# Lead-Free Solder FAQ's

*Why is there so much concern about lead?*

Lead is a well-known toxic metal. Past uses of lead and lead chemicals in water supply plumbing, paint and gasoline resulted in a measurable increase of lead in the environment and as a consequence, increased blood levels of lead in humans. Paint chip ingestion, mainly by children, resulted in numerous cases of lead poisoning. Consequently the use of lead in these applications has been prohibited for several years. The primary concern now is from groundwater leaching of lead bearing solder in electronic products ultimately disposed in landfills.

*Won't lead-free solders also cause environmental problems?*

Some studies suggest that silver and antimony may pose more of a threat than lead from contamination in landfills since these metals are more soluble under certain groundwater conditions.

*Isn't the amount of lead in car batteries more of a concern than on PC boards assembled with tin-lead solder?*

Of the 13.5 metric tons per year of the worldwide lead consumption, storage (car) batteries account for 80% vs. only 0.6% for electronic solders. However storage batteries are almost 100% recycled, and unlike electronic equipment do not end up in a landfill.

*Is there any U.S. legislation pending on restricting or banning the use of lead containing electronic solders?*

No. Legislative bills introduced in Congress in the early 1990's commonly known as the Reid, Cardin and Bradley bills died in Congress and never became law. There is no U.S. legislation presently on the horizon pertaining to lead containing solders. Most of the focus presently on eliminating lead in electronic solders is from European community countries and Japan.

*What effort in eliminating lead containing solders is coming from Europe?*

The European Union will ban lead in electrical and electronic applications effective July 1, 2006. The basis for this is two closely related Directives: WEEE (Waste Electrical and Electronic Equipment) and RoHS (Restriction of Hazardous Substances. These Directives are quite lengthy and complex, but their intention however is simple: to promote recycling and re-use of materials on the one hand, and to prevent the use of substances considered hazardous to health or the

environment on the other. The RoHS is a European wide directive, which will be uniformly enacted and enforced throughout the EU by each member Government - it simply prohibits specified chemicals. Chemicals prohibited in addition to lead are mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE). The situation with the WEEE directive is a little more complex, but basically involves the recycling of waste electrical and electronic equipment.

The key date is July 1 2006. From that point forward, any electrical or electronic goods (subject to some limited exceptions) "placed on the market" in the EU cannot contain materials mentioned in the directives, including lead. This therefore includes products made outside the EU but sold within it.

*What are the exceptions?*

1. Lead in the glass of cathode ray tubes, electronic components and fluorescent tubes.
2. Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85% lead).
3. Lead in solders for servers, storage and storage array systems (exemption granted until 2010).
4. Lead in solders for network infrastructure equipment for switching, signaling, transmission as well as network management for telecommunications.

*Since WEEE and RoHS pertains only to European Community member countries, can lead-containing solders still be manufactured in the United States and other non-EU countries?*

Yes, but selling for use in the EU countries will be prohibited after July 1, 2006. Most manufacturers are global and most certainly will not produce one product lead-free for Europe and another lead-containing product for other global customers.

*Where can I find more detailed information on the European Union Directive, WEEE and RoHS?*

The Dionics website, http://www.pb-free.info/ has a good in-depth overview of WEEE and RoHS. The WEEE Official Journal website is:
http://www.dti.gov.uk/sustainability/pdfs/finalweee.pdf
The RoHS Official Journal website is:
http://www.dti.gov.uk/sustainability/pdfs/finalrohs.pdf

*What about Japan?*

Although no legislation is pending, major Japanese companies have set voluntary timetables for the phase out of lead. Matsushita, for example, announced in at the Soldertec Pb-free conference in Brussels in June 2003 that all consumer products have been converted to lead-free.

