The Most Frequently Asked Questions on Lead-free

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Q1. What is the definition of "lead-free"? Is there an allowable threshold limit?

A1. This is not included in the WEEE or ROHS Directives. However, it is mentioned in the sister EOLV (End-of-life Vehicles) Directive which defines 0.1wt% as the threshold for lead per homogeneous material if not intentionally introduced (i.e. each material prior to soldering), and it is likely that the same threshold will be used for the ROHS Directive. This should be decided by mid 2003.

Q2. When does the ban on the use of lead-free soldering come into force?

A2. The ban on the use of lead (and other heavy metals and some flame retardants) will be effective from 1 July 2006. Although various dates were proposed during the drafting stages of the Directive, the European Parliament gave its consent in December 2002 to what had been agreed in final conciliation negotiations with the Council of Ministers. The Directives come into force on the day of publication (expected March 2003) and Member States must put national laws into place within eighteen months of that date (Sept 2004), with the ban coming into force on 1st July 2006. This is a tight timescale for transition to the new lead-free soldering technologies, and it requires that the necessary actions are started as soon as possible.

Q3. I understand there are certain exemptions to the industries covered by the ban. We manufacture small electrical tools and kitchen equipment " are we exempt?

A3. No your business is not exempt. There are eight categories that are specifically covered by the ROHS Directive, and they include your industry. Other categories are only "exempted" by omission (e.g. medical, defence, aerospace). The categories listed cover essentially the products used by the general public i.e. the high volume, low cost products:

- Large household appliances
- Small household appliances
- IT and telecommunication equipment
- Consumer equipment
- Lighting equipment
- Electrical and electronic tools
- Toys (including leisure and sports equipment)
- Automatic dispensers

These are only indicative categories, and the list will be reviewed and may be altered in the future as more data on the impact on the environment and human health of other hazardous materials become available. For example a review is

expected in early 2005 of both medical and monitoring equipment, both of which are included in the WEEE Directive.

Q4. My company manufactures components and sub-assemblies for the automotive industry. Are we covered by the WEEE/ROHS ban on lead?

A4. There is a separate Directive which applies to the automotive industry - the ELV (end-of-life vehicles) Directive. This Directive, which is already in force also bans the use of lead and other hazardous substances, but it does specifically exempt lead in solder for electronics. This is apparently at odds with the WEEE/ROHS Directive, but the situation may change since the Commission can "on a regular basis, according to technical and scientific progress, amend, add to or delete from the list of exemptions". Currently it is generally understood that "solders for electronic circuit boards and other electrical applications" for vehicles are exempt, but lead in solders for non-electrical applications (e.g. radiators) is banned for products put on the market after July 2003.

Q5. We import sub-assemblies and components from non-EU countries. Do they need to be lead-free? Who has the responsibility for complying with the ban, manufacturer or importer?

A5. After July 2006, both assemblies and components that are imported to the EU must be lead-free in compliance with the ban. The onus is on the "producer" which means anyone who manufactures and sells electrical and electronic equipment under his own brand, who resells under his own brand equipment produced by other suppliers OR who imports that equipment into a Member State. Importers of electrical and electronic equipment (including components) into the EU are therefore considered to be "producers" and hence responsible for ensuring compliance. This is true even if the ultimate destination of the equipment (manufactured in the EU) is outside the EU. The Directive applies to products and producers irrespective of the selling technique, including distance and electronic selling.

Q6. Who will monitor and police enforcement of the legislation?

A6. This has not yet been confirmed, but it is anticipated that at the local level this will be the responsibility of the Trading Standards Authority.

Q7. Is there a drop-in replacement for the traditional SnPb solder?

A7. No, but there are several possible alternatives commercially available. But the choice is not necessarily straightforward, and will depend on the application, thermal and solderability factors, assembly technology, component sensitivity, service life, volume, cost etc. However, there is an increasing consensus for using the SnAgCu family of alloys for many applications for both reflow and wave soldering. But there are certain implications, mainly regarding the higher soldering temperatures required (~215-227°C). At these higher temperatures there may be issues of component sensitivity, assembly equipment robustness, materials stability etc.

Q8. What are the available lead-free solder alternatives to traditional SnPb?

A8. There are several families of alloys commercially available as lead-free solders.

