Electronic Components
Meeting Homogeneous Requirements

Mark Frimann
Texas Instruments
Brussels - October 2009
Agenda

• Electronic components in finished product
• UK DTI Homogenous Guidance
  Homogenous Issue for components
• Test Methods
• UK DTI Due Diligence Guidance
• Examples
• China RoHS Definition
• Summary
Examples of Electronic Components

- Bare Board
- IC
- Screws
- Resistors
- Capacitors
- Assembled Unit
- Housing
- Connector
- Connections
- Wires
- Sheathing
- Cable

[Diagram showing connections and components]
27. “Homogeneous material” means a material that cannot be mechanically disjointed into different materials.

- 28. The term “homogeneous” is understood as "of uniform composition throughout", so examples of "homogeneous materials" would be individual types of plastics, ceramics, glass, metals, alloys, paper, board, resins and coatings.
- 29. The term “mechanically disjointed” means that the materials can, in principle, be separated by mechanical actions such as unscrewing, cutting, crushing, grinding and abrasive processes.

- 30. Using these interpretations, a plastic cover (for example) would be a ‘homogeneous material’ if it consisted exclusively of one type of plastic that was not coated with or had attached to it (or inside it) any other kinds of materials. In this case, the maximum concentration values of the RoHS Regulations would apply to the plastic.

- 32. A semi-conductor package (as a final example) would contain many homogeneous materials, which include the plastic moulding material, the tin-electroplating coatings on the lead frame, the lead frame alloy and the gold-bonding wires.
The Homogeneous Issue for Components

- Electronic component suppliers are required to provide/have available yearly destructive testing reports of the homogeneous materials within components to meet EU RoHS
  - This is coming from the supply chain, not regulation, to meet EU RoHS due diligence
  - For components made of single materials, this is straightforward
    - Plastic housing
  - For common electronic components, this may require sub-component or even sub sub-component analysis to meet theoretical homogeneous material testing
    - Resistors, capacitors, screws, integrated circuits, bare printed circuit boards
    - Once assembled, these components cannot be separated into their original subcomponents

- Question: What is a practical material reporting requirement to achieve ‘homogeneous’ for these electronic components?
2 Basic Types of Test Methods

• Testing requirements can come from 2 basic test methods
  – Non-destructive X-Ray Fluorescence (XRF)
    • Fast, cost less, and less accurate
    • Usually test the component/product of interest without destroying it
    • Go / No-Go test
  – Destructive, with minimum sample size (mass)
    • Cost more and more accurate, more time required
    • Mass of samples required
      – PBB/PBDE = 100mg,
      – Cd = 400mg (further testing, add 5 g)
      – Hg = 1 g
      – Pb / Cd = 400mg
      – Total = 1.9 grams to 6.9 grams minimum for test samples

• Destructive testing is the expectation, XRF is seldom accepted
Due Diligence - Guidance

Excerpts from *UK BERR Government Guidance Notes* July 2008, URN 08/1061

- 44. The defence of ‘due diligence’ is available where a person can show he took all reasonable steps and exercised all due diligence to avoid committing an offence. This may include reference to an act or default of, or reliance on information given by, a third party, in which case it must be accompanied by such information identifying the third party, as is information in the possession of the defendant.

- **Note 5 – Analysis Requirements**
  - The need for *regular analysis depends on the risk of non-compliance* as well as the *risk to the environment*. Therefore components/materials used in large numbers will require more frequent scrutiny (and possibly analysis) than those used in small numbers.
  - Due diligence *does not expect analysis of every component/material, this would be unreasonable* but where there is a risk of non-compliance, the frequency that analysis should be carried out may depend on the potential risk to the environment so that components/materials used in very large numbers would need to be analysed more often than components/materials used in small numbers.

To show “*due diligence*”, material declarations & testing have become the required methods to verify components meet EU RoHS requirements.
Testing to Homogeneous

• With due diligence requirements being focused on testing, the theoretical term of homogeneous has not been aligned with practical mechanical disjointment
Homogeneous Question

– When a component can not be mechanically disjointed into different materials, should it be considered ‘homogeneous’?

• **Electronic component definition per IEC 62542:** electrical or electronic devices that cannot be taken apart without destruction or impairment of design use

  » **EXAMPLE** Resistors, capacitors, diodes, integrated circuits, hybrids, application specific integrated circuits, wound components and relays.

