EUROPEAN POWER SUPPLY MANUFACTURERS ASSOCIATION
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The Status of Lead-Free Electronics and its Impact on Power Electronics Summary

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The European Power Supply Manufacturers Association was established in 1995, to represent the European power supply industry.

Scope

This summary document gives an overview of upcoming WEEE (Waste of Electrical & Electronic Equipment) & ROHS (Reduction of Hazardous Substances) legislation & roadmap with respect to implementation, and the main technical challenges which the power electronics industry will face due to the proposed legislation. The original full document, on which this summary is based, was instigated by the EPSMA Management Committee and produced by members of the EPSMA Technical Cluster. This document summarises some of the key points from the original 20-page report.

Introduction & Background

In 1998, six million tonnes of waste electrical and electronic equipment were generated (4% of the municipal waste stream). The growth of this waste is about three times higher than the growth of the average municipal waste. Due to its hazardous content, electrical and electronic equipment can cause major environmental problems during the waste management phase if not properly pre-treated. As more than 90% of WEEE is deposited in landfill, incinerated or recovered without any pre-treatment, a large proportion of various pollutants found in the municipal waste stream comes from this electronic waste. The WEEE and ROHS directives aim to promote recycling, as well as the elimination, of a number of hazardous substances (including lead) from electronic equipment. Lead is recognised as one of the most significant environmental health threats to humans, especially to pregnant women, infants, and children up to six years of age.

The lead used in electronics accounts for less than 2% of total world consumption, with batteries accounting for 90%. Only 40% of the amount of lead in landfill is from WEEE, but of that, only 4% is from lead in PCBs while 36% is due to the use of leaded glass in monitors and televisions. For example, the CRT in a TV can contain 2 kg of lead. Hence, the elimination of lead used within power electronics is an insignificant factor compared to total global lead usage. However, despite the weight of arguments against the decision to ban lead from passive and active components, the electronics industry has started to move towards reducing the use of hazardous substances and to implement global recycling policies, before local or global regulations come in force.

Drivers for Lead Free

Driving the interest in lead and its effects are regulations and legislation changes. The only direct legislation pending anywhere in the world are the impending WEEE and ROHS directives in the EU, and hence the EU has become the focus of attention for global electronics companies addressing this issue.

In 1998, the European Commission introduced two draft proposals called the “Waste Electrical and Electronic Equipment” (WEEE) directive and the “Reduction of Hazardous Substances” (ROHS) directive. The primary objective of these complementary proposals is to minimise the risks and impacts that the production, use, treatment, and disposal of waste electrical and electronic equipment have on the human health and the environment. Additionally, the directives intend to prevent uncontrolled disposal of electrical and electronic equipment and to foster the development of reuse and recycling methods in order to reduce the amount of waste for disposal.

After various revisions and negotiations within the Commission, the European Parliament and the Council of Ministers, agreement was reached on an implementation date. The final version of the directive adopted on Jan. 27th 2003 proposes a date of July 1st, 2006 as the ROHS implementation date. This means that no new products introduced for sale in the EU after that date can contain any of the banned substances including lead. Note that there are a number of exceptions, some of which are very important to aspects of the power electronics industry serving communications and computing infrastructure.

The key issues in both of the directives are as follows

WEEE (Waste of Electrical & Electronic Equipment)

The WEEE directive is primarily concerned with the implementation of take-back facilities for WEEE.

- Collection systems are to be set up 30 months after the entry into force of the proposed Directive, allowing final holders and distributors of equipment to return WEEE free of charge.
- When supplying a new product, distributors shall be responsible for ensuring that such waste can be returned to the distributor at least free of charge on a one to one basis as long as the equipment is of equivalent type and has fulfilled the same functions as the supplied equipment.

- Member States may, for a period not exceeding 5 years after the entry into force of the Directive, set up or facilitate alternative free take-back systems.
- Member States may allow producers to set up and operate individual and/or collective take-back systems.
- The collection target for private households should be set at a minimum rate of four kilograms on average per inhabitant per year and is to be reached within 36 months from the entry into force of the Directive.
- Recovery and recycling targets are to be reached within 46 months of the entry into force of the Directive.
- For large household appliances, the rate of recovery shall be increased to 80%, the rate for re-use and recycling to 75%. For IT, telecommunication and consumer equipment, the rate of recovery is 75% and the rate for re-use and recycling 65%. (*For the other categories the rate of recovery shall be 70% and the rate of re-use and recycling 50%).*
- Producers will pay for the collection, treatment, recovery, and environmentally sound disposal of WEEE from private households. The financing shall be provided by means of collective and/or individual systems.
- The responsibility for the financing of the costs of "historical waste" shall be provided by one or more systems to which all producers present in the market when the respective costs occur contribute proportionately.
- The setting up of the financing systems should be reached within 30 months from the entry into force of the Directive. (*An exemption from the financing requirements was granted to small independent manufacturers with fewer than 10 employees and a turnover of less than 2M EUROS for a transitional period of 5 years after the entry into force of the Directive).*

ROHS (Reduction of hazardous substances)
The purpose of the ROHS directive is to restrict or eliminate the use of certain hazardous substances in electrical and electronic equipment which cause significant environmental problems during the waste management phase and to substitute them by a certain date.

