Lead-free and RoHS Implementation - Questions from the Frontline, Part 3

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A new year has begun and the activity with lead-free has increased dramatically as engineers struggle with implementing the RoHS Directive, lead-free soldering and WEEE.

RoHS and WEEE are not going away, in fact, RoHS has gained momentum and the WEEE is causing headaches in reference to its interpretation and what it means to assemblers supplying products to Europe.
This article like the previous publications is a compilation of some of the questions customers are asking. As 2006 progresses Kester will bring more of these questions to you and a summary answer. They are summaries since each question could be answered in expanded form and if additional information is required please do not hesitate to contact Kester for further help.

Of course stay tuned for more answers coming from customers on the frontline of the transition. 2006 will be an exciting year as some begin shipping lead-free RoHS products while others are just starting to investigate this.

Here are some often asked questions for January and February 2006. You will find several questions in reference to lead-free SMT, wave soldering and handsoldering. I also include two questions, which I get weekly about RoHS exemptions and labeling.

I think I qualify for an exemption, is it acceptable for me not to worry about lead-free?

If an assembler qualifies for an exemption and is not intending to go with lead-free soldering this may reduce the urgency to comply with the Directive from a legal perspective. However, it is always wise to see what a competitor is doing to avoid the added marketing pressures later. Components are changing to new finishes and this is impacting everyone, it is important to be aware of these changes and avoid incompatibilities in process. Procurement should be working with suppliers anyway to avoid surprises. If you are doing military assembly for example pure tin finishes are not allowed due to the whisker issue.

Where do I find the RoHS compliancy label?

The RoHS Directive does not require that compliant products be labeled with any label. Although some are using RoHS ready labels, the law does not require it and they are being used for now for marketing purposes.

After July 1, 2006 all products not covered by exemptions will be assumed to meet the requirements of the RoHS Directive if sold in Europe.

Should I use SAC or Tin-Copper based solder in my wave solder machine?

Both can be used in wave soldering and today on a global basis approximately 50% are using SAC (Tin-Silver-Copper) and about 20% are using Tin-Copper based solders in wave assembly. Because Tin-Copper solders do not contain silver the cost is less for filling large solder pots but also pot balancing and top-off costs will also be less than Tin-Silver-Copper. Most assemblers using Tin-Copper based solders at this time are consumer electronics manufacturers; SAC solders are used primarily by higher reliability electronics.

Many Tin-Copper solders available to assemblers today will contain other additives to give them particular properties. Some contain nickel, bismuth, gallium, or phosphorus.

Can I use Tin-Copper and SAC in dip tinning operations or selective soldering systems?

Both alloys can be used in dip tinning and selective soldering systems. Tin-Copper solder will require slightly hotter temperatures than SAC to maintain adequate wetting ability. Tin-Copper solders will have slower wetting speeds than SAC solders and they may also require longer contact times when soldering.

In many cases an additive is added to reduce oxidation of lead-free solders. In general these alloys have a higher degree of dross creation, due in part to their higher melting temperatures.

Will the same fluxes be used with Tin-Copper and SAC soldering?

It is important to select fluxes that are designed for lead-free soldering. If the flux chemistry is properly designed, it will function with both types of solders adequately.

Lead-free designed fluxes are those fluxes that have higher thermal stability and compensate for the reduced wetting ability of these alloys when compared to 63/37.

Can I intermix Tin-Silver-Copper and Tin-Copper alloys in my solder pots?

This question is often asked by customers that start up with either alloy but wish to keep the cost at its lowest later if they switch to the other alloy. Intermixing of these alloys is not acceptable and doing so creates a new lead-free alloy with all its unknowns. If an assembler fills their solder pot with either solder and then decides to switch over, the only alternative will be to empty the pot completely, cleaning it and refilling it with the other lead-free solder.

If the solder pot gets contaminated with lead, how can I remove the lead and bring it back into specification?

Although refiners can remove lead chemically or by electrolytic means there is no way for an assembler to remove lead from a pot. Once a pot gets contaminated with lead and the limit is low at 0.1% for RoHS compliance, the only alternative is to dilute it down or empty the pot and refilling it with virgin solder. Dilution rarely works because if for example a 1000 lbs solder pot has lead of 0.15%, over a 1/2 must be emptied before refilling with virgin solder. Even virgin grade solder will contain some lead in the range of 0.02 to 0.05%.

Controlling what goes into the solder pot is critical and leaded terminations are not allowed.

Avoiding operator error especially where both 63/37 and lead-free is used is important. Training is the key and will prevent increased operating costs.

What steps should be taken with solder pots to avoid unintentional contamination of lead?

These are some useful process changes that may help reduce costs in general. The cost of these changes is small compared to the cost of lead-free solders or the liability that can be incurred in RoHS non-compliance.

