Lead-Free Hand Soldering – Ending the Nightmares

As facilities continue their transition to lead-free assembly, hand soldering remains a necessary process. Unfortunately it has been known to cause more problems than lead-free SMT or wave soldering combined, and these complications are typically more than simple material issues.

Successful lead-free soldering requires a firm grasp of basic concepts, as well as proper training and experience. Suddenly making the switch to lead-free solder can lead to line stoppages, operator complaints, decreased reliability and poor joint quality.

The following FAQs illustrate some of the key issues encountered during the lead-free soldering process.

Which alloys and fluxes are compatible with lead-free hand soldering?
One drawback of lead-free solder is its lack of availability in wire form, as certain alloys such as tin--bismuth are not easily drawn into wire. The most widely used alloys are tin-silver-copper (SAC) and tin-copper (SnCu). Wire solders in these alloys designed for hand assembly are widely available.

From a performance perspective, the primary difference between SAC and SnCu solders is their melting temperatures, which are 217°C and 227°C respectively. As SAC wets more readily, it offers better flow than SnCu based solders. Both are offered in water-washable, no-clean and rosin-based flux options. No-clean wires are by far the most commonly used, accounting for more than 85% of overall wire usage in the US, with water-washable solders accounting for less than 15% and rosin-based less than 5%.

What are the main variables in selecting lead-free solder wire?
The primary factor in determining wetting performance is flux content of the wire. For instance lead-free solders including SAC, SnCu or high-temperature SnSb wet less rapidly than 63/37 in a comparable environment.

While leaded solder wire may contain as little as 1% flux, lead-free solders should contain at least 2%. If wetting is slow a 3% flux wire can be used, but this may leave more residue and limit cosmetic appeal for no-clean tasks. It is essential that the flux used is designed for lead-free applications to ensure it can withstand high temperatures.

The IPC classification must also be considered in solder wire selection. The most reliable options meet ROL0 classifications and are rosin-based, halide-free and low-activity. Lead-free alternatives have a greater tendency towards high activity to offset reduced wetting, which may be detrimental in some cases.

More compatible with lead-free soldering applications, water-washable fluxes are higher activity and often classed as ORH1. However, ionic contamination testing should be performed to ensure residues can be entirely removed. A clean process change may be necessary if ionic contaminants linger, such as increased cycle time or water temperature.

Wetting balance tests have demonstrated that, when used with the same flux, SAC offers greater performance characteristics than SnCu solders – including those with additives such as nickel or cobalt – in time to reach maximum wetting.

How does lead-free hand assembly impact cosmetics?
At the same activation levels, lead-free solder typically flows slightly slower than 63/37, with marginally bigger contact angles, less defined feathering and less reflective solder joints. Shrinkage effects may also be a factor in certain cases.

What is the optimal tip temperature for lead-free SAC and SnCu?
Essential to lead-free soldering operation, optimal tip temperature or contact temperature is approximately 700-800°F as the high temperature offsets the slower wetting associated with these alloys. However, temperatures as low as 650°F have been used successfully with 63/37. Temperatures exceeding 800°F risk damage to the board or components, while low temperatures may lead to flagging or cold solder joints.

What are the best tips for use with lead-free solders?
Selection of the proper tip design is essential to any lead-free soldering task to help prevent soldering defects. The proper tip should offer an appropriate level of heat delivering capacity.

Using a tip designed for lead-free soldering is essential. Some tips are only tinned with lead-free solder, with the same iron plating as traditional soldering tips. Solder containing high levels of tin will dissolve the iron, reducing tip life. Dissolution rates should be carefully considered when selecting a compatible tip for any lead-free application.

How can I improve my lead-free soldering process?
Studies demonstrate that hand soldering is more problematic than both wave soldering and SMT work. This could be due to operator error as well as the higher surface tension and slower wetting properties common to lead-free solder.

Optimization of the lead-free soldering process is essential to reduce user error and improve wetting. Use of a solder with 2-3% flux content by weight and a solder tip temperature of 700-800°F is ideal. Again, SAC solders flow more easily than SnCu alternatives.

Problematic cold solder joints, flagging and poor wetting can be addressed through a few simple steps:

- Invest in tips designed for lead-free soldering
- Maintain a tip temperature of 700-800°F
- Ensure that wire flux content is at least 2% by weight
- Use lead-free tips with the lowest dissolution rates
- Invest in the correct tip for the application
- Select a flux that ensures easy soldering ability
- Prevent prolonged contact times
- Avoid nonessential joint rework

- Eliminate use of liquid flux

How can potential defects be avoided?

Some common issues surrounding use of lead-free solder include:

- ***Grainy joints*** can be the result of a tip temperature that's too high, causing dissolution of the metals being joined.
- ***Cold solder joints*** can be caused by low tip temperature, a weak flux or a solder wire with a low flux content.
- ***De-wetting*** is created with prolonged tip contact or excessive temperatures causing the dissolution of plated metals and a less solder-ready surface.
- ***Flagging*** may be the result of too high tip temperatures, or solder wire with a low flux content.
- ***Flux charring*** and cleaning difficulties could be due to soldering temperatures too high for the selected flux. Prolonged contact could aggravate the issue.

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