Reflow soldering: SnAgCu, SnAgCuBi, SnAg, SnAgBi, SnZnBi, SnIn (the bismuth and indium-containing solders are more suitable for low temperature

soldering)
Wave Soldering: SnAgCu, SnCu

Q9. We use a high melting point (90/10 Pb/Sn) solder for hierarchical soldering. What is the replacement for this lead-containing solder?

A9. No suitable alternative has yet been identified for this solder which melts at around 302°C. This lack of an alternative has been recognised by the authorities, with the result that "lead contained in high melting temperature type solders" (i.e. tin-lead solder alloys containing more than 85% lead) has been added to the list of exemptions within the WEEE/ROHS Directives. So, until further notice you can continue to use this particular lead-containing solder.

Q10. We are thinking of changing to lead-free SnAgCu soldering for all our products. Will we need to install any new equipment?

A10. Using SnAgCu as your lead-free solder will mean that you will have a narrower process window and will have to tighten your process control. In turn, depending on the equipment you already have, you may need to purchase new equipment. For example, with the higher soldering temperatures it may be necessary to consider pre-heating for the larger components. Other points to consider are:

Reflow soldering
Convection ovens are preferred to IR ovens to provide good temperature control and adequate temperature range; nitrogen inerting may be required to widen process window.

Wave soldering
Equipment may need to be modified to avoid damage at the higher soldering temperatures; solder pot corrosion may be an issue; nitrogen inerting may be required to widen process window.

Hand soldering
There should be few problems, and no new equipment is necessary; operator training may be appropriate on issues associated with the higher temperature lead-free soldering. See **Q11** **and** **Q20** for more information.

Q11. Will we still be able to hand solder (for assembly, rework or repair) using the new lead-free solders?

A11. Yes, but there will be certain practical consequences. For example the iron tip may dissolve more quickly, and this will be worse with the finer tips that are being increasingly used within the industry.

Q12. Will changing to lead-free solders affect the reliability of my product?

A12. In general there should be no problem - all the major data available suggest that reliability is not really affected by the change to lead-free soldering. Indeed, the cyclic fatigue resistance at constant temperature of SnAgCu soldered joints can be better or worse than that of SnPb soldered joints depending on levels of strain. Hence it is vital to generate reliability data specific to your product and working temperatures.

- Good long-term reliability depends on appropriate choice of materials and

compatibility considerations.

- The reliability of the lead-free solder joints is largely similar to that of their traditional lead-containing counterparts. So if the nature of your product means that solder joint reliability is not a major issue, then using a lead-free solder should not affect the reliability of your product. SnBi can be used to provide reliable joints for low temperature service.
- There may be some issues with temperature sensitive components, especially in the transitional stage. You must consider the component stability at the higher soldering temperatures e.g. with electrolytic capacitors, and with "pop-corning" in plastic encapsulated components.
- Substrate reliability may be affected as a result of the higher soldering temperatures, especially when using complex fine feature pcbs.
- In general, lead-free soldering technologies require increased process control to achieve the same process yields provided by traditional SnPb soldering. If attention is not paid to the narrow process window associated with lead-free soldering, then the resulting lower process yield takes place.

Q13. Will we need better process control with lead-free soldering?

A13. Yes, the process window is markedly narrower with lead-free soldering. A particular concern lies with the ability of the reflow ovens to provide the smaller deltaT necessary. Some manufacturers have successfully used nitrogen inerting during soldering to widen the process window. There should be no changes in process control required for printing, placement and inspection of lead-free product.

Q14. Are there any issues with lead-free wave-soldering?

A14. Yes, for example, maintaining the composition of the solder bath, and advice should be sought from your solder and equipment suppliers. For example, the copper levels must be taken into account when replenishing the solder bath, and copper dissolution of the tracks and pads can result in their being less than the minimum acceptable thickness. There may also be an issue with the compatibility of the solder pots, pump impellors and solder bath nozzles (or any components in contact with the solder) especially at the higher soldering temperatures associated with lead-free soldering. Process settings should be based on the results of trials or R&D exercises. Some manufacturers have successfully used nitrogen inerting during soldering to widen the process window. Dross rates using lead-free solders vary markedly " they can be twice that with SnPb for solders containing silver, to less than half that of SnPb.

