EA1: Phasing Out Lead-based Solders

"Discuss the social, political and engineering challenges imposed by phasing out lead-based solders for electronics manufacture."

The transition, by the electronic and electrical manufacturing industries, to lead free soldering is of a similar magnitude to the removal of CFCs from consumer products over ten year's ago. There are many reasons for the transition that are spread across many different social and political areas. As the change matures more implications – some advantageous and others disadvantageous – become apparent. Traditionally, solder is an alloy between tin and lead, the proportions of which are carefully chosen so that the mixture is eutectic. On heating, a eutectic mixture will all melt at the same time: as opposed to the lead melting first and leaving the tin solid. Other favorable properties of traditional lead / tin solder include its ability to 'wet' metal, its reasonably low melting point, its mechanical strength and the fact that is is not expensive. The properties of lead / tin solder are extremely well suited to is application in the electronics and electrical industries. However, an increase in awareness of the ecological problems that lead, and especially its salts, can cause, coupled with the recent increase in the quantity of electrical and electronic goods has raised a question over the way in which appliances that are coming to the end of their useful lives should be discarded. The goods cannot be buried in a landfill site because the lead would slowly dissolve into the soil. Eventually it could end up in the food chain. The goods may also contain other harmful chemicals that must be discarded thoughtfully.

The reasons that many companies are modifying their manufacturing processes in order to use lead free solder are threefold; There are the ecological reasons as outlined above. There are the social aspects, which are also highly influenced by the ecological aspects and there are the political aspects, which include commercial and governmental considerations. The move towards the use of lead free solder in Europe was initially started by the Directive on Waste Electrical and Electronic Equipment. This states that, "The proposed directive ..... introduces a substitution requirement for those substances in electrical and electronic equipment, which pose the main environmental problems during disposal and recycling ..... This requirement will support ongoing efforts to substitute these substances by less harmful substances. ..... the targeted substances include the heavy metals, lead, mercury, cadmium and hexavalent chromium". - Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Waste Electrical and Electronic Equipment. This directive has not yet come into effect and it is now largely irrelevant to the industry. There are two main reasons for this. Firstly, it would only apply to European countries: the Electrical and Electronics industries are world wide. Secondly, the move to lead free solder is now driven by the commercial advantages that companies can benefit from if they use lead free solder in their products. Although lead free solder is more expensive than traditional solder and several major changes in manufacturing processes are required, companies can gain a long term commercial advantage because customers are more willing to buy "environmentally friendly" products. This selling point has been particularly successful in Japan, where industry is naturally environmentally driven due to the country's geographical circumstances. The prevalence of "green" goods in Japan has caused America and then the rest of the world to adopt similar practices. This is mainly because these counties do not want to loose any markets that they may have in Japan and they do not want their home customers to favor Japanese products over their own. Companies can also ask higher prices for environmentally friendly goods because the customer is generally willing to pay slightly more to "keep their conscious clear". Not only will this eventually cover the cost of converting to lead free solder but it may, in the long run, increase the company's overall profits. Additionally, although lead free solder is relatively expensive at the moment, an increase in the use of lead free will open up competition between solder manufacturing companies such as Ecosol and prices will be driven down.

The move to lead free solder is taking place very rapidly and the changes that companies must

make to their polices and practices are not trivial. There are several engineering challenges to overcome and there are subtle differences in the way in which lead free solder behaves when compared to traditional solder that will require substantial retraining of staff members. Currently, the best general purpose substitute for lead / tin solder is a tin / silver / copper alloy. A tin / copper alloy is also in development for use in circumstances where cost is an important consideration. A tin / silver / bismuth alloy has been found to perform well with surface mount components. The melting points of all of these new alloys are higher than that of lead / tin solder and this has several implications; The iron tip temperatures will have to be higher which will shorten the life of the tip. An increase in the heat output of the iron will mean that soldering actions will have to be swifter, which will in turn, require operator retraining. Components must also be constructed that have a higher tolerance to heat. - Many soldering actions already often exceed the manufacture's recommended heat tolerances. In July 1999, Ecosol developed a tin / silver / copper alloy which is eutectic. It is a suitable substitute for almost all tin / lead solders. It also has the advantage that it is mechanically stronger and more durable than traditional solder. Tin / silver / copper solder is easy to process and highly reliable. - It conducts well and wets the surface of components and circuit boards properly. This means that the solder flows easily over the surface of the metal rather than forming globules on the surface. The wetting property of solder is extremely important because it allows a proper join to be formed between the components and the circuit board. If the solder does not wet the metal properly, dry joints will be formed. The conductivity of a dry joint is nowhere near good enough for reliable operation of equipment and it is also mechanically weak. Lastly, the inspection process that products go through must also be revised. A proper lead / tin solder joints looks different to a tin / silver / copper solder joint and therefore new standards must be researched and tested in order to maintain the quality of the end product and inspectors must be retrained.

So far in the development of new lead free solders there has been one aspect of the soldering process that has not been affected. The chemistry of the existing fluxes does not appear to be a problem and no modification is planned although research is still continuing. Flux helps to clean the metal, prevents oxidation and may also help the solder to wet the metal. Some of the new solders also appear to be able to tolerate less clean surfaces than traditional solder.

The lead free solder revolution is only just beginning, and a lot of research is still being conducted. As of yet, no viable alternatives for high lead, high temperature solders have been found. Zinc solders continue to be investigated due to their close melting point to tin / lead solder, although their poor resistance to oxidation and corrosion is proving problematic. There are also more political hurdles to overcome. - Many patents have been issued to various companies for various alloys and some of these are suitable for use as solders. Problems with the Castin alloy which consists of tin, silver, copper and antimony have been overcome through licensing but problems may arise in the future, especially if profits are at stake and commercial interests conflict.

Bibliography

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2. Lead free soldering – An analysis of the current status of lead-free soldering
   Lead free soldering – An analysis of the current status of lead-free soldering – One Year On
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Appendix B - Note about sources

Where information has been based on or paraphrased from a source it appears between double quotes and marked as follows; “Information from source” - Source name.