10 steps towards RoHS compliant products

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Introduction: The legislation

- The RoHS directive 2002/95/EC “on the Restriction of certain Hazardous Substances in electrical and electronic equipment” becomes effective: 1 July 2006

Hazardous Substances:

Pb, Hg, Cd, **hexavalent Cr**, PolyBrominated Biphenyls (PBB) and PolyBrominated Diphenyl Ethers (PBDE)

Electrical and electronic equipment:

RoHS directive refers to the WEEE directive with additions and exemptions

- The WEEE directive 2002/96/EC:
  - “on Waste Electrical and Electronic Equipment”
  - effective 13 August 2005,
  - take-back obligation for the producers

Introduction: The legislation

Electronic and Electrical Equipment affected by WEEE (Annex 1A):

- Large household appliances
- Small household appliances
- IT and telecommunications equipment
- Consumer equipment
- **Lighting equipment (except light bulbs and luminaires in households)**
- Electrical and Electronic tools (except large-scale stationary industrial tools)
- Toys, leisure and sports equipment
- Medical devices (except implanted and infected products)
- Monitoring and control instruments
- Automatic dispensers

Anything which is not in this list is outside the scope of this directive: Electronics for automotive, avionic, military, some industrial,...

Introduction: The legislation

Electronic and Electrical Equipment affected by RoHS:

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- Small household appliances
- IT and telecommunications equipment **(with exemptions)**
- Consumer equipment
- Lighting equipment
  (except light bulbs and luminaires in households)
  + light bulbs and luminaires in households
- Electrical and Electronic tools (except large-scale stationary industrial tools)
- Toys, leisure and sports equipment
- ~~Medical devices (except implanted and infected products)~~
- ~~Monitoring and control instruments~~
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Anything which is not in this list is outside the scope of this directive:
Electronics for automotive, avionic, military, some industrial,
medical, monitoring & control, ...

Introduction: Lead-free soldering

- Lead-free soldering forms the basis of a massive, mandatory change in the electronics industry.
- A change that is NOT limited to the electronic assembly plant!
- A change that affects the complete electronic supply chain.

Why?

- SnPb solder has been used for well over 50 years as the general purpose soldering material.
- There is NO drop-in lead-free solder replacement.
- Major adaptation required of: (temperature/metallurgy)
  - Soldering processes and equipment
  - Components
  - Printed Circuit Boards

Introduction: Towards RoHS compliancy

The chain of events:

RoHS bans lead which leads to…

- **lead-free soldering** at increased temperature which leads together with the RoHS requirements to…
- **modified components, PCBs** and soldering **processes** leading to…
- massive **product** review and modification leading to…
- a major **logistical challenge** for the complete electronic supply chain leading to…
- a **company wide impact** of nearly all electronic business processes extending to customers and suppliers which results in…

A hell of a job to be accomplished!

Introduction: Towards RoHS compliancy

Why the product review and adaptation?

Two basic reasons :

1. Legislation:
   A RoHS compliant product requires a RoHS compatible Bill-of-Material RoHS and a RoHS compatible assembly technology.

2. The product must be made compatible with lead-free soldering. There are quality and reliability issues!
   - Modified components
   - Modified PCB substrates
   - New assembly technology: lead-free soldering
   - New/modified failure mechanisms

Note: Review of exempted products is also required
- The components are changing.
- Is the BOM still compatible with the SnPb soldering process?
- Will the SnPb component version be available in the future?

Introduction: Towards RoHS compliancy

1. Lead-free components/products
2. RoHS compatible components/products
3. Lead-free soldering compatible components/products

... are three DIFFERENT things!

- A CdS photocell is NOT RoHS compatible but lead-free.
- A RoHS compatible component may contain lead:
  a CBGA, a ceramic thick film component, a SnPb balled BGA to be used on a Telecom PBA,…
- Lead-free, RoHS compatible Al-capacitor (Elco) may not be compatible with temperature conditions of lead-free soldering!

Be aware and acknowledge the complexity!

10 steps towards RoHS compliant products

Step 1: Corporate management buy-in Corporate RoHS conversion project

- The electronics OEM is fully responsible for the RoHS compliancy of its products.

- Therefore the OEM is fully responsible for the successful RoHS implementation in all the affected business processes including that of the outsourced activities! It is not the (legal) responsibility of the component and/or manufacturing service provider.

- It affects all business activities of the OEM company including the outsourced activities!

- A conversion project lead at corporate level with sufficient priority and resources is mandatory for a successful RoHS compliancy implementation.

