Achieving Greater Through-Hole Soldering Reliability Without Sacrificing Throughput

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Abstract

Original equipment manufacturers (OEMs) and electronic manufacturing services (EMS) companies need to adapt automated selective soldering processes to improve the consistency and quality of their electronic products. The competitive marketplace is a major driver for automated selective soldering since it results in faster processing times, decreased direct labor costs, reduced rework, easier board handling as well as other important considerations.

Key Terms: Through-hole electronic components, manual soldering, selective soldering, solder joint reliability, key process parameters, flux application methods, system versatility, process repeatability, operational cost savings

Soldering Methods

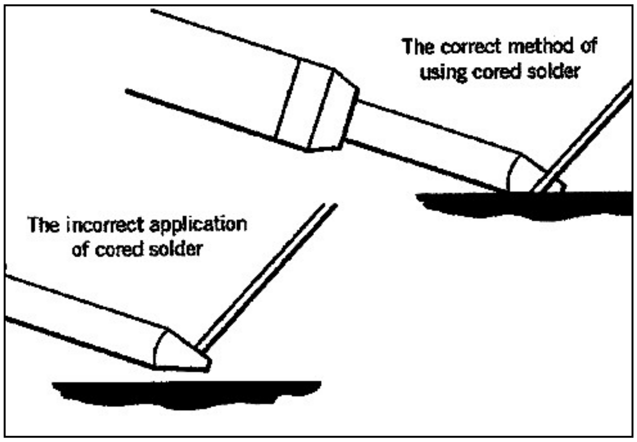
For certain low-volume through-hole soldering applications, some end-users may opt to use manual soldering rather than selective soldering. While useful for small series production, manual soldering is no longer used in mass production because of quality assurance concerns and is no longer allowed in the automotive industry and other high-reliability applications. Increasing printed circuit board design complexity and ever higher quality standards have contributed to soldering by hand no longer accepted as an adequate technique.

While useful for some one-off applications, or for repairing of individual solder joints, manual soldering has several disadvantages since reproducibility is operator dependent which means throughput and quality cannot be guaranteed on a consistent basis. Adding to this, excessive flux residues can result from manual soldering as well as higher localized thermal loads due to the small soldering iron tip and the small contact area of most soldering irons.

Manual Soldering

Manual, or hand soldering, can be performed on printed circuit board assemblies after reflow soldering providing the operators are properly trained and certified. Insufficiently trained personnel should be minimized to avoid what is referred to as the ‘Seven Deadly Sins of Hand Soldering’. These include excess solder tip pressure, improper heat bridge, incorrect solder tip size, excessive solder tip temperature, improper use of flux, transfer soldering, and unnecessary rework and repair.

Excessive solder tip pressure can cause cracks in the iron oxide coating applied to the soldering iron tip exposing the soft copper core resulting in premature, and costly, solder tip replacement. Operator dependent improper heat bridge often results in incorrect application of cored solder wire to the solder pads and through-hole or surface mount components.



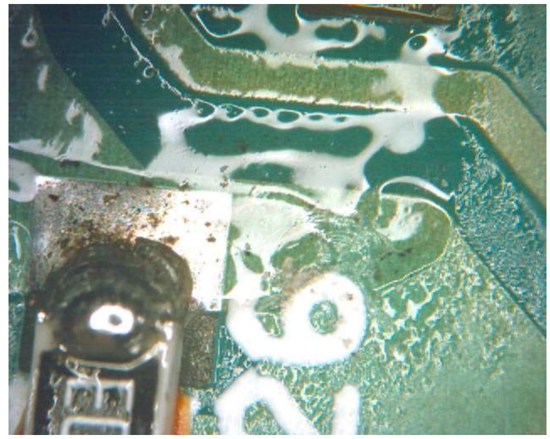


Figure 1. Operator dependent improper heat bridge (left), and excessive flux during rework and repair (right)

Hand soldering iron tips should be properly selected so the solder tip is no more than one-half the pad width. The use of excessive solder tip temperature should be avoided to minimize recovery and overshooting of the soldering station controller. Improper use of liquid flux, or flux pens, during rework and repair should be avoided to minimize the accumulation of excessive flux residues. Adding to these factors, the subjectivity of human visual solder joint inspection by a hand soldering operator often results in unnecessary, and excessive cosmetic touchup adding to costly rework and repair.

