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April 2026



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Process **verification** in aerospace electronics manufacturing

By Chris Williams, head of European sales, **SolderStar**



In aerospace electronics manufacturing, soldering processes must deliver repeatable and controlled performance across high-value, mission-critical PCBs during manufacture. As electronic systems become more compact and thermally diverse, maintaining stable reflow conditions has become more complex. Temperature profiling remains fundamental, but on its own it no longer provides sufficient assurance of sustained process control.

Modern aerospace PCBs frequently combine small passive components with high-mass connectors, shields and large packages positioned in close proximity. These variations in thermal mass make it difficult to achieve uniform heating across the entire PCB. A profile that appears acceptable at one location may not accurately represent conditions elsewhere on the board.

Efficient profiling

Aerospace manufacturers often operate in high-mix production environments, where multiple product variants must be introduced efficiently without compromising control. Profiling therefore needs to be accurate, repeatable and time-efficient. Increasingly, engineers are defining solder paste specifications and acceptable process windows in advance, allowing temperature profiles to be aligned more quickly with material requirements. By reducing manual adjustment during setup, changeovers can be completed with greater consistency while maintaining engineering oversight.

Profiling is also being treated less as a one-off validation exercise and more as part of ongoing verification. Once a baseline profile has been established and approved, routine checks can confirm that key parameters remain within specification. This approach

helps maintain confidence in the stability of the process window while avoiding unnecessary downtime.

Beyond temperature

Temperature is no longer the only factor influencing solder joint quality. Modern reflow systems used in aerospace PCB production may incorporate nitrogen atmospheres, vacuum capability and high-speed conveyor systems, each introducing additional variables that must be controlled and verified.

In nitrogen reflow processes, oxygen concentration plays a critical role. Excess oxygen can contribute to oxidation and inconsistent wetting, while extremely low levels may increase nitrogen consumption and alter process behaviour. Single-point measurements provide limited insight into atmospheric consistency. Profiling oxygen

levels across the length of the oven provides a clearer picture of stability, allowing leaks or imbalances to be identified before they affect product quality.

Vacuum reflow presents further challenges. The purpose of vacuum is to remove trapped gases during solder melting to reduce voiding. However, the timing and rate of vacuum pull-down, hold and release must be carefully controlled. Incorrect settings can limit void reduction or cause component movement. Measuring the vacuum cycle under actual production conditions allows these parameters to be optimised while maintaining throughput.

Mechanical stability is equally important. Vibration introduced by conveyors or vacuum mechanisms can cause subtle component movement during reflow, particularly on densely populated PCBs. Measuring vibration in three axes provides visibility of internal mechanical behaviour, enabling early detection of misalignment or wear before defects occur.

Conveyor speed is often assumed to be constant, yet small deviations can alter thermal exposure when combined with other variables. Monitoring actual conveyor performance ensures that validated

recipes are executed as intended and that deviations are detected promptly.

Predictive control

The shift from reactive correction to predictive control is particularly relevant in aerospace production. By establishing a reference condition across temperature, oxygen, vacuum and mechanical parameters, manufacturers can monitor gradual change over time. Increasing vibration may indicate developing conveyor wear, while variations in contact time can signal mechanical drift. Identifying these trends early allows maintenance to be scheduled based on equipment condition rather than fixed intervals, reducing unplanned disruption.

Comprehensive verification also supports more efficient troubleshooting. When deviations occur, access to detailed multi-parameter data enables engineers to isolate root causes more quickly and implement targeted corrective action. This reduces investigation time on high-value PCBs and limits unnecessary rework.

Environmental considerations are also becoming part of process control. Monitoring nitrogen usage and detecting leaks not only

stabilise the soldering environment but also prevent unnecessary gas consumption. Undetected losses over extended periods can represent significant inefficiency. Full atmospheric profiling provides the visibility required to manage these variables effectively.

Sustained control

As aerospace electronics continue to increase in complexity, reliance on temperature-only profiling is becoming less sustainable. Multi-parameter verification, incorporating thermal, atmospheric and mechanical monitoring, provides a broader and more reliable understanding of process performance.

In high-reliability aerospace electronics manufacturing, maintaining control is not limited to achieving an acceptable initial profile. It requires sustained verification that approved parameters remain stable over time. A structured approach to process verification helps ensure that soldering operations remain consistent, predictable and aligned with the demanding standards of aerospace production.



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