AN OVERVIEW TO RoHS COMPLIANCE

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SCOPE

This paper will provide a consolidated view of the major RoHS compliance points to consider. Written from APSCO's perspective, and based on thorough review of public data and internal interpretation, it is not intended to be all encompassing or to define solutions. For comprehensive support in establishing a certifiable RoHS-compliant product, please contact our sales department.

OVERVIEW

The electronics industry is facing the greatest technological change since the transition from vacuum tubes to solid-state technology. This change, however, is not about reducing the family radio from a piece of furniture to wearable fashion. This change is about environmental responsibility, which is the basis for many pending legislative acts aiming to restrict hazardous substances in electronics manufacturing.

At the forefront of this change is the European Union's (EU) Directive 2002/95/EC, which bans the use of the following items after July 1, 2006: Lead (PB), Cadmium (Cd), Mercury (Hg), Hexavalent Chromium, Polybrominated biphenyl (PBB) flame retardant and Polybrominated diphenyl ether (PDBE) flame retardant. Products being shipped into the EU must be RoHS-compliant by the July 1, 2006 deadline.

In early 2004, the Technical Adaptation Committee (TAC) adopted the following product definitions for banned substances:

Substance	Maximum Levels Allowed
Lead	1000 ppm
Mercury	1000 ppm
Hexavalent Chromium	1000 ppm
PBB	1000 ppm
PBDE	1000 ppm
Cadmium	100 ppm

The EU has outlined a narrow group of exceptions that are either exempt or eligible for an extension to the compliance date. Exemption will be based upon the country of destination and interpretation of the legislation. Helpful guidelines are available through the United Kingdom's Department of Trade and Interior (DTI) at www.dti.gov.uk.

Although each member country of the European Union was to define the laws, regulations and administrative processes for enforcement by August 13, 2004, most have yet to comply. So providing definitive compliance, enforcement, and certification requirements is fundamentally impossible. However, at this time there is no indication that the directive will be delayed in any way. So interpretation from EU members and industry experts will be the best guideline in preparing for the 2006 deadline.

For further clarification on the scope of the RoHS directive, the EU has established a Technical Adaptation Committee (TAC) with members from each EU state.

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APSCO'S PERSPECTIVE

As early discussions of this legislation developed, APSCO, like many, believed that the complexity, scope and risks of compliance would outweigh the intended benefits. It soon became clear that similar legislation was being considered worldwide, and the RoHS concept was here to stay. In 2003, APSCO began developing a fully compliant manufacturing process, developed around industry data and internal experiments.

The ability for an EMS to manufacture a RoHS-compliant product is only a small piece of the overall compliance puzzle. The EMS must also accept the role of project manager, determine where the OEM is taking responsibility and establish a framework of support to best serve their customers and themselves. Ignoring this responsibility could be catastrophic, because an unprepared OEM will have obvious implications to the EMS business model.

The EMS must also ensure that their recommendations are compliant with the businesses they serve. There are plenty of magazine articles and white papers on how the top tier market will attempt to respond to RoHS. However, small- and mid-market players also must consider the effects of volume, mix and technology on their decisions.

APSCO's position is to offer individually tailored solutions for each customer seeking RoHS compliance support. Our goal is to provide you with the most economic solutions to offering certifiable RoHS-compliant products.

ALLOY SELECTION

The manufacturing process is probably the most developed of all of the RoHS-related issues. In current electronics manufacturing there are two primary alloys, 63SN/37PB and 60SN/40PB. Current leaded alloys have a melting point of 183× to 191× Celsius. The following are just a few of the alloys APSCO has reviewed in our process to establish a RoHS compliant process:

Alloy	Industry Name	Melting Point (°C)	Cost Penalty vs Sn/Pb
Sn96.5/Ag3.5	AUTOMOTIVE HIGH TEMP	221	3.5°
Sn96.5/Ag3.0/Cu0.5	SAC305	217	3°
Sn88.5/In7.0/Ag3.5/Cu1.0	Viromet 347	207	6°
SN95.5/Ag3.9/Cu0.6	NEMI alloy	217	3.5°
Sn99/Cu.5Cu/ Ni.O5	Sn100C	227	2°

Alloy selection is not based upon thermal properties alone. Wetting ability, bond strength, alloy compatibility, costs and availability were also considered. In many cases, alloy selection is dependent upon the process, with manufacturers using different alloys for surface mount assembly, wave solder and hand soldering applications. Unfortunately, no alloy being marketed today has proved to be a true drop-in replacement for Tin/Lead (SNPB).

FORWARD/BACKWARD COMPATIBILITY

There are also concerns about the forward and backward compatibility of both the component finish and the soldering process. During the development of a lead-free (RoHS compliant) product, it may be necessary to use leaded parts while waiting for the availability of lead-free counterparts. In a very conservative approach, some component manufacturers do not warrant the intermixing of leaded and unleaded products. However, passive components with lead-free terminations have been successfully

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processed with leaded solder for many years. Current data indicates that the greatest risk exists with intermixing solder alloys when processing Ball Grid Array (BGA) packages. Thru-hole technology can be processed with intermixed alloys as long as Tin/Lead finished parts are processed by hand or through a Tin/Lead wave solderer to prevent lead from leaching into the solder bath.

HIGHER PROCESS TEMPERATURES

Of greater concern is a component's ability to withstand the higher process temperatures. RoHS certification alone does not indicate that a given component can be processed in the same way as its leaded counterpart. Complete understanding of material composition is required to determine if component structure, performance or shelf life will be affected. For example, will the plastics used in sockets and connectors survive an intrusive reflow process?

TIN WHISKERS

In a lead-free process, Tin (Sn) becomes a major component of the plating process used to replace traditional Tin/Lead (SNPB) finishes. According to NASA research, "pure tin-plated finishes are susceptible to a spontaneous growth of filament-like structures commonly referred to as tin whiskers." Under research conditions, these spontaneous crystalline grow at unpredictable rates with a wide range of morphologies, and could cause latent product failure. Various methods of eliminating or mitigating whisker growth have been adopted, such as the control of plating thickness, under plating materials, avoiding bright finishes and using conformal coatings. OEMs and their EMS partners must understand the inherent risks and determine the best course of action to eliminate failures.

INSPECTION

Manual and automated inspection methods will also need to change. The IPC is revising IPC-A-610B to incorporate standards for visual inspection and verification of Lead-Free solder joints. Current Tin/Lead technology yields bright shiny solder joints, but removing lead from the solder alloy often yields a solder joint with a dull and grainy finish. Additionally, issues related to the wetting and voiding of solder joints will effect how future inspection methods will validate the quality of these joints.

PRODUCT MARKING

Product marking guidelines have been established by the IPC (IPC-1066). These guidelines require products to be marked with the symbol at left.

Additionally, space on the printed circuit board needs to be allocated for information related to the alloys used in the manufacturing of the circuit card assembly. Codes will be required to identify the specific alloy used for SMT, Wave Solder and Hand Solder processes. Labels with an ellipse surrounding the letter "e" and numbers 1-9 will be required to identify each alloy used during the manufacturing process. Multiple labels will be required if more than one alloy was used during the process.

As the industry deadlines draw nearer, various issues will develop that require further investigation and resolution. APSCO has a commitment to continue reviewing these issues and study the potential effect on your products. Most often, the key to avoiding these problems will lie in selecting the right solder alloys, component plating and printed circuit board (PCB) finishes.

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SUPPLY CHAIN MANAGEMENT

When managing the transition to a lead-free supply chain, issues of product availability, identification techniques, product marking, shelf life, inventory liability and cost must be considered. The current supply chain is almost exclusively based upon a Tin/Lead finish. With the exception of lower cost passive devices, much of the industry has only begun the transition to RoHS compliance.