Hand Soldering Reliability

There are three main factors to consider in hand soldering reliability; solder joint behavior, potential component damage, and post soldering cleanliness. Hand soldering can involve solder iron tip temperatures as high as 400ºC with ramp rates of more than 100ºC per second, and one needs to consider these thermal effects upon the components. Multilayer chip capacitors, particularly larger ones, are at high risk for thermal damage during hand soldering. Proper guidelines should be followed to ensure acceptable processes as used for specific components.

The differences in solder joint reliability for hand soldering and selective soldering are difficult to predict and in most cases can be minimized if the applicable soldering standards are applied. With respect to solder joint quality, it should be remembered that the defect rate for hand soldering will almost always be higher than for automated soldering processes such as selective soldering.

The cleanliness risk to a printed circuit board will also be greater with hand soldering compared to automated soldering but can be minimized if well-developed manual soldering processes are practiced. In addition to the cleanliness risk, electronic assemblies can be exposed to ESD risks or potential mechanical damage during the additional handling involved with hand soldering.

Process Considerations

Several factors need to be considered when implementing a selective soldering process including the type of operation, production volumes, automation requirements, tact time and ancillary process equipment. The type of operation determines if the required production can be achieved in a normal eight-hour shift, five-day work week or if it pays to invest in equipment with a higher production rate.

For moderate production volumes, standalone selective soldering systems are often used since they tend to have a smaller factory floor footprint and require low capital expenditure. The disadvantage of standalone systems is the continuous operator intervention required to load and unload boards during the operational cycle.

Tact time, or cycle rate, commonly refers to the amount of time it takes to load boards, execute a selective soldering operation, including fluxing, board preheat and soldering, as well as unloading the boards from the selective soldering machine. Tact time is also a measure of production capability and can be used to determine bottlenecks within an operation as well as to determine the number of machines required to fulfill a predetermined production rate. The ancillary equipment depends upon the process demands for a product and is based on what the cycle rate is and how the process is setup. Examples of ancillary equipment include material handing consisting of in-line conveyors, board inverters, board stackers or product accumulators. These are typical of in-line systems and are necessary to maintain the continuous process flow and to minimize operator intervention.

Versatility vs. Throughput

End-users often must choose whether they want to prioritize versatility or the throughput of their selective soldering operation. With the introduction of the Hentec/RPS Vector 300 compact selective soldering platform, this system maintains the versatility that is necessary for small batch production or cell manufacturing, without diminishing throughput. The Vector 300 is also exceptionally compact for an in-line system, requiring less than 1.8 square meters, or 21.6 square feet of factory floor space.

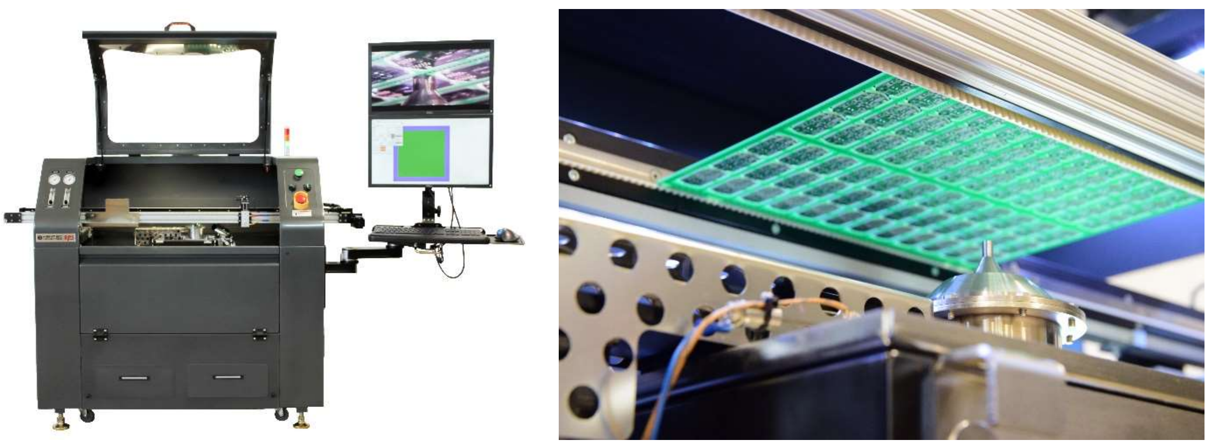


Figure 2. Vector 300 compact selective soldering system (left), and soldering of 72-up PCB panel (right)