- Even if the OEM's product are not in the scope of RoHS (are you sure?) they will be affected by the RoHS conversion now and for sure in the future. Act accordingly.

Step 1: Corporate management buy-in Corporate RoHS conversion project

If your products need to be RoHS compliant you are **NOT ALLOWED TO SELL ANYTHING** that is not RoHS compliant from July 1st of **THIS YEAR**!

Implementing RoHS requires a company wide multi-disciplinary conversion project that should be high on the corporate management priority list.

It requires substantial and dedicated resources!

Step 2: Information collecting

- Realizing RoHS compliancy is a **complex** matter.
- It is a highly **multi-disciplinary** activity.
- There are many **open issues**.
- An important aspect is **risk management** regarding:
  - the legal aspects
  - the product quality and reliability aspects.

To succeed it is mandatory that:

- One knows what can be known.
- One knows what is not known.
- Understands the impact on the business activities.
- Collects all the relevant information to establish and execute a company wide RoHS conversion project.

Step 2: Information collecting

Mandatory know-how:

- RoHS directive content and its interpretation
  - Relation with WEEE directive
  - Scope & product categories
  - Exemptions
  - Implementation requirements (still highly unclear)
- Basics and impact of lead-free soldering
  - Basic technology
  - Metallurgy and temperature requirements
  - Risks: quality, production yield, product reliability
  - Impact on product design and material, component and PCB selection
- Impact of elimination of the RoHS banned substances
  - Realization of product functionality: e.g. banned components.
  - Availability, cost, performance, reliability,… of alternatives.

Step 2: Information collecting

- Internal company business processes
  - Electronic product design methodology
  - Manufacturing practices (in-house or out-sourced)
  - Supply chain practices
  - Business processes tools: ERP/MRP, CAD, CAM,…
  - Quality
  - Installation, after sales and repair
- Your competitor(s)
  - RoHS strategy
  - Marketing strategy
  - Environment: number of players, local or international, hostile or colleague-like,…
- Your customer(s)
  - Their expectations towards RoHS compliancy
  - Quality, reliability, cost, volume,… requirements

Step 3: Product RoHS conversion plan

Based on the knowledge of the RoHS requirements, the companies product portfolio, the market and an assessment of the risks involved one needs to set up a product RoHS conversion plan.

This plan involves:

- All existing products
- Products under development
- Planned product R&D

It plans the activities, timing and resources needed to accomplish the RoHS (non)-conversion of each product covering the full product life cycle and all relevant business processes.

Step 3: Product RoHS conversion plan

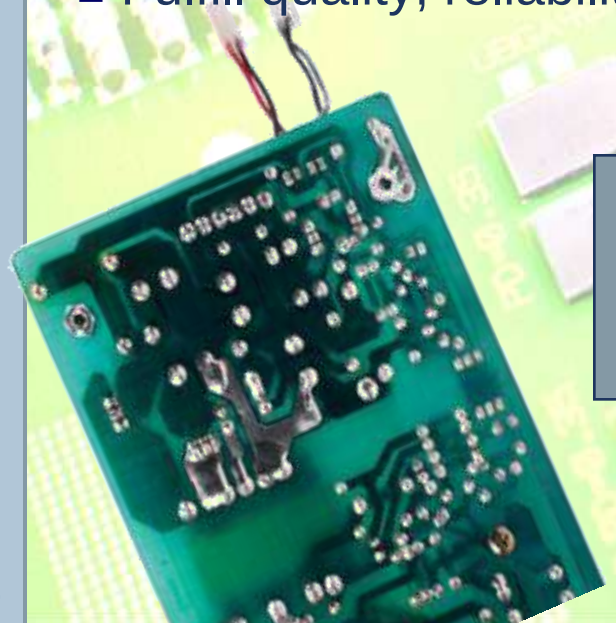
View on questions to be answered (non-exhaustive):

- All products
  - Do they have to become RoHS compliant?
  - Do they have to be lead-free soldered?
  - Are the above requirements coming from a legal or a customer requirement?
  - Future availability of components (lead-free/SnPb compatible)
  - Product qualification: what and how?
- Existing products:
  - Do they need a design modification?
  - Go for a re-design or out-phase the products (in Europe)?
  - Use as spare parts?
- New product design:
  - What products to be made RoHS compliant?
  - What products to be lead-free soldered?
  - When and how will this be implemented?