- Identify the equipment with Lead-free and Leaded symbols and signs
- Use LF bar solder that is triangular in shape instead of rectangular, usually 63/37
- Dross bins for lead-free can be white; those for leaded can be red since high tin dross has higher value
- Train both procurement and process personnel about leaded and lead-free identification systems used by suppliers, example IPC-1066 or JES-D97
- Use solder pot covers with triangular openings to avoid unintentional addition of leaded bars to a pot, where feasible
- Analyze solder pots regularly for main constituents but also lead and iron.

Iron concentration increasing in a solder pot may indicate the pot is not lead-free compatible or the protective pot finish is worn. Usually iron is below 0.005% in fresh solder.

How can I reduce leaching of the parts being soldered when using lead-free alloys?

Some assemblers have reported issues with aggravated leaching of component terminations with lead-free solders. This is due to the fact that high tin alloys do like to dissolve metals better than lead bearing solders. This applies to both tin-copper and tin-silver-copper solders and a way to reduce leaching is to reduce the contact time and soldering temperature used in the process. Excessive leaching of metallization will increase the risk of de-wetting and promote thicker intermetallics sometimes leading to brittle-fracture.

If discoloration of SMD component terminations occurs during lead-free reflow, is this a problem?

Some customers are noticing at times a discoloration of exposed terminations after soldering with lead-free solder pastes. Often the component termination is tinned and therefore grey in color but after reflow the termination may be darker or lighter and sometimes yellow in color.

This is not necessarily a problem often the tin coat on the termination because of the melting point of tin is 221?C will melt and dissolve the base metal slightly causing a coloration of the surface; in other cases solid diffusion of the base metal occurs.

In some cases however the metallization may leach off to a point of causing de-wetting.
Here a possible way to reduce this would be to reduce the time above liquidus and or reducing the peak temperature.

SMT joints with lead-free look cosmetically good but fail during thermal cycling and vibration testing, what is happening?

If joints look good and the wetting, contact angles and spread are good and per IPC standards this usually indicates reliable joints. However, lead-free soldering is different in respect to leaded soldering in several ways. They can be summarized as below.

- Alloy properties are different and process temperatures are higher

- New flux systems are used
- Wetting is slower and at times not as complete as 63/37
- Voiding potential is higher than 63/37
- Intermetallic bond layers tend to be thicker
- Spread on metallization more variable
- Different LF component terminations are used
- A different finish on the board may be also the case
- Cross contamination risks are higher

If when compared to 63/37 tests, lead-free boards indicate a higher failure rate understanding these differences can help in finding a solution. Understanding the component finish is important since these are changing and in some cases they are not as solderable as they were previously but also leaching and de-wetting may be occurring.

Voiding within the joint may be higher and this should be verified with X-Ray. This can be caused by joint geometries which at times prevent flux and gases from escaping to the surface but also can be due to the slightly higher surface tension of lead-free solders which tend to free gases and flux more slowly.

Intermetallic bond layer, usually the harder more brittle region of the joint may be a cause and this should be measured to confirm if it is within normal limits. This will depend on the board finish and component metallization; copper tending to dissolve more readily than nickel for example.
Since soldering time and temperature are critical elements with all bonding of metals, it is important to thermally profile an assembly carefully before producing the boards to be tested. The thermal requirements for each part must be matched carefully to avoid thick intermetallics, de-wetting, non-wetting and voids.

If BGA's are assembled this is even more critical since the solder joints are difficult to inspect. Here both X-Ray and endoscopic inspection are necessary.

This is therefore a complex question and can only be answered after understanding every component of the process.

My soldering iron tips are charring, turning black and de-wetting when I use lead-free solder wire, what can I do?

Not all fluxes are created equal and some are thermally incapable of sustaining the higher soldering temperatures used with lead-free solder. A recent video clip from OK International demonstrates this well when two solder wires are compared side by side and this is called the "black tip syndrome".

Once "black tip syndrome" occurs the reduction in heat transfer makes lead-free handsoldering difficult, tip life is reduced, tip costs and operator frustration goes up and reliability goes down. Proper flux selection, using lead-free tips and lead-free handsolder process training for operators will offset these costs. The important points to avoid these phenomena are listed below.

- Use lead-free solder wires with lead-free designed fluxes
- Avoid using too high temperatures
- If tip-tinner is used, wipe excess tinning material on a clean sponge
- Do not use pressure to compensate for lack of wetting
- Use the right tip geometry
- Use the correct wire diameters
- Segregate work areas for lead-free and leaded

- Identify lead-free irons and work stations
- Lead-free training for existing and future new employees

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He has been involved in numerous consortia within this time and has assisted many companies implement lead-free successfully. He is an active member of IPC, SMTA, and ASM. He is the author of many technical papers delivered globally. He is also a Certified SMT Process Engineer.

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