Tasks for Lead-Free

Prof. A. Rahn, Ph.D
Rahn-Tec, Montreal, Canada

The third draft of a proposed ‘Waste Electrical and Electronic Equipment’ EU legislation circulated relatively freely but unofficially during the recent Productronica 1999 exhibition and conference in Munich, Germany. The response was a general ‘soul searching’. *Well-placed individuals* reported that this draft was likely to go to parliament without major changes. Thus, at least for Europe, lead-free solders will be arriving and questions whether this change is logical or not, may rest for the foreseeable future.

The fact that Japan expressed willingness to hasten this development (lead-free by 2001) supports the obviously general feeling of European lawgivers that lead-free must be possible in Europe as well. Hence the 01.01.2004 as a target date appears to be fixed. However, on the international scene one may expect more discussion as the word 'possible' is not synonymous with 'necessary’ or even ‘sensible’.

The electronic industry faces a situation where the question ‘WHETHER’ has been replaced by the question ‘WHAT’. The different partners in this branch of industry must now examine which tasks they will have to perform to make things happen. Who is challenged?

The User:
He has to decide which lead-free solder he wants to use with his product. There are approximately 200 – 300 alloys from which to choose (freely?). He might even have to choose several, as he will find that one will work with one product but not another. Tailoring the alloy to each product may be the only way to succeed. He will have to experiment to find the correct process parameters for each of these processes and he will have to check whether his products can tolerate such parameters. He thus has to study:

- The components (perhaps he will have to replace inappropriate ones with those better suited),
- The PCB (e.g. T_g, planarity etc.) inclusive those finishes
- Any potentially acceptable defect rate (DPMO)
- The reliability of the new connections and entire products considering the new alloys and process parameters as far as they are already known to him.

He deals with the new cost structure, considers whether he now needs nitrogen (for most replacement solders necessary or recommended) and checks whether his equipment (Flow- and Reflow-systems) will have to be replaced.

As a special task, he will have to re-train his QA department and personnel in general. A solder joint made with lead-free alloy looks different than one made with eutectic tin-lead. The x-ray inspections systems will find it more difficult to look into the joint’s interior. Clarification, training and education will have to rank high – and don’t forget those involved in touch-up!

The Equipment Manufacturer:
He has to face two questions: Is his equipment compatible with:

1. The new solders and
2. With any new fluxes?

The most promising replacement solders are based on a higher content of tin and feature higher melting points. They will have to be used at higher temperatures. As tin is a very aggressive metal, the equipment manufacturer will have to consider the impact of these two major changes in his flow soldering machines.

Today’s fluxes may show deficiencies when used at higher process temperatures. Tests have shown that some of them ‘die’ already during pre-heating. Is it known how the equipment reacts to the fumes of those new fluxes?

Other changes caused in the process by new alloys may have their consequences too. For example, the peel-off behavior of the lighter solders may affect the process as well as the way flux is deposited.

The blower motors of reflow systems are thermally challenged already. If we increase the peak temperature another 30 or even 50 K the manufacturer may have to vote for liquid cooling to ensure proper and reliable running in mass production environments. Flux traps have become quite efficient by now. Will they perform as designed when the temperature is raised and new pastes/fluxes are introduced?

The Solder Manufacturer:
He has explored his major tool, the periodic table of Mendeleyev for a long time to present a lead-free solder that at least matches the properties of tin/lead. He does not lack questions and still must keep in mind that the alloy has to be produced. Lots of alloys can be made in the lab, but much of it is declared 'non manufacturable' when production is tried. Naturally, his customer will only buy if he can convince him that the end product will produce acceptable results. But how will he convince his customer without a proper database re reliability, wetting etc. Only large companies are able to check such results independently and on their own. Production data about defect rates with these new alloys are presently unavailable.

He may have more problems with pastes than with bar solders where he may only have to puzzle how to get the bars out of their casting form. Trials with several of the suggested lead-free alloys have not resulted in an acceptable powder. Experiments with Zn containing alloys yielded pastes that were rock-hard within hours. Wire cannot be pulled with several new solders and a special problem is the flux core.