*Will U.S. electronics manufacturers go lead-free, and if so, when?*

U.S. electronics manufacturers who supply products for European countries will need to be lead-free by July 1, 2006. It is doubtful that U.S. companies supplying the global marketplace will maintain one tin-lead production line for the U.S. market and one lead-free for the European market. Competitive pressure to produce "green" products additionally may fuel the conversion to lead-free. Most companies will begin by a controlled phase in; first producing a lower volume product with lead-free solder and gradually converting other product lines to lead-free after gaining manufacturing experience.

*What problems will our customers experience as they convert to lead free?*

Most lead-free solders have a melting point above 215$^{o}$ C. Components and the PC board material need to be able to withstand higher soldering temperatures. Since all lead-free solders exhibit poorer wettability compared to tin-lead solders, solder defects may increase, requiring additional rework. Flux activators in solder paste and wave solder flux must be designed to function properly at higher soldering reflow temperatures. Higher reflow oven temperatures equate to higher energy usage and energy costs. Board and component metallizations need to be lead-free. Since lead-free solder joints differ from tin-lead in appearance, quality guidelines for visual inspection will require modification.

*What trade organizations are addressing issues pertaining to lead-free solder?*

Primarily NEMI and IPC in the United States and Soldertec and Smartgroup in Europe. NEMI, which develops technology "roadmaps" for the electronics industry, identified a gap in the manufacturing infrastructure necessary for conversion to lead free in the early 1990's when the first WEEE draft appeared. Since then NEMI has been instrumental in providing leadership and coordination to facilitate the conversion to lead-free. NIST has done extensive research on the material properties of lead-free solders.

*Which lead-free solders are candidates for replacing tin-lead?*

Although many lead-free solders exist, the following table lists solders considered primary candidates for replacing tin-lead. The group comprising tin-silver-copper alloys is considered the mainstream alloy system that will replace tin-lead. This family of close composition solder alloys is near eutectic, with acceptable thermal fatigue properties, strength and wettability. The tin-silver-bismuth composition was found by NEMI and NIST to have exceptional thermal fatigue performance,

better wetting and a lower melting point than the SAC group of alloys. However if any lead is present on component terminations or PC board pads, a low melting ternary tin-lead-bismuth phase can form which has a melting point of 96$^{O}$ C. Therefore NEMI has recommended that general use of this alloy should be avoided until it is assured lead on component terminations and board pads has been completely phased out, perhaps 7-10 years. The tin-silver eutectic alloy has a history of use, but has a higher melting point and exhibits poorer wetting than the SAC group of solder alloys. The tin-copper eutectic will find application in wave soldering due to it lower cost (contains no silver). However this alloy has the disadvantages of a higher melting point than the SAC alloys and may corrode iron containing solder pots.

| Indalloy No. | Composition | Solidus ($^{o}$C.) | Liquidus ($^{o}$C.) | U.S. Patent | Comments |
|---|---|---|---|---|---|
| 241[1] | 95.5Sn/3.8Ag/0.7Cu | 217 | 220 | | Popular SAC alloy for SMT assembly. |
| 246 | 95.5Sn/4.0Ag/0.5Cu | 217 | 225 | | Petzow (German) prior art reference makes this alloy patent-free. |
| 252[1] | 95.5Sn/3.9Ag/0.6Cu | 217 | 225 | | NEMI promoted alloy |
| 256[1] | 96.5Sn/3.0Ag/0.5Cu | 217 | 220 | | Reduced silver SAC alloy. |
| 232 | 93.6Sn/4.7Ag/1.7Cu | 217 | 244 | 5,527,628[3] | Original Iowa State Ames Lab SAC alloy. |
| 249 | 91.8Sn/3.4Ag/4.8Bi | 211 | 213 | 5,439,639[3] | Board & component metallizations must be completely Pb-free. |
| 121 | 96.5Sn/3.5Ag | 221 | (eutectic) | | Simple binary alloy solder has history of use; marginal wetting. |
| 244[2] | 99.3Sn/0.7Cu | 227 | (eutectic) | | Inexpensive, popular use in wave soldering. |

[1] Alloys of choice for general SMT assembly

[2] Alloy of choice for general wave solder assembly

[3] ICA Licensed Patent