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How Important Is Thermal Profiling?

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Thermal profiling is always necessary — no matter what. Or is it? If this sounds like a contradiction, there are currently ways of profiling that provide alternatives to the most time-consuming or labor-intensive methods. For example, oven verification may in some cases replace repeated board profiles, but only if strict parameters are met. The trick is in knowing when to profile the board or verify the oven performance.

PCBs often contain a mix of active and passive components, varying widely in size, functionality and heat tolerance. J-STD-075, issued by the IPC in December 2008, illustrates that even "penny-priced" passive components such as capacitors can be damaged during reflow — so much so that these components can, as far out as two years after production, cause failure in a product worth thousands of dollars. These latent failures do not show up even in the best of assembly test and inspection processes. When they do show up, the OEM faces warranty, or even worse, liability issues.

Self-contained Reflow Oven Verification Tool.

During ECD-University profiling classes, we show that thermal profiling consists of both characterization and verification, and liken the entire process, which we call Thermal Quality Management (ThQM™), to maintaining the health of the human body — perhaps the largest and most complicated assembly of all. There are times to have a complete physical, including an EKG, to determine whether you are in the correct range for your age, size and weight. This is similar to profile characterization.

Then there are times you need only regular checks to make sure you are still within the set boundaries (blood pressure reading, for example) which is similar to profile verification.

And finally, there are times when you need a full re-examination because some things have changed (weight gain or loss, for example). This would be similar to reprofiling after maintenance. The profiling tools may vary for each stage of PCB assembly and for each type of physical checkup, but the goals are the same — assuring the health of your assembled end product.

An ECD survey at APEX and online showed that while 90 percent of EMS and OEM companies are diligent about initial thermal profiling, nearly 60 percent admit much less diligence in verifying successive, simultaneous, or repeated production runs. Knowing that a lack of profiling can result in field failure, why isn't profile verification a routine part of every quality-conscious EMS and OEM company?

Cost Effective

Factors cited were time constraints, labor-intensive procedures, and lack of known simpler alternatives. It becomes clear in addressing those reasons, however, that the bottom line is positively affected to the extent by which thermal profiling is employed. In general, the cost of product quality assurance escalates as it gets closer to the customer.

Today's profiling tools and methods can actually cut setup and production time, help prevent human error, and reduce both field failures and warranty or rework costs. They can even speed up time to market when brought in at the NPI phase, since design for manufacturability plays a large role in the success of the product. So as we examine the roadblocks cited, let's discuss some alternative profiling methods, and when they could be used.

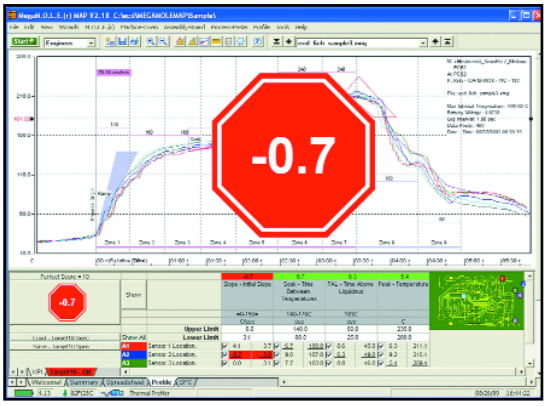
Roadblocks to Profiling

Knowledge. J-STD-075 should go far in convincing companies of the need for consistent thermal profiling.

Training for dealing with sensitive components and other profiling issues is available from multiple sources, including profiler manufacturer's classes and seminars, IPC and SMTA industry information, and trade shows and conferences.

Time/Labor. Time is money. But eliminating a vital process to save time is foolhardy, at best, especially in hi-rel applications such as medical, military, or aviation. Instead, let's discuss ways to more quickly and cost-effectively characterize and verify profiles. EMS companies will, in fact, be much more marketable if they can document profiling practices, demonstrating themselves to be quality minded and ahead of the curve.

You cannot shortcut the initial thermal characterization of a new board assembly. One pass through your oven with a recipe estimated to properly solder without damage to sensitive components, using enough measurement points to see the range of component thermal variation, will provide major insights into how the board reacts thermally. Advanced software can then be used to adjust the oven's recipe to both meet the needs of the solder paste and stay within the component's limits. The savings of only doing one profile, in conjunction with advanced software, rather than the trial-and-error of repeated profiling should be obvious.



Screen Shot: Simple Indication of "Go/NoGo".

Savings can also accrue rapidly from oven verification. Once a board has been characterized, the oven can then be verified instead of repeatedly profiling the same board at the start of a production shift or part-number run. This also saves expensive "golden boards," — which cannot always weather repeated profiling — from wearing out. Each zone influences the "shape" of the thermal profile. The amount of that influence depends on the oven recipe's temperature set point for each zone, the conveyor speed, and the convection rate (fan or air speed). Convection rate changes are one of the leading causes of profile changes when neither the conveyor speed nor zone temperature set points have been altered. So understanding what part of the profile each zone influences (and making sure it is operating properly) is critical in oven verification.

A Binghamton University study clearly showed that unless the product or oven settings have changed since the initial profile, and as long as the oven is verified, successive runs will meet target profile parameters. Verifying that an oven is still achieving target profile will also tell you whether it requires maintenance or service, allowing you to avoid potential problems.

Verification frequency is determined by usage. Depending upon the profile verification products used, the oven receives either a thorough "physical" (similar to a person's receiving an EKG or MRI) to determine its uniformity with the norm, or a quick "checkup" (similar to quick and easy blood pressure checks) to measure stability.

Complexity of Equipment

Profile manufacturers have made time- and labor-saving hardware and software changes that improve first-pass yields and profit margins. These changes cut down production time, help eliminate wasted product, and simplify the profiling process.

For example, alternative ways to attach thermocouples in board profiling have been developed that proved effective in addressing one of the major impediments to consistent profiling. Multi-T/C-per-connector devices allow timesaving hookup to the profiler. Advanced software allows multiple-run data storage before download, and customizable data extraction provides quicker, targeted analysis and customized reports. There are also patented items such as ECD's "OK" button, which gives reliable "Go/No Go" profile decisions at the operator level. For oven verification, there are single-piece pallets with thermal barrier and profiler within which make oven verification faster and more hassle-free.

What Cost?

Controlling costs while achieving maximum throughput is always a major objective. But as we saw in discussing latent field failures, eliminating or cutting back profiling is not a way to achieve either. The real savings come in increased first-pass yields, decrease of rework and warranty/liability costs, and in preserving expensive "golden boards." It comes in production time saved, and in knowing the oven still hits the target profile because you verify it.

Savings also occur in R&D and NPI phases of new products, since most costs are incurred at design and NPI stages. Thermal profiling is critical to design for manufacturability from the very beginning, eliminating the potential for waste, failure, or future rework. So, is thermal profiling always necessary? Absolutely. Must it always be done before each production run? Absolutely not — with this caveat: the initial board profile is critical. That must be done adhering to the engineer's and OEM's parameters. But we have touched on thermal quality management techniques light years ahead of even five years ago to both obtain that initial profile and perform frequent checks to verify the process and/or the oven performance. This is the combination that helps avoid defects and field failure.

Even with the best profiling products and best communication between OEM and EMS provider, the bottom line is that thermal quality management is a process, not a single step. A true thermal quality management program entails initial thermal characterization of the board, followed by board verification, and then, to complete the picture, oven verification to prove sustainability and repeatability of the oven process. The sooner that mindset becomes standard, the sooner PCB quality, performance, and longevity, as well as the company bottom line, will increase. And that's process improvement that can be taken to the bank.

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