Step 4: Design-for-RoHS compliancy

Electronic products need to be (re)-designed to be:

- RoHS compliant according to the legal requirements.
- Compatible with the selected/required soldering process:
  - SnPb soldering for exempted applications or products out of the RoHS scope.
  - Lead-free (SnAgCu) soldering: metallurgy and thermal load
- Fulfill quality, reliability, manufacturability and cost requirements.



What do we have to do?
A step-by-step guide.

Step 4: Design-for-RoHS compliancy

- Full screening of all components (50K-150K) actually used and to be used components with regards to their:
  - RoHS compatibility
    - All substances!
    - Also non-electronic parts!
  - Lead-free soldering compatibility
  - SnPb soldering compatibility

- For this purpose a large amount of data has to be collected:
  - RoHS compatibility of components taking into account the exemptions.
  - Technical information regarding the soldering compatibility of components: lead-finish metallurgy, temperature tolerance, moisture sensitivity,…
  - Component qualification test results: solderability, solder joint reliability, Sn-whiskering, electrical performance,…

Step 4: Design-for-RoHS compliancy

- To handle the additional information adapt the part data management and CAD systems (or whatever is used for design purposes) to handle the increased number of design parameters and part codes.
- Before the components can be screened, selection criteria are needed:
  - Identify quality and reliability areas of risk.
  - Set-up component selection criteria/algorithms/filters for design of RoHS/non-RoHS/SnPb solder/lead-free solder/… products.
- Screen components and assign RoHS related and soldering related statuses to them.
- Basic information is now available for RoHS product design.

Prior to starting RoHS product design we need to:

Step 4: Design-for-RoHS compliancy

- Set-up design guidelines
  - Many design rules embedded in the component selection criteria.
  - Design-for-RoHS is mainly a design of the Bill-Of-Material (BOM)
  - Rules to handle more complicated, product- and application dependent requirements.
  - Layout rules (limited)
  - How to handle the available information.
  - Information to be provided in design output (more than before!)
- Adapt CAD output to provide RoHS and soldering process information to manufacturing and procurement. Provide adequate Printed Circuit Board, component and Printed Board Assembly specifications.
- Implement the design methodology and train the designers.
- Review existing designs in the light of the new design rules.
- Define required modifications of existing products.

Step 4: Design-for-RoHS compliancy

Now the redesign of existing products (if necessary) and the design of new products with the new design rules and methodology can start.

- (Re-)Design products
- Prototype the new designs.
- Qualify the prototypes.
- Industrialize and ramp-up to volume.
- Monitor manufacturing yield, quality and field performance.
- Adapt design rules including the component selection criteria if necessary.

Step 4: Design-for-RoHS compliancy

Step-by-step D-f-RoHS-guide:

1. Define the information needed.
2. Adapt the part management database to store additional information and the CAD systems to be able to retrieve it.
3. Collect all the necessary information from the component suppliers.
4. Identify areas of quality and/or reliability risk.
5. Set-up component selection criteria.
6. Screen components and assign RoHS/soldering statuses
7. Establish Design-for-RoHS rules and guidelines
8. Adapt design output to provide mandatory information towards PCB, component and assembly supplier.

Step 4: Design-for-RoHS compliancy

9. Implement the new design methodology.
10. Train the designers.
11. Screen existing products in light of new design rules.
12. Define modifications of existing products.
13. Execute (re-)design of products using the D-f-RoHS methodology.
14. Prototype
15. Qualify
16. Industrialize
17. Monitor
18. Adapt selection criteria and design rules if necessary.

Step 5: Procurement process

Procurement of components for electronic products manufacturing must be in-line with the D-f-RoHS process.

- Collect supplier **information**
  - Suppliers conversion planning:
    RoHS, lead-free soldering compatibility
  - (Future) component availability
- Define component **acceptability criteria** in line with the design criteria.
- Define component **part coding** and **labeling** requirements towards suppliers and internal ERP systems and logistical procedures.
- Provide supplier **instructions**.
- Set-up procurement **plan** for RoHS/lead-free soldering conversion.
- Set-up **excess and obsolete mitigation** plan.

Step 6: Manufacturing process

The change-over to lead-free soldering and the need to provide both SnPb and lead-free processes in a manufacturing plant requires major adaptations.

- Replacement of some **equipment**: wave soldering machine(s), soldering irons, selective soldering,…
- Selection and qualification of solder **materials**: solder paste, wire, bars, flux, cleaning agents,…
- Adaptation of **process** set-up rules, procedures, control and maintenance.
- Set-up of RoHS, lead-free soldering and mixed SnPb/lead-free compatible manufacturing **logistics** including identification and traceability procedures.
- **Training** of operators, supervisors, quality auditors, process engineers, factory management,…
- Prepare for increased need for product trouble-shoot and **repair**.