There is also a new so-called failure mode which sometimes occurs with leaded components in wave soldering if there is any lead in the system (i.e. fillet lifting). The phenomenon is manifest as a lifting of the solder fillet away from the land after soldering, and is caused by differential contraction on cooling of the lead-containing phase. But it is not yet clear whether or not this has any deleterious effect on either the joint or the product. It can be avoided by ensuring there is no lead in the system and by optimising the cooling profile.

Q15. Do we need to change our inspection criteria and procedures for lead-free product?

A15. Probably, but only in minor ways associated with the appearance of the lead-free joints. For example, lead-free soldered joints are less shiny and more

uneven than their traditional counterparts, and the pcb land/pad coverage tends to be lower giving rise to copper halos. However, neither appearance seems to degrade joint reliability. You may have to alter the settings of your inspection techniques, manual or automatic, to take account of the reduced contrast associated with the reduced lead content.

Q16. Will my current flux cope with the new lead-free solders? Will I need to requalify my product?

A16. It is likely that you will have to change your flux. Lead-free solders do not wet as well as the traditional SnPb solders, and the higher soldering temperatures mean that new fluxes containing different activators will probably be required. In turn there may be potential issues of flux residues, corrosion, dendritic growth etc. Where possible no-clean or low-VOC fluxes should be chosen. Testing/requalification may be necessary for many applications, and this can be accomplished using SIR techniques.

Q17. Will I need to clean boards assembled using lead-free soldering systems?

A17. If your boards already require cleaning, then you will need to continue to clean boards assembled using the new lead-free solders. But the cleaning may be more challenging, since there is opportunity for more corrosive residues to be present, and they are likely to be more tenacious and baked-on. If you already have a no-clean process, you will probably not need to clean using your new lead-free process. If you currently have to comply with a customer specification, you will have to re-qualify your new process.

Q18. Will we be able to source lead-free components?

A18. Most component manufacturers and their distributors have strategic roadmaps to comply with the WEEE/ROHS legislation i.e. to be lead-free by 2006. In the transition period there is likely be a variation in lead-free component availability, with high usage and cheaper components having lead-free terminations becoming available earlier than some other niche or expensive components with lead-free terminations. In the transition period it is important to ensure that the change to lead-free components and lead-free board finish is carried out before changing the solder. It is recommended that component suppliers are regularly asked about the labelling and timing of their change to lead-free product, and about when ALL the product has been changed.

The reasoning behind this approach is that there are no common documented concerns with using lead-free board and component finishes with lead containing solder, however for the converse situation this is not the case. If lead-containing components are used with lead-free solder high levels of lead at the lead-joint interface can allow formation of a low melting point phase, potentially harmful in terms of joint reliability.

Q19. What are the lead-free finishes currently available for components and boards?

A19. The following components terminations are available: Sn, SnCu, SnBi (silver and palladium finishes are also available but may be more expensive)

The following lead-free board finishes are available: tin, tin alloys, ENIG (electroless nickel immersion gold), silver, silver alloys,Lead-Free HASL (hot air solder levelling with SAC or other LF alloy)), OSP (organic solderability preservative).

Q20. Will we encounter problems if we mix lead-free and lead-containing solders during surface mount rework or repair?

A20. The available evidence suggests that it is unlikely there will be any reliability issues from mixing during rework. But it is sensible to rework/repair with the same alloy (if known), and it may be sensible to label boards to indicate the solder alloy used.

Q21. Are there going to be any increased costs in moving to lead-free soldering?

A21. Yes, but they are not likely to be great and many will be of a one-off nature. Initial costs may include new equipment purchase (where necessary), existing equipment modification (for higher temperatures, inerting etc), implementing new inspection procedures, training and stock control. On-going costs may include those associated with tighter process control and increased power consumption from higher temperature soldering. Any increase in materials costs is likely to be minimal. However, recycling and/or disposal costs are likely to be less, and there is likely to be a marketing advantage for "green" product.

Q22. Do I need to retrain my staff?

A21. Yes. In addition to general awareness raising exercises, training will be required in a variety of functions ranging from design, assembly, inspection and use. It may be sensible to consider cascade training, i.e. training key people in each relevant function to act as trainers for other staff.

Further information on any of the above, or indeed any other aspect of lead-free soldering, can be obtained by contacting:

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