The Flux Manufacturer:
His chemists recognized that the present fluxes are challenged today. Squarely sitting between the two chairs 'contamination' and 'wetting' she now must ask herself whether she can apply the same chemical recipe. She faces lead-free solders and at the same time probably higher process temperatures. Furthermore, the trend is towards finer pitch, larger components and requests for higher reliability are heard above the roar.

If she plans to replace those well-known activators of today, she hardly can choose effective but toxic chemicals. She will have to ponder the effects of possible vapors and reaction products. Will the user need a new exhaust system, will he have to modify his old one or is a change of filters all that is needed?

Finally the intelligent question: what remains on the assembly? The old problem of ion mobility raises its head again. Are the old standbys: Solvent Extraction and SIR tests sufficient or will we need to develop new ones?

The PCB Manufacturer:
For years he has faced the continuous pressure of price reduction and the customer's threat 'to buy in the Far East if…'. The same law that bans lead in solder also robs him of flame retardant. He now has to produce new boards with a higher temperature stability, better planarity, smaller TH and vias and improved solderability at extended storage. He can choose among the different surface finishes: Ni/Au, organic Ag, Pd, OSP etc. – because lead is 'out'. Whether the HASL process yields acceptable results even without Pb must still be researched.

The Component Manufacturer:
Many components use lead in their interior or in solders to tin their leads. It is usually a soldering job in their interior that contains lead. The role of lead on the leads is to counteract the development of dendrites. This doubly perplexing problem means: thermal sensitivity because of the interior soldering; soldering lead-containing leads with lead-free solders may lead to eutectic phases in the newly created solder joints. How will the component manufacturer replace 10/90 Sn/Pb in SCCs and BGA components? Which lead finishes will be acceptable when soldering with alternative solders and new (?) fluxes? Will the component manufacturers react quickly enough to avoid complications in the lead-free processes?

The Recycler:
He is used to recycle lead and has created a well-established circuit. He can also deal with many of the nobler metals. Now he has to deal with the new solders. He needs data and numbers. He needs to know how much electronic waste he may expect and what solders they will contain. He knows they won't be tin-lead, but he does not know what they will be. And he now has to decide how pure his product will finally have to be because this is his market.

The Gas / Nitrogen Manufacturer:
An increased tin content in lead-free alloys and augmented application temperatures will, because of strong oxidation, require nitrogen to inert soldering atmospheres. Small and medium sized companies will require information. The gas manufacturer must become an advisor and councilor. He also must make sure that cost does not rise unchecked. What has been done or what is planned to help – especially the small and medium sized user – to change from lead to lead-free successfully? Is it true e.g. that the use of nitrogen allows a lowering of the peak temperature during reflow?

The decision for or against the use of nitrogen will be based on economic principles again. The answer to this question will be found in cooperation with the customer on the basis of personalized investigations (even if different alloys are used for reflow and wave soldering). Consultation as to the use of nitrogen and making available the appropriate infra structure is of major concern. Many have experienced that when using nitrogen in the different soldering processes the least one may expect is that the costs can be balanced against the savings. The situation will be even more advantageous when lead-free solders enter into the equation.

The Environmentalist:
His wish to remove lead from solder will be granted. Now he has to weigh the new situation: which replacement metals will be used? Leaching tests already indicated that certain metals (e.g. Ag and Sb) caused contamination above those set for drinking water. Using landfill sites will be out of the question.

The American listing of those chemicals that are most dangerous to humans (the ATSDR listing that originally caused the entire movement to ban lead) puts lead at the beginning of its 275 'nominees'. But none of the potential replacement metals are forgotten either. As such metals may react in the process, the environmentalist is challenged to investigate all those potential products with regard to toxicity, exposure of humans to them and their effects on the environment.

A. Rahn
Rahn@vaxxine.com

February 2000