engineering, training, and auditing functions in the production, maintenance and servicing environments. A liaison with the electronics industry in the development of IPC soldering and acceptance standards, she is also a Certified IPC Trainer (CIT) for soldering, electrical acceptance, cable and harness requirements, and rework and repair.



Graham K. Naisbitt is a Freeman of the City of London, a Liveryman of The Worshipful Company of Marketors, and the recipient of the IEC Lord Kelvin 1906 Award. Graham began his career in 1969 at Socaltra, a French industrial engineering consortium. Later, he worked with French heavy-engineering giant Fives Group, and between 1979 and 1985, he served at Babcock International, a subsidiary of Claudius Peters in Germany.

In 1979, the Naisbitt family created Concoat Ltd., to which Graham returned in 1985, making the logical step change from heavy engineering into the electronics industry as the U.K. distributor of HumiSeal. From 1979 to 2005, Concoat grew to become the manufacturing licensees of HumiSeal conformal coatings whilst also creating many of its own coating formulations.

Concoat began to develop conformal coating application equipment that extended to both in-line dip and spray coating systems in 1982. By 2002, Concoat acquired Multicore Solders SPCID (Soldering Process Instrumentation Division) from Henkel KGaA, thus expanding its equipment manufacturing division. Following the sale of Concoat to HumiSeal, Gen3 Systems was created in 2005. Both of Graham's sons have since joined the business as the third generation of the family.

With over 40 years in the electronics industry, Graham is a specialist in conformal coating, cleaning, SIR and CAF testing, electrochemical reliability issues, solderability, and process control matters; has authored over 100 technical papers; and given presentations around the world. He is also the current vice-chair of IPC 5-30 Cleaning and Coating Committee that embraces 15 test standard groups and a maintenance leader with IEC TC91 for SIR, CAF, ionic contamination testing, and solderability. Graham is chairman and CEO of Gen3 Systems, which continues to be a successful, family-controlled business.



Jason Keeping is the Global Process Subject Matter Expert for Ruggedized Electronics within the Global Technology and Operations team at Celestica. He holds a B.A.Sc in Electrical Engineering from the University of Ryerson, is a Six Sigma/Lean Professional and a licensed professional engineer. Jason has focused his career on assessing the manufacturability and capabilities of conformal coating, potting, underfill chemistries & their interactions, dispensing technologies/

processes and on assembly-level cleaning for the past fifteen years. Jason is the recipient of several awards, including the 2016 SMTA Excellence in International Leadership Award, the Shingo prize for Celestica's site in Monterrey, Mexico in 2007, and has contributed to Celestica's Frost & Sullivan awards in 2005, 2009, 2012 & 2013. Jason is the co-chair of the IPC-HDBK-830 handbook; author for conformal coating chapter of the Printed Circuits Handbook and was featured in the cover of Circuits Assembly in May 2008 and is currently the chair of the 5-30 Cleaning and Coating Committee within IPC.

Most recently, Jason presented with Dave Hillman of Collins Aerospace; an industry wide baseline study, on conformal coating, supporting a J-STD-001 initiative with data and support of industry leading organizations. Jason has worked alongside Steph Mescheter of BAE Systems as a principle investigator on two of Celestica's joint U.S. DoD Strategic Environmental Research and Development Project (SERDP) examining corrosion induced whisker growth



Doug Pauls holds a B.A. in Chemistry and Physics from Carthage College, Kenosha, Wisconsin, and a B.S. in Electrical Engineering from the University of Wisconsin, Madison. He worked 9 years for the Navy, 8 years as Technical Director of Contamination Studies Labs, and 20 years at Rockwell Collins (now Collins Aerospace), in the Advanced Operations Engineering group, where he is a principal materials and process engineer. Doug was awarded the Rockwell Collins Arthur A.

Collins Award in 2004. Doug is a long time IPC chairman and was awarded the IPC's Hall of Fame Award in 2017. Doug is most notably known for his expertise in surface insulation resistance testing, cleaning and cleanliness assessment, conformal coatings, and how to qualify manufacturing processes. He has been a U.S. representative to ISO and IEC working groups on SIR, electromigration, and cleanliness reliability standards. He has participated in numerous national and international consortia on electronics manufacturing materials and processes. Doug has 3 adult children and has been happily married for 34 years and hopes the marriage survives the work-from-home provisions of the pandemic.

Related Content

- [PICT Roundtable Discussion audio file \(mp3\)](#)
- [*The Printed Circuit Assembler's Guide to... Process Verification*](#)
by Graham Naisbitt, Gen3
- [IPC White Paper: WP-019A](#)
- [*The Printed Circuit Assembler's Guide to... Conformal Coatings for Harsh Environments*](#) by Phil Kinner, Electrolube
- [Micro Webinar: *Coatings Uncoated*](#) by Phil Kinner, Electrolube
- [*Clean vs. No-clean: A Generational Difference*](#) with Tom Forsythe
(SMT007 Magazine, December 2019, p. 48)