Some industry sources indicate that nearly 40% of component manufacturers still have not declared their plans for becoming RoHS compliant. The majority of these companies are "specialized" component manufacturers. Of the mainstream companies that do have a published RoHS compliance plan, it appears that only 60% plan to identify RoHS-compliant products through a part number change.

It is APSCO's recommendation that component manufacturers identify their RoHS-compliant products with new part numbers, and OEMs establish new internal part numbers for RoHS products and components. We believe separation of RoHS compliant product is the key to successful conversion and certification traceability. APSCO discourages the use of AVL (Approved Vendor List) changes as a sole method for RoHS part number additions. Current industry guidelines are being established to identify RoHS-compliant components through the use of standardized marking techniques at the component, package and product level.

Availability of RoHS-compliant components is also a major concern. Many product manufacturers have established RoHS-compliant part numbers, but may not have a schedule for manufacturing these products. Lead times will depend upon overall market demand and availability of a RoHS-compliant fabrication center. While generic products such as passive devices are more readily available, product-specific items like unique semiconductors, relays, magnetics, and connectors must be investigated on an individual basis.

Determination also needs to be made to ensure that components are both Lead free and RoHS compliant. Tin, Palladium and Gold finished components have been available for years, and while these components are Lead free, they may not be RoHS compliant.

Projections indicate that component costs are expected to rise an average of 5-10%. During the transition to RoHS compliance, these increases are almost certain to be based upon the laws of supply and demand. Design changes, documentation requirements, material costs and engineering resources are the driving factors behind this increase.

MATERIAL DECLARATION

Although all EU countries have yet to adopt formal legislation, the UK's Department of Trade and Interior (DTI) is recommending self-certification as the means by which suppliers and manufacturers would certify RoHS-complaint product. Furthermore, DTI recommends that the EU adopt a test standard for the self-certification process. It has also been suggested that the EU establish a standard for reporting that allows auditable exchange of information between member states.

Understanding the measure of concentration becomes the first step in maintaining compliance records. It was initially hoped that measurement would be made at the assembly or component level. Unfortunately, the TAC has proposed that levels be measured for each "homogeneous material," which basically requires RoHS compliance for each product component. For example, an electric cable would need to be separated into insulation and wire, or a connector into its housing and pin.

At the assembly level, the analysis required to verify RoHS compliance could be massive. Component manufacturers must provide appropriate documentation, certification and declaration in order for EMS

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providers to trace and certify at the assembly level. Some component manufacturers are resistant to declare this level of detail, sighting concerns over the release of proprietary information. Debate exists over whether component self-certification is sufficient for the component manufacturer. Component self-certification may prompt concerns from higher level assemblers as they struggle to understand the liabilities associated with components that may fail RoHS testing. Since formal legislation has not been passed in all EU states, the issue will be whether the assembler will have sufficient auditable data to comply with any pending laws. Therefore, we believe material declarations should be made and documented in a centralized database whenever possible.

Standardization on material declaration methods is still under development. A Joint Industry Material Composition Declaration Guide is being developed by the EIA (Electronic Industries Alliance), EICTA (European Information & Communication Technology Industry Association) and JGPSSI (Japan Green Procurement Survey Standardization Initiative). This guide calls for the declaration of not only the RoHS-banned substances, but 23 other substances, as well.

Annex A of the Declaration Guide lists 15 items that have been either prohibited, restricted or require reporting under existing enacted legislation. Annex B lists items singled out based upon criteria established by the Joint Committee, but not restricted or banned at this time. This kind of standardized material declaration will ensure worldwide compliance to developing legislative acts and will provide a standard, auditable format for communication.

TIMING

As the deadline for compliance draws near, careful consideration must be given to the requirements of a RoHS compliance project. Identifying RoHS-compliant replacements is a complex, time-consuming process. Engineering groups must determine if they can allocate the needed resources to this task in a timely enough fashion.

