# Design-for-RoHS

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Met steun van:

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# 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

## RoHS: 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!**

# Design-for-RoHS
# A step-by-step Guide

# Step 1: Knowledge build-up

## Mandatory know-how:

- RoHS directive content and its interpretation
  - Relation with WEEE directive
  - Scope & product categories
  - Exemptions
- 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 1: Knowledge build-up

- Internal company business processes and tools
  - Electronic product design methodology
  - Manufacturing practices (in-house or out-sourced)
  - Supply chain practices
  - Business processes tools:
    - CAD
    - ERP
    - Part Data Management
    - Product Data Management
  - Data structure

- The product RoHS conversion plan of the company

  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 2: Information collection

Component information

- Full screening is needed 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,…

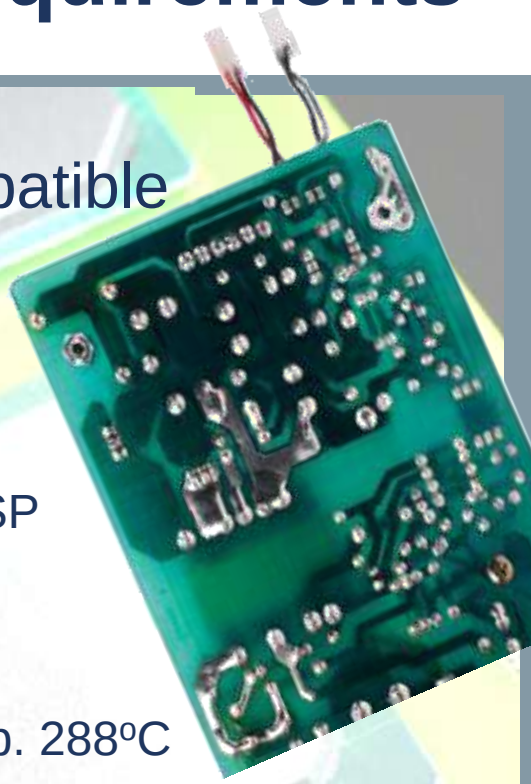
# Step 3: Component acceptability criteria

Before the components can be screened, acceptability criteria are needed:

- Identify quality and reliability areas of risk:
  - Temperature sensitivity
  - Solder joint reliability
  - Moisture sensitivity
  - Metallurgical incompatibilities
  - Contamination impact
  - Sn-whiskers
  - …
- Product and application dependent
- Define component acceptability criteria for the design of
  - RoHS/lead-free solder
  - RoHS/SnPb solder
  - non-RoHS/SnPb solder
  - Non-RoHS/lead-free solder

  products

# Step 4: PCB requirements



PCB must be RoHS compliant and compatible with lead-free soldering conditions.

Specify!

- Lead-free finishes
  - Ag, Sn, ENIG-NiAu, lead-free HASL, NiPdAu, OSP
- Laminate requirements
  - Td: Decomposition temperature
  - T260, T288: time-to-delamination at 260°C resp. 288°C
  - CTE, $\alpha 1$, $\alpha 2$: Coefficients of thermal expansion of z-axis
  - Tg: Glass transition temperature
  - Curing system: dicy/non-dicy
  - Conductive Anodic Filament CAF resistance
- Cost!

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# Step 5: Assembly requirements

Specify lead-free assembly requirements

- Soldering materials
  - Acceptable alloys
  - Acceptable solder materials: flux classification
- Soldering processes
  - General minimum/maximum temperature/time reflow conditions
  - Special reflow requirements: e.g. temperature sensitive components
  - Acceptability criteria: e.g. IPC-610D (Define class!)
  - Repair requirements
- Logistics
  - Labeling requirements

# Step 6: Design-for-RoHS rules

Set-up design RoHS/lead-free design rules

The good news:

- Many design rules embedded in the component acceptability criteria.
- SnPb soldering footprints/libraries can re-used!
- Design-for-RoHS is mainly a design of the Bill-Of-Material (BOM)

Additional rules:

- Rules to handle more complicated, product- and application dependent requirements. e.g: include Sn-whisker requirements
- Layout rules (limited): e.g. repair clearance
- Specials: e.g. mechanical reinforcement

# Step 7: PDM and CAD upgrade

- 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:
  - RoHS/non-RoHS
  - Lead-free/SnPb solder compatible
  - Lead-free reflow compatibility
  - Lead finish
  - …
- Screen components and assign RoHS related and soldering related statuses to them.
- 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
- Train the design engineers.
- Basic information is now available for RoHS product design.

# Step 8: Design-for-RoHS execution

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

- Review existing designs in the light of the new design rules.
- Define required modifications of existing products based on the RoHS conversion planning.
- (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 8: Design-for-RoHS execution

**Customers of design: procurement - MANUFACTURING**

- Design determines product quality, reliability and cost. Major responsibility towards (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** to make good RoHS/lead-free solderable designs!

# Step 9: Business process alignment

Make sure that what has been designed will be produced and delivered to the customer!

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!

- It is all about identification and traceability.
- 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!

**Somebody has to take care of this!**

# Step 10: Quality control

Major change in the product and 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, …

- TAKE CARE OF THE INPUT to manufacturing!
  - Stick to the design rules.
  - Stick to component, PCB and electronic assembly acceptability criteria.
  - Qualify
  - Check and control: there will be violations!
- Closely monitor all quality aspects from design over procurement and manufacturing up to delivery.

# 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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