Robert C. Pfahl Jr.

The Environmental Mandate

In the first of an exclusive NEMI series, we look at the looming deadlines and what they mean.

Although not yet in effect, the European Union's RoHS (Restriction on Use of Certain Hazardous Substances) and WEEE (Waste from Electrical and Electronic Equipment) directives are already having a dramatic impact. These two directives govern the material content and end-of-life management of electronics sold in Europe. They ban or severely curtail the use of certain materials and require manufacturers to take responsibility for disposal, recycling and/or reuse of their products at end of life. Requirements of the WEEE Directive take effect Aug. 13, 2005 (less than eight months from today), and the deadline for RoHS compliance is July 1, 2006.

LEAD-FREE WATCH
18 months
Countdown to July 1, 2006

RoHS bans six substances, listed in **Table 1.** Lead is the most pervasive of the six targeted substances, and as such has received the most attention. It plays a critical role in electronics assembly and, therefore, is the most challenging of the substances to remove. Eliminating lead from electronic solders has required extensive research over the past decade.

WEEE mandates that companies selling electrical and electronics equipment bearing their trade names in the EU arrange and pay for the collection, treatment, recycling, recovery and disposal of said equipment. **Figure 1** provides a timeline for implementation of the directives, with target dates for specific requirements. These legal requirements will impact a number of organizations within each firm (in addition to manufacturing). OEMs that are successfully preparing for, or have already accomplished, the transition to lead-free have identified project managers, empowered by high-level management, to coordinate and execute in-house actions.

The precedents of WEEE and RoHS have triggered legislative activities in all major geographic regions to address management, reporting or elimination of hazardous substances, and electronics waste collection and treatment. RoHS has spawned comparable legislative initiatives in China and elsewhere in Asia. California recently enacted legislation restricting RoHS substances in certain electronics, and several states are proposing to ban brominated compounds. Similarly, several countries have enacted or are developing WEEE-like legislation that will require manufacturers to provide, both financially and logistically, for the recycling and takeback of products in an effort to minimize waste.

Eliminating lead affects all aspects of manufacturing. The most pervasive lead-free solder alloy being adopted has a melting point 34°C higher than the commonly used tin-lead solder. It requires higher processing temperatures, which raises concerns about components. Although existing equipment can be used for the new processes, manufacturers will need to optimize their processes to adjust to new temperatures. Rework also raises concerns, as assemblies must withstand additional processing at higher temperatures.

Another issue that has emerged is tin whiskers, which is of particular concern in high-reliability products. Tin-based platings used in lead-frames and as a

Banned/Restricted Substance	Use/Where Found in Electronics
Cadmium	Batteries, paints, pigments (yellow); additives in plastics (especially poly vinyl chloride [PVC, used in cable assemblies]); phosphorescent coatings; detectors/devices/LEDs
Mercury	Switches, pigments, paints, polyurethane materials (high gloss PU windows); lamps, bulbs/lighting (displays, scanners, projectors).
Hexavalent chromium	Metal finishes for corrosion protection (chasses, fasteners); aluminum conversion coatings, alloys; pigments, paints
Polybrominated biphenyls (PBBs)	Used as flame retardants (plastics, housings, cables, connectors, fans, components, paints)
Polybrominated diphenyl ethers (PBDE)	Same as PBBs
Lead	Solder and interconnects, batteries, paints, pigments, piezoelectric devices*, discrete components, sealing glasses, CRT glass*, PVC cables (UV/heat stabilizer), metal parts, chasses, washers

**Exempt under RoHS Directive.*

TABLE 1: Substances banned by RoHS Directive.

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component finish are known to be susceptible to the formation of needle-like protrusions, or whiskers, under certain conditions. Whiskers have the potential to grow to critical lengths and even to break off, causing electrical shorts, disruption of moving parts and degrading RF/high-speed performance. Adding lead to tin plating mitigated whiskering problems, but as lead is eliminated whiskers are again a concern.

These and other technical issues have been the focus of several industry efforts over the last decade. Early efforts (1994-1997) by the National Center for Manufacturing Sciences (ncms.org) provided in-depth analysis of many alternatives to lead-free solder. Work by the National Electronics Manufacturing Initiative (nemi.org) and the National Institute of Standards and Technology (nist.gov) have helped identify, characterize and prove the reliability of the tin-silver-copper (SnAgCu, or SAC) family of alloys, which are being widely adopted. Additional studies by the IPC Solder Products Value Council have confirmed the flexibility of SAC alloys for reflow soldering (pcdandm.com/pcdmag/specialreports). Ongoing efforts at NEMI are focusing on lead-free rework, tin whiskers, lead-free wave soldering, substrate surface finishes for lead-free assembly and more.

Individual manufacturers as well as industry consortia and trade associations have invested significant efforts wrestling with the technical issues of eliminating lead. While not all problems have been solved, significant strides have been made toward "going lead-free." However, several infrastructure issues exist, for both directives, which have not received much attention, yet are quickly becoming critical.

