自动清洁通常不可行。很多部件怕水 - 是从一开始要手工焊接元件到电路板的一个主要原因。通常清洁机都放在设施的偏远地方，或是以最高容量操作，或对高生产量需求来说太慢。另一个选择是用刷子清洁，然后用喷雾剂清洗。这是一个好的选择，可快速而可靠地清洁，但是不整洁、浪费和通常昂贵。最佳的选择是使用某种形式的喷雾剂分配系统，以控制清洁液的流量。

The 'Big Brush Off' Revisited

By Mike Jones

In rework and repair, if you can't rinse, you can't clean.

Last December in this journal, Terry Munson offered up a unique analysis of benchtop cleaning.[1] In one brief piece, he managed to be both exactly right and precisely wrong – a phenomenon typically observed only in members of Congress. This is a brief attempt to set the record straight.

First, let's review the parts Munson got right. He asserted localized brush cleaning is widely used to remove flux buildups after assembly, rework and repair. He noted few, if any, SMT manufacturers have ever properly "qualified" their benchtop cleaning process to determine it was delivering the desired results. He scored a perfect "10" when he noted the result of conventional brush cleaning was merely "the redistribution of flux residue to nearby areas of the assembly."

Munson also observed erratic cleaning is a particularly severe problem with no-clean fluxes, which is true. Last, he diagnosed the problem correctly when he observed that localized cleaning without rinsing posed a significant risk of contamination, voltage leakage, corrosion and ultimately premature failure of the PCB.

When you're right, you're right; and he's absolutely right on every count.

So the Process Doctor has correctly identified the problem, but neglected to write a prescription to cure it. Luckily, I know some experts in benchtop cleaning. And any of those experts would report there are a handful of acceptable ways to clean a circuit board after hand-soldering, but "dip-and-brush" cleaning isn't one of them.

Why clean? Mr. Munson never challenged the requirement to clean. Yet unless you're making the cheapest possible product, any circuit upon which hand-soldering has been performed must be cleaned. Even "no-clean" fluxes need to be cleaned, *unless the soldering process is totally automated.*

Fluxes work because they contain halites (which are salts, also called "activators"), which lower the surface tension of the melted solder and thereby improve the solder surface wetting. Salts corrode metals, so it always has been a requirement with traditional fluxes (R, RA, RMA, SA and so on) that those halites be removed from the board by cleaning.

In contrast, most no-clean chemistries use the heat of the soldering process to encapsulate the activators in a microscopic, protective bubble. This physically separates the salts from the metals, which keeps the halites from corroding the components and board. The encapsulation process is performed chemically when the flux reaches a critical temperature during the soldering process. And that is the heart of this story: Because cleaning "breaks down insulative

residues formed during soldering," as Munson notes, if those residues are not removed from the board, they will have been released from their encapsulation to damage the PCB.

No-cleans do not need to be cleaned after automated soldering because the temperature control is generally perfect. But hand soldering is far less precise. Some portions of the flux quite close to the soldering iron tip will get sufficiently hot for the encapsulation to occur, but other areas, millimeters farther from the tip, will not. These unencapsulated residues can and will cause leakage, corrosion, dendrite growth and "infant mortality."

So hand cleaning hand-soldered boards is essential, even with no-clean fluxes. In addition to the unencapsulated activators in the no-cleans, erratic cleaning on a PCB will dissolve the encapsulation around properly cured activators. It was this double-whammy that Munson found in his SIR testing: the unencapsulated activators were not removed because of the inadequate cleaning, which released the encapsulated activators from their cages, permitting corrosives to run amok on his boards.

Figure 1. The typical dip-and-brush bottle with IPA is unsatisfactory in most instances.

Four steps. At the heart of the issue is the realization that every cleaning process requires four steps: wet, scrub, rinse and dry. Whether washing your car in the driveway, your hair in the shower or the baby in the tub, every cleaning process requires the same four steps: wet, scrub, rinse and dry.

Consider the humble chore of the dinner dishes. Slathered in gravy and bits of your favorite meatloaf, they dried rock-hard while you watched *Dancing with the Stars*. But now it's your time to face the music; the dishes aren't going to clean themselves. So what to do?

First, we rinse the largest chunks of debris from the plates using the hottest water we can get. This softens the hardest residues and starts to begin to dissolve the water-based contaminates. Grabbing a sponge, we scrub the surfaces (both sides, please!) and dislodge the residues. Do we then put the plate in a rack to dry? Never (or I'm not coming to your house for Thanksgiving)! Instead, we rinse the plate thoroughly with scalding hot water, removing the last traces of Mom's cooking, as well as any soapy residues. Now they're ready to either air dry or wipe with a dishtowel.

With everything you clean, the process is the same. The dishwasher uses the same four steps. The drive-through car wash? Wet, scrub, rinse and dry. In the shower? Who can forget the stern "wet, lather, rinse, repeat" every shampoo carries on its label? It's a simple truth: If you can't rinse, you can't clean.

Back to the world of electronics. It is amazing engineers around the world think a jar of alcohol and a dirty toothbrush are suitable tools for benchtop cleaning. Sure, it may have worked in the 1960s, but today's tiny, dense, hot circuitry absolutely will fail if the four steps of cleaning are not properly used.

Benchtop cleaning options. The first, best way to clean the board is through an automated cleaning process, either a vapor degreaser or some type of aqueous cleaner. Like the dishwasher or the car wash, this delivers an automated form of wet, scrub, rinse and dry. The human factor is eliminated. Without doubt, this process produces the most consistently clean boards over the longest possible term.

However, automated cleaning is often not practical. Many parts are sensitive to water – which is one of the primary reasons for hand soldering a final few components onto a board in the first place. Often, the cleaning machines are in distant parts of the facility, or are operating at capacity, or too slow for high-throughput requirements. So the benchtop technician needs a faster, cheaper answer.

Another option is not to clean with a brush, as described by Munson, but to rinse the board with an aerosol flush. This is a very good option and delivers fast and reliable cleaning, especially using today's fast-drying, ozone-safe solvents. The problem is that techs will run through a lot of cans in fairly short order. It's a sloppy, wasteful and often expensive process, but it will deliver clean boards, if the customer can afford it.

The best option is to use some form of dispensing system on an aerosol solvent to control the flow of the cleaning fluid. In this process, the brush's mechanical scrubbing action is complemented by a controlled spray from an aerosol container. It forces the technician to implement "wet, scrub, rinse and dry" every time. It also allows the technician to clean better, more consistently and thoroughly, with far less solvent. Because the solvent is fresh and pure ("virgin" is the term in the cleaning industry), it will deliver far better cleaning than some tired, contaminated alcohol sitting in a dirty pump bottle.

In one study conducted by a major New England OEM, a benchtop aerosol cleaning system produced SIR results of 12.5E-9 to 13.5E-9 across four different solvents. So we see it's not the solvent that matters; it's how you use it. The conclusion of that customer was that manual PCB cleaning can be quick, affordable and reliable at the benchtop, provided the technician is equipped with the proper cleaning tools that permit rinsing the board without waste.

Munson did us a favor by highlighting the problems with dip-and-brush cleaning, which has been the conventional circuit cleaning process since the dawn of the space age. What must be emphasized, though, is the crucial factoid: If you can't rinse, you can't clean. Engineers should review their benchtop cleaning processes to make sure they are using all four steps. If not, call some cleaning experts and see how they can boost your quality and save you money at the same time. ■

References

1. T. Munson, "The Big Brush Off," *Circuits Assembly*, December 2007.

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