Step 6: Manufacturing process

- To be taken care of by the OEM for in-house manufacturing.
- OEM has also a responsibility for its **subcontracted** manufacturing:
  - Formulate clear requirements:
    - acceptable lead-free alloy(s)
    - solder material requirements related to product reliability
    - process boundary conditions: minimum/maximum values
  - Provide proper design.
  - Provide unambiguous data.
- Because of the increased complexity (variation in materials, process conditions, components, PCB), the increased process temperatures and the reduced process windows **more** and **more accurate** assembly **instructions** are required!
- This requires basic **knowledge of electronic manufacturing!**

Step 7: Business process alignment

Crucial business processes must be aligned: Design – Procurement – Manufacturing – Delivery

- Procurement must buy what the product design specifies.
- Manufacturing must assemble the correct component using the correct soldering process as is specified in the design and as ordered by the customer.
- Products must be delivered according to the customer's order.

This is not obvious! Because:

- It is all about identification and traceability.
- But there are many more parameters that make a difference. More part codes needed!
- ERP systems and Part Data Management systems are usually not ready to handle more data elements and part codes/part code extensions. ERP soft is hard!
- Alignment of design CAD, procurement ERP, manufacturing ERP, manufacturing CAM … across different companies!

Step 7: Business process alignment

Set-up a complete operational supply chain that can make a difference between:

- RoHS/lead-free solder products and components
- RoHS/SnPb solder products and components
- Non-RoHS/SnPb solder products and components
- Non-RoHS/Lead-free solder products and components

- In the ERP systems: coding required!
- Identifiable on components and products in warehouses and the factory floor: ex. Labeling.
- Clear and strictly applied identification procedures required.
- Carefully planned and strictly controlled implementation needed to avoid chaos and high costs related to obsolete component and product inventory.

Step 7: Business process alignment

Business process alignment and strict management of its implementation is crucial.

- **Legal**:
To be able to supply RoHS compliant products and to prove RoHS compliant development, supply and production capability.
- **Product**:
To guarantee product quality and reliability.
- **Business**:
To avoid major costs and loss of market share.

The business process aspects especially the logistics are the hardest part of the RoHS conversion project!

Step 8: Marketing

How will the customer be approached?

- Will the RoHS conversion project be made visible to the customer?
- Will RoHS conversion and/or lead-free soldering conversion be exploited? E.g., if not mandatory, does it provide added value to the customer?
- How will a non-conversion be presented to the customer?
- Green image or not?
- How will customers requests to go RoHS compliant or lead-free when not mandatory be handled?
- How to handle conversion capacity limitations, delays, etc. towards the customer?
- …

Step 9: Quality control

RoHS compliancy requires a major change in both the product itself as the manufacturing process.

There are many quality and reliability risks:

- Modified components
- Modified PCB's
- Modified designs
- New solder materials and process conditions
- Reduced processing windows at increased temperatures
- Significant increase in logistical complexity, mixed supply chain: RoHS/non-RoHS, SnPb/lead-free soldering
- Mixed production: SnPb and lead-free
- Major learning curve
- Major risk for (human) error
- RoHS/lead-free reliability issues: solder joint fatigue, contamination, Sn-whiskers, … not yet quantifiable.
- …

