Considerations for Choosing Wave versus Selective Solder

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Two mass soldering methods are used to attach electrical components to a printed circuit board (PCB). Both wave and selective soldering apply flux, preheat the board and transfer molten solder to form the solder joints. Cycle time and access differentiate the two methods. Wave soldering is faster because the board goes over a molten wave of solder, which solders dozens or hundreds of leads at a time. However, wave soldering is not well suited for boards that are densely populated with SMT components on the secondary side. This is where selective soldering usually has the advantage because it can be programmed to selectively solder through-hole components while avoiding the SMT components.

WAVE SOLDERING
All soldering processes require flux, heat, and solder application. A wave soldering machine combines these steps into a single machine process. During wave soldering the underside of a board is fluxed, preheated, immersed in molten solder and subsequently cooled during an in-line continuous process.

Flux
Flux can be applied as a foam or spray. A foam fluxer uses air passing through a porous cylinder containing flux to create foam that is applied to the board above the cylinder as it rolls past. A spray fluxer applies a flux mist to the bottom of the board using a spray nozzle attached to a moveable platform.

With either method, managing the amount of flux that is applied is key to soldering success.

Preheating
Once flux is applied, the board enters the pre-heating zone to slowly bring the board up to soldering temperature and to avoid potential thermal damage to the board and components. This process also activates the flux and boils off flux carrier solvents. Either convection and/or infrared heaters are used for the pre-heating cycle. Temperature rise is carefully managed by monitoring the temperature of the preheaters.

Soldering
When pre-heating is complete, the board moves into the soldering section of the machine. The board passes over a solder pot that contains a dynamic wave of molten solder. As the board makes contact with this wave, the components are soldered to the board.

Boards move quickly through this process with a high level of reliability. But, there are some design complications that require adding fixtures, at often significant additional cost, for processing the board when:

- The PCB size is too small to be handled with a conveyor
- The PCB has an irregular shape, especially along the edges
- SMT components are soldered to the bottom side of the board

Fixtures can cover and protect bottom side SMT components, allowing solder into adjacent spaces that need to be soldered.

SELECTIVE SOLDERING
A drawback of wave soldering is exposing bottom side SMT components to the solder wave. This can cause solder joint problems and/or damage the components. Manual soldering is time consuming and requires the highest level of training for operators to reach the consistency needed for high-reliability, low volume products such as avionics or military-grade battlefield electronics. Manual soldering also makes it more difficult to control the resulting soldering quality.

For low to medium volume assembly, selective soldering machines resolve the problem of both time and consistency in hand-soldering. Selective soldering machines automate the process through programming to gain assembly speed and predictability. Programming is the key to achieving good solder results.

The board CAD file is used to program the selective soldering machine. Importing the CAD file into the
machine provides the references for X, Y and Z axes. The programmer determines and sets the start/stop locations for fluxing and soldering. A visual imaging system verifies the location of the board in the machine during the actual soldering process. Once the machine is programmed, it controls the movement speed and direction of the spray fluxer, solder pot and all parameters of the soldering process.

In selective soldering, the flux is applied by a spray fluxer to the board according to the program. Properly programmed, flux application is very precise with minimal overspray. Solder is applied using specialized nozzles in a range of sizes from 3mm to 25mm. The nozzle is covered in a nitrogen blanket during soldering. This promotes better soldering and creates less dross (solder waste).

Selective soldering requires experience on how to properly deal with the thermal mass of the board and the components being soldered. Component height, distance between components, avoiding solder bridging, all need to be considered in the programming.

Nozzle size is an important consideration. The ideal is to use the largest nozzle possible for good component soldering while avoiding solder contact with adjacent SMT components and avoiding the need to swap nozzles.

RoHS (lead-free solder) requirements add additional factors to the selective soldering process.

Fortunately, many selective solder machines are able to swap pots to allow for both lead and lead-free soldering, the pot contains its own pump and nozzle setup. This setup avoids cross-contamination during soldering.

The decision to use wave or selective solder are based on several factors including:

- High or low to medium-volume production
- Component variety and placement
- Production speed needs
- Complexity of solder placement

Wave soldering is the fastest process if the board is not densely populated with bottom side SMT components. Selective solder allows for more variations in dealing with bottom side SMT components. The cycle time is slower but it avoids compromising SMT components on the bottom side of the board.

While automated soldering processes should be used for consistency and production speed, hand soldering can be appropriate for the lowest-volume production when highly trained operators are available.

When it comes time to make a soldering process decision for your project, call us and let’s discuss your project requirements and which soldering process best fits your requirements.

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Rob joined Axiom in 2013. Previously, Rob was the Senior Manager of Processing Engineering for 15 years at Radisys Corporation. Rob serves on two IPC task groups: IPC-7095, design and assembly process implementation for BGAs; and the IPC-7093, design and assembly process implementation for bottom termination components. Rob has also been the director of the technical committee for the SMTA International conference for 12 years. He received the SMTA Founders Award and the SMTA Member of Technical Distinction Award, along with IPC awards. Rob graduated from Weber State University, Ogden, UT, with a BS in manufacturing engineering.