The features of the Hentec/RPS Vector 300 allow users to have the ‘best of both worlds’ and not have to worry about this difficult decision when purchasing a selective soldering system. The Hentec/RPS Vector 300 compact system includes fluxing, preheating, and soldering functionality. By integrating all three processes into one compact platform, the Vector 300 can process printed circuit boards at the same speed as larger or more expensive machines. However, the modularity of the design allows users to quickly adapt the machine when application requirements change. Larger and more expensive machines that prioritize throughput, often do not provide this level of adaptability. The Vector 300 offers the throughput of larger machines and the versatility and adaptability of smaller machines. This combination provides great value for users looking for a standalone or in-line system with excellent process capabilities and throughput speed.

Fluxing Control

As with all Hentec/RPS systems, the Vector 300 is available with either a drop-jet flux dispenser that ensures fluxing of liquid flux precisely to the individual droplet processing for both individual points and entire lines for connectors in a single pass, or a spray fluxer for mass flux application, or a dual spray and drop-jet fluxing with separate plumbing for each fluxing system.

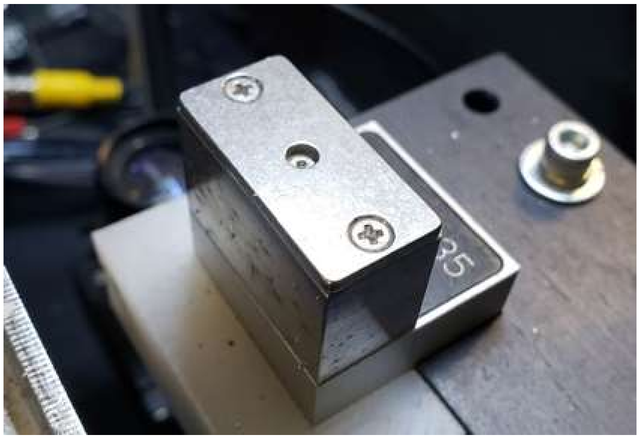
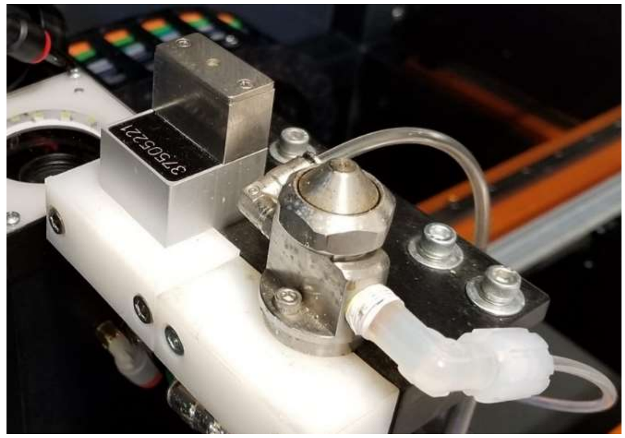



Figure 3. Drop-jet flux dispenser (left), and dual spray and drop-jet fluxing system (right)

An additional advantage of drop-jet dispensing is that it provides complete control of an adjustable droplet size together with low consumption of the liquid flux being applied. Because no-clean flux residues are completely consumed when using selective soldering, a drop-jet flux applicator is a distinct advantage of selective soldering over wave soldering using aperture wave pallets since no-clean flux residues cannot become entrapped underneath wave soldering pallets. Another distinct advantage of using a drop-jet flux applicator for selective soldering is that it allows for true no-clean processing and mitigates the need for post-soldering cleaning as well as reduced rework and repair.

Process Repeatability

Technologies including the drop-jet flux dispenser, combined with dual spray and drop-jet fluxing, automatic solder level sensing, fiducial alignment and live PCB image teach, automatic wave height sensing and other closed-loop process controls, provides the Vector 300 with unparalleled process capability.