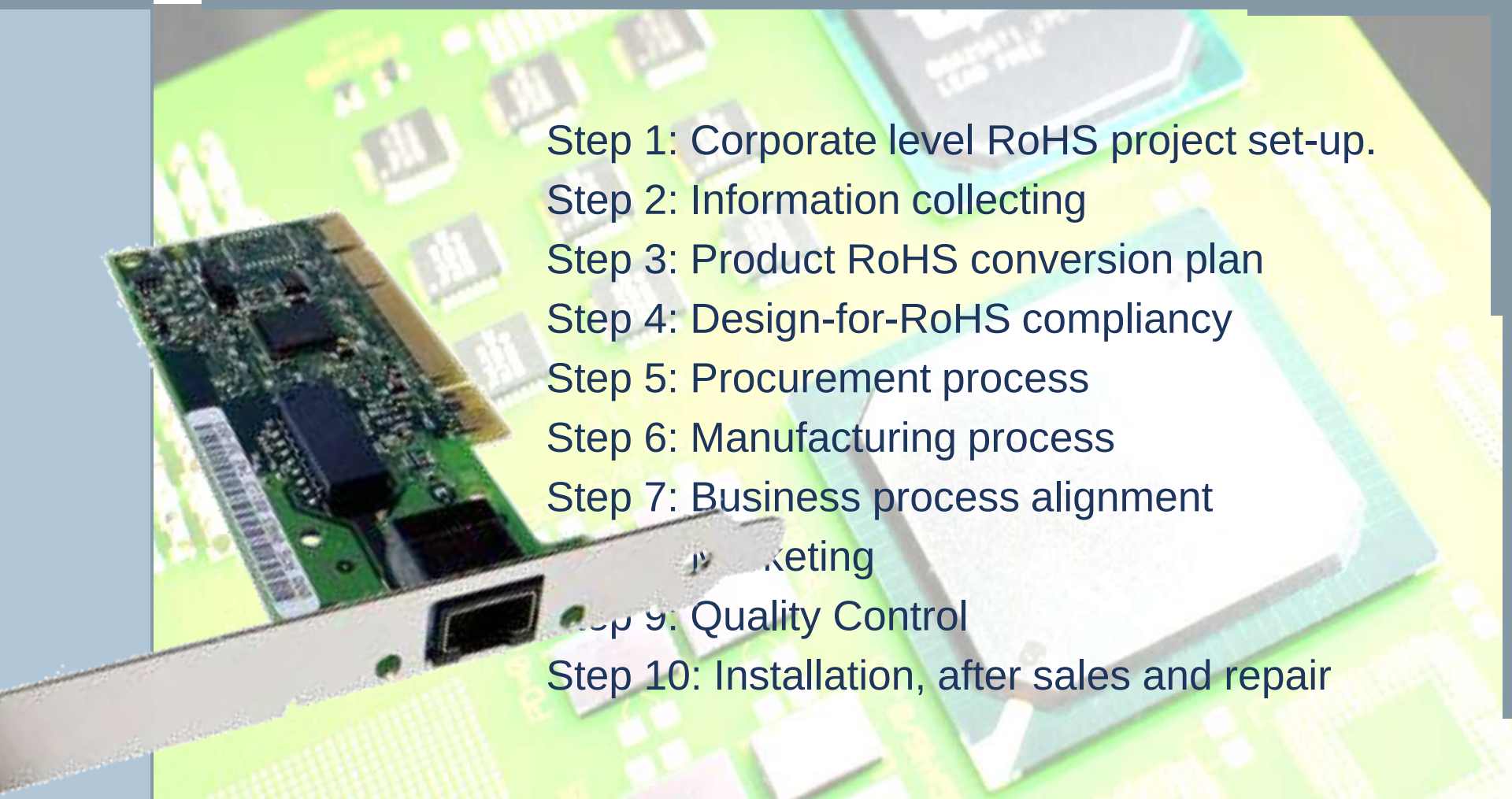
Step 9: Quality control

- TAKE CARE OF THE INPUT to production!
  - Stick to the design rules.
  - Stick to component, PCB and electronic assembly acceptability criteria.
  - Qualify
  - Check and control: there will be violations!
- Identify areas of quality and reliability risks.
- Prepare for more and new quality and reliability issues.
- Adapt quality control procedures.
- Train auditors and quality engineers.
- Closely monitor all quality aspects from design over procurement and manufacturing up to delivery.
- Set up a PCB/component/product quality issue traceability system.
- Make sure you have access to field performance.

Step 10: Installation, after sales and repair

- Set-up installation, after sales and repair of field return procedures depending on:
  - RoHS/lead-free solder products and components
  - RoHS/SnPb solder products and components
  - Non-RoHS/SnPb solder products and components
  - Non-RoHS/Lead-free solder products and components
- How will the products be repaired?
  - All lead-free solder?
  - Solder depending on product's soldering process?
  - Replacement of non-RoHS and/or SnPb soldered products?
- How will replacement be done?
  - RoHS with RoHS, non-RoHS with non-RoHS?
  - All RoHS?
- How do service technicians and engineers know what they are working with and what they have to do?

10 steps summary



Step 1: Corporate level RoHS project set-up.
Step 2: Information collecting
Step 3: Product RoHS conversion plan
Step 4: Design-for-RoHS compliancy
Step 5: Procurement process
Step 6: Manufacturing process
Step 7: Business process alignment
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Step 10: Installation, after sales and repair

The road to RoHS compliancy

… promises to be a rough ride…

- Revolution in electronics manufacturing.
- Company wide impact.
- Highly complex and multidisciplinary.
- Many unknowns and open issues:
  legal, technical, logistics, business,…

… but there is no turning back !

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Met steun van:

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