Beyond development of the Bill of Material (BOM) is the obvious need to test and evaluate the component changes. The full development and evaluation process needs to include Prototype/Pilot builds, product testing, performance evaluations, modifications and final product development. Throughout the entire process, a reliable, supportive and knowledgeable partner is a necessity. Your EMS partner's vast experience of industry trends and developments may be your best path to success given the tight timeframe.

Those companies that are exempt or receiving extensions must look beyond the July 2006 deadline and ask themselves the following questions:

1. What will happen to the "lead-based" supply chain?
2. Will the laws of supply and demand cause my business to embrace lead-free product due to availability?
3. What are other countries or states doing about RoHS-type legislation?
4. Are other legislative acts looming?

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PENALTIES FOR NON-COMPLIANCE

Penalties for non-compliance with the RoHS initiative will obviously vary somewhat by EU member state. However, the DTI's current recommendation is as follows:

1) Product Non-Compliance
    a) Quarantine and removal from marketplace

2) Individuals Responsible for RoHS violation
    a) Summary conviction
        i) Up to 3 months imprisonment and/or a fine of up to £5,000
    b) Indictment
        ii) Up to 2 years imprisonment and an unlimited fine

COSTS

Cost is a major area for concern when establishing a comprehensive plan to become RoHS compliant. OEMs are looking for solutions that maximize results and minimize investment. EMS providers are seeking reimbursement for efforts beyond the scope of the typical EMS/OEM partnership. The following list highlights areas for concern:

1) Cost of Non-Compliance
    a) Impounded products
        i) Loss of shipments
    b) Fines
    c) Imprisonment

2) Cost of Inventory
    a) Lead-finished materials
        i) Finished goods
        ii) Field product
        iii) EMS supply chain
            1) Derived through minimum/multiples or forecast data
    b) RoHS-compliant materials
        i) Potential for shorter shelf life
            1) Changes to Moisture Sensitivity Levels (MSL)
            2) Solderability issues

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3) Design Costs
    a) BOM conversion
        i) Identify current material status
        ii) Identify alternates
        iii) Identify items not currently available for RoHS
            1) Recommendation for product design change
        iv) Addition of new part numbers to manufacturing system
    b) Material Cost Increase
        i) Component cost increases
        ii) Solder cost increases
    c) Product design development
        i) Prototype
        ii) Re-qualification testing
        iii) Reliability testing
    d) Engineering change notices
        i) Internal
            1) Addition of new part numbers
            2) Addition of new assembly numbers
        ii) External
            1) EMS Providers
            2) Custom fabrication suppliers
            3) Product vendors

4) Data Collection of Material Declaration Data
    a) System to provide auditable records of conformance

5) EMS infrastructure improvements to support RoHS
    a) Equipment
        i) Reflow ovens
        ii) Wave solder
    b) Utility costs
        i) Due to higher process temperatures
        ii) Seasonal effects
    c) Process development
    d) Documentation

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SOLUTIONS

It would be nice if a top-level revision change could yield a RoHS-compliant assembly with a simple notice stating, "This assembly must be RoHS Compliant." Unfortunately, creating fully- compliant assemblies will be much more challenging than that. But you will not have to tackle this process alone. As your EMS partner, APSCO is fully prepared to help you through the challenges of becoming compliant, including services to:

- Track the latest updates to the legislation
- Convert your bill of materials
- Assemble prototypes to evaluate the effects of process and component changes on your design
- Manufacture your product with a RoHS-compliant process
- Provide certificate of compliance and data collection that will pass audit

As an EMS provider, we know that final decisions over the product conversion process rest with the OEM – just as design ownership rests with the owner of the intellectual property. However, we believe that as your manufacturing partner, we can leverage our understanding and insight into the industry to ease the burden on your already overworked organization. By sharing the workload during the incredibly tight compliance deadline, APSCO can help ensure your success.