RoHS requires manufacturers to provide material content information about their products to prove compliance, which will require collecting this information from all suppliers. As yet, there is no standardized reporting system or data structure for materials declaration, although several efforts are focusing on this issue. The Electronic Industries Alliance (eia.org), European Industry Association (eicta.org) and the Japan Green Procurement Survey Standardization Initiative (JGPSSI) are developing a joint guide (eia.org/resources/2003-09-19.10.pdf) that establishes the materials and substances that, when present in products and subparts, must be disclosed (i.e., "declared"). It is intended to help provide consistency and efficiency to the material declaration process and to promote development of standardized data exchange formats and tools that will facilitate and improve data transfer along the global supply chain. Along these same lines, IPC (ipc.org) is developing a handbook for circuit boards to help suppliers comply with materials declaration requests (see page 58).

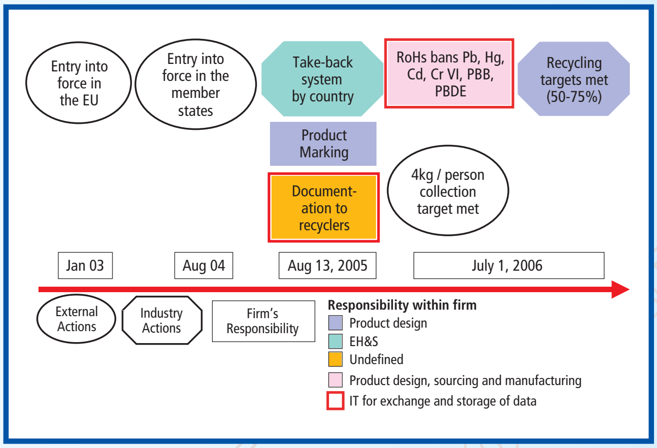

FIGURE 1: WEEE and RoHS will phase in over the next 17 months and will affect the entire organization, not just manufacturing.

Two NEMI efforts are working to address infrastructure issues. The first is identifying requirements to support WEEE and RoHS, define standard business processes around these and identify information content requirements. The second is working with international standards bodies to define and develop standards for data content, formats and exchange protocols that will allow these processes to be optimized and automated (where possible), while also helping to define the information technology required to provide support across the supply chain.

Note that under the WEEE Directive, manufacturers must comply with product marking and documentation requirements by Aug. 13, 2005. While many firms are addressing the requirements of RoHS, fewer have addressed the WEEE requirements. WEEE requires firms to have the proper recycling markings on their products (**Figure 2**) and to provide documentation to recyclers on the location of hazardous materials in all of their products.

Selective treatment requirements for materials and components in Annex II of WEEE mandate the separation of 15 categories of materials and components from waste equipment for distinct processing and handling procedures. These categories range from cathode ray tubes, liquid crystal displays and batteries to printed circuit boards greater than 10 cm^2, brominated plastics, capacitors and refractory ceramic fibers.

The emerging regulations are particularly difficult to accommodate in that they require modifications to

existing standards, as well as development of new ones. Several IPC and JEDEC (jedec.org) standards are being revised or written to reflect changes required for lead-free processing. These standards include, for example, definition of requirements for soldered assemblies; solderability tests for boards and component leads, terminations, lugs, etc.; requirements for fluxes and pastes; acceptability of assemblies, and more. The International Electrotechnical Commission (IEC) has recently begun to develop analytical test methodologies for determining material content of assemblies.

FIGURE 2:
The WEEE Directive requires that this symbol be printed "visibly, legibly and indelibly" on all electrical and electronics equipment.

Marked Up

Additionally, marking and labeling standards are needed to identify lead content on the shop floor during the transition. Modified component numbering systems are needed to differentiate lead-free and lead-bearing components. Standards are being developed by JEDEC, IPC and JEITA to address these issues, supported by several NEMI project teams. Unfortunately, because these standards must be developed and implemented quickly, regional rather than international standards are emerging. For example, JEITA and IPC have developed different standards for marking components and boards.

Today, there is widespread introduction of lead-free solders in consumer products, particularly from Japanese OEMs such as Panasonic, Toshiba, Sony and Hitachi. In the past two years, several North American OEMs, including Motorola, HP and Intel, have also announced lead-free products. Leading EMS providers (Solectron, Celestica, Sanmina-SCI, Jabil Circuits and Flextronics) have announced lead-free manufacturing capabilities. However, complex commercial products with lead-free solders are limited.

A recent NEMI survey of component suppliers indicates that, for all component types, two-thirds of suppliers can currently provide lead-free components that meet thermal specifications. It appears that many manufacturers will convert in the second or third quarter of 2005. Component suppliers must, therefore, make lead-free parts available in the first or second quarter of 2005.

The North American electronics industry is focused on meeting the requirements of the RoHS Directive. Firms have established cross-functional programs and identified program managers. Trade associations and industry consortia are coordinating activities to identify remaining gaps. Resolving and implementing the remaining technology issues by July 1, 2006, will require major effort throughout the industry, but appears possible.

The development of regional rather than international standards is problematic. The deadline for conversion has created this situation, and it underscores the need for streamlining standardization processes. It also emphasizes the need for improved cooperation between regional bodies.

The major concern at this point is that the industry has not really focused on and is, therefore, behind on meeting WEEE requirements. Manufacturers and their suppliers must quickly begin to address the end-of-life requirements mandated by this directive.

Over the next 16 months, this column will address further issues raised. Copies of the directives can be downloaded from circuitsassembly.com. ■