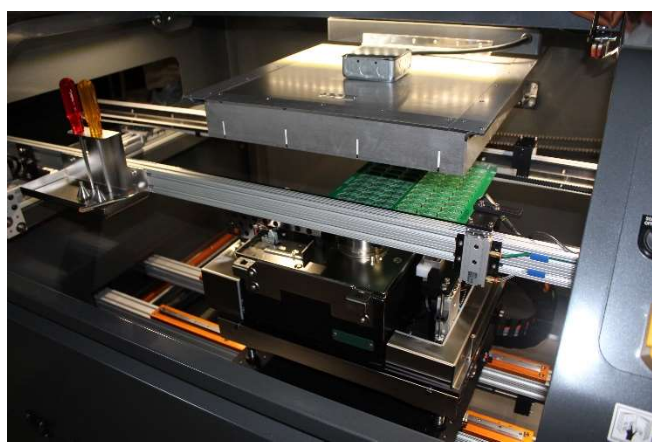



Figure 4. Electropolished solder pot and drop-jet flux module (left), and topside infrared preheater (right)

Adding to its ease of use, the Vector 300 is equipped with an electropolished solder pot that is compatible with all solder alloys, plus quick change magnetically coupled solder nozzles that allows for easy tool-free changeovers. The Vector 300 is available with a full surface topside infrared preheat or an available in-line preheat module that provides scalable preheating from 2.0 kW to 4.0 kW to match a broad range of preheat requirements. Despite its compact footprint, the Vector 300 can handle printed circuit board assemblies up to 300 x 300 mm (12.0 x 12.0 inches) with an available in-line SMEMA edge conveyor which is equipped with an automatic conveyor width adjustment.

System Flexibility

There are applications where component density requires the use of a solder nozzle with limited keep away when soldering fine-pitch through-hole components with limited adjacent nozzle clearance. To fit these tighter clearance applications, Hentec/RPS offers a proprietary Gaussian solder nozzle that produces a taller, more stable, and precise solder height with a minimum keep away of 0.5mm that is ideally suited for soldering micro-connectors and other fine-pitch through-hole components.

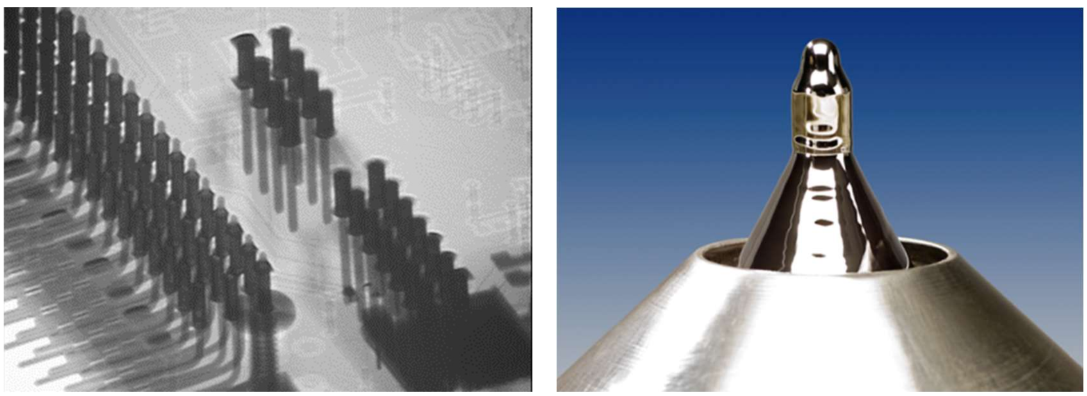


Figure 5. X-ray image of 1.0mm pitch micro-connector100% PTH fill (left), and Gaussian solder nozzle (right)

Summary

Selective soldering is a well-know and highly effective process performed on many electronic assemblies to form solder interconnections in a highly efficient manner The capability of compact selective soldering systems such as the Hentec/RPS Vector 300 provides a cost-effective alternative to manual soldering and can process printed circuit board assemblies at similar speeds as larger or more expensive machines.

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