The directive stipulates that by 1 July, 2006 at the latest, Member States shall ensure that new electrical and electronic equipment put on the market does not contain the following,
- lead,
- mercury,
- cadmium,
- hexavalent chromium,
- polybrominated biphenyls (PBB) and/or
- polybrominated diphenyl ether (PBDE).

The annex to the directive contains exceptions for
- Mercury in CFLs and standard fluorescent lamps and other lamps
- Lead in CRTs and fluorescent tubes
- Lead as an alloying element in steel (max. 0.35%), aluminium (max. 0.4%), and copper (max. 4%),
- Lead in the following solders
  - Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85% lead),
  - Lead in solders for servers, storage and storage array systems (exemption granted until 2010),
  - Lead in solders for network infrastructure equipment for switching, signalling, transmission as well as network management for telecommunication,
- Lead in electronic ceramic parts (e.g. piezoelectric devices).
- Cadmium plating except for applications banned under Directive 91/338/EEC amending Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances and preparations
- Hexavalent chromium as an anti-corrosion of the carbon steel cooling system in absorption refrigerators.

These exemptions and further amendments are under evaluation. The amendments suggest that exemptions should be granted if scientific evidence demonstrates that a materials use poses no significant risk to human health or the environment.

In the USA, there are currently no specific regulations banning lead in electronic components, although there are several initiatives underway to get products and processes ready to meet European, Japanese and future US market requirements. These include work by non-governmental organisations (NGOs) such as the National

Electronics Manufacturing Initiative (NEMI), the Institute for Printed Circuits (IPC) and the High Density Packaging Users Group (HDPUG).

The level of environmental awareness in the Japanese electronics industry is probably higher than in either Europe or the USA and is demonstrated by the fact that of the 700 organisations which were certified to ISO 14001 in 1997, two-thirds were related to electronics companies. Lead-free initiatives started long before any industry regulation was introduced.

For example, in the early 1990s the Japanese started to implement control of the lead released out of landfills and waste disposal. In 1994, "The Water Pollution Prevention Law" lowered the permitted lead content of rivers from 0.1 mg/L to 0.01 mg/L. Then in 2001, "The Consumer Electronics Recycling Law" required manufacturers to recover harmful material. Japan's version of take-back legislation applies to a variety of its domestic products and passed the obligation for collection and recycling of waste appliances to the producers of those appliances. Colour televisions are included in the first wave of products that fall under the legislation.

Despite these moves there is currently no legislation requiring the elimination of lead from electronics. However, the Japan Electronics and Information Technology Industries Association (JEITA) supports lead-free investigations and consolidates independent test results. Their lead-free initiative fixed three milestones to gradually remove lead from all components and sub-assemblies.

1. From 2003, lead-free solder should be used preferentially.
2. From 2005 to 2010 solder containing Pb should only be used by exception.
3. By 2015 the use of Pb in solder should be eliminated.

Strong manufacturing initiatives and an objective to use lead-free solder in mass production, starting in 2001, combined with strong NGO support, gives significant leadership to Japanese manufacturers. Several of them have already released lead-free components and end-user products made without the introduction of lead during manufacturing (lead-free solder, low lead components…).

During 2001, most CEMs and in-house manufacturing plants migrated from SnPb to lead-free solders (e.g. SnAg or SnAgCu). The 2001 implementation of lead-free processes in manufacturing by the Japanese electronics industry is the first step before the next milestone of 2003.

Summary

The case for a positive environmental impact of the elimination of lead from electronic products is far from proven. At a minimum there is the materials processing cost needed to refine and run lead-free soldering operations at higher temperatures with narrower process windows. This energy cost has been estimated at more than twice the equivalent cost of SnPb processing. Many of the main lead-free alloying elements, including silver and bismuth, have their own associated toxicity concerns and are listed as elements of concern.

The long-term reliability of products assembled at these increased reflow temperatures and subsequently used in harsh environments such as automotive is also of concern. The concerns are mainly in the following areas:

1. Availability of lead-free components capable of surviving the higher reflow temperatures,
2. Failing solder joints due to thick intermetallic layers,
3. Damage (cracks, delaminations) in plastic IC packages occurring during field use,
4. Electromigration due to PCB cleanliness issues.

All of these concerns have to be addressed during the lead-free implementation phase.

Despite all of this, the change to lead-free technologies is imminent, if not for environmental or regulatory reasons, then for market differentiation. Many Japanese consumer product manufacturers are ahead of the proposed regulated ban on lead. One of the early lead free consumer electronics products was the Matsushita MJ30 mini-disc player that was launched in 1998. This product, differentiated only by being lead-free, immediately secured an estimated 11% of the available market.

With a few exceptions, such as the large telecomms and computing OEMs, the industrial market for power electronics has been slow to request lead-free products. However, the move to lead-free looks certain to happen and power electronics companies must start preparing for the changes that will take place.