– Mechanical disjointment should meet recyclable criteria to be easily and quickly taken apart using commonly available tools

• **Such as Screwdriver, pliers, hammer, hands, etc.**
Comparison of Homogeneous as it moves from substances/preparations to finished product

A component supplier is the **transition** between material suppliers and products with working functions.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Simple Substances &amp; Preparations Supplier</th>
<th>Simple Material Supplier</th>
<th>Transition Component Supplier</th>
<th>Complex Sub-tier Supplier</th>
<th>Complex OEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform Composition Throughout?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes / No <strong>?</strong></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Mechanical Disjointment?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Component</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Product / Sub-product</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Supply Chain Information (Homogeneous for RoHS &amp; Component/product for all Others)</td>
<td>Homogeneous</td>
<td>Homogeneous</td>
<td>Sum of Component ** Homogeneous ?**</td>
<td>Sum of Sub-Product</td>
<td>Sum of Product</td>
</tr>
<tr>
<td>Recycling</td>
<td>Sum of material</td>
<td>Sum of material</td>
<td>Sum of Component</td>
<td>Sum of Sub-Product</td>
<td>Sum of Product</td>
</tr>
</tbody>
</table>

Components may be homogeneous or they may be heterogeneous.
- If heterogeneous, they can not be mechanically disjointed back into their previous homogeneous subcomponents.
- ** These types of components would have to be ground to make them homogeneous per IEC 62321.
Examples of Electronic Components

• 3 examples of the theoretical “homogeneous” material definition without consideration of disjointment capability
  – Resistor
  – Metallic Tape
  – Integrated Circuit (IC)
### Homogeneous Material Definition – Resistor

<table>
<thead>
<tr>
<th>Resistor Component</th>
<th>Plastic Overcoat</th>
<th>Ink</th>
<th>Lead &amp; Lead Finish</th>
<th>Resistor</th>
<th>Metal Cap</th>
<th>Welded Joint</th>
<th>Finished Resistor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform Composition Throughout</td>
<td>Yes</td>
<td>Yes</td>
<td>No**</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Mechanical Disjoint – &quot;In principle&quot; (Per RoHS FAQ May 2005)</td>
<td>Yes*</td>
<td>NA*</td>
<td>Yes**</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical Disjoint – &quot;In practice&quot; (Per IEC/PAS 62956 Sample Disjointment &amp; IEC 62321 RoHS Test Std)</td>
<td>Yes</td>
<td>No*</td>
<td>Yes**</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Notes: * Plastic coating can be mechanically disjointed from rest of part. However, ink cannot be practically mechanically disjointed from plastic. FAQ Example #1 indicates that this plastic would not be “homogenous” since it is “coated” with ink and, therefore, not uniform composition throughout.
** Lead can be mechanically disjointed from rest of part, but plating cannot be mechanically disjointed in practice from the lead alloy. FAQ Example #3 states that lead coatings is a separate uniform layer from lead.
**Homogeneous Material Definition – Metallic Tape**

<table>
<thead>
<tr>
<th>Metallic Tape</th>
<th>Tin Plated Copper Foil</th>
<th>Adhesive</th>
<th>Silicone Coating</th>
<th>Release Liner</th>
<th>Finished Metallic Tape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform Composition Throughout</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Mechanical Disjoint – &quot;in principle&quot; (Per downstream customer)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes*</td>
</tr>
<tr>
<td>Mechanical Disjoint – &quot;in practice&quot; (Per EMI tape mfg supplier and guidance in IEC/PAS 62956 Sample Disjointment)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No* (not part of final product)</td>
</tr>
</tbody>
</table>

* Note: Different interpretations exist today within industry of when parts can be mechanically disjoined “in principle” and therefore, different interpretations of “homogenous material” for metallic tape
**Homogeneous Material Definition – IC**

<table>
<thead>
<tr>
<th>Lead Frame Component</th>
<th>Bond Wire</th>
<th>Die</th>
<th>Die Attach</th>
<th>Lead Frame</th>
<th>Lead Frame Finish</th>
<th>Mold Compound</th>
<th>Lead Frame Finished IC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform Composition Throughout</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Mechanical Disjoint – &quot;In principle&quot;</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes*</td>
<td>Yes*</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>(Per RoHS FAQ May 2005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Disjoint – &quot;In practice&quot;</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Maybe**</td>
<td>No**</td>
<td>No</td>
<td>Np</td>
</tr>
<tr>
<td>(Per IEC/PAS62956 Sample Disjointment &amp; IEC 62321 RoHS Test Std)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: * Only exposed portion of lead frames can be mechanically disjoined from rest of package. For smaller package sizes, too many samples would be required to obtain sufficient weight for testing that analytical result will not be technically valid.

** Lead finish material cannot be mechanically separated in practice from lead frame though UK FAQ Example #3 calls the lead coatings and lead alloys separate uniform composition layers.
# Homogeneous Progression – Mold Compound

<table>
<thead>
<tr>
<th>Homogeneous 1</th>
<th>Homogeneous 2</th>
<th>Homogeneous 3</th>
<th>Homogeneous 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Disjointable</td>
<td>Not Disjointable</td>
<td>Not Disjointable</td>
<td>Not Disjointable</td>
</tr>
<tr>
<td>Raw Mat'l 1a</td>
<td>Raw Mat'l 1b</td>
<td>Raw Mat'l 1c</td>
<td>Raw Mat'l 1n</td>
</tr>
<tr>
<td></td>
<td>Bisphenols</td>
<td>Bromine, antimony</td>
<td>Other additives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and/or non-halide</td>
<td></td>
</tr>
<tr>
<td>Raw Mat'l 2a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Mat'l 2b</td>
<td>Silica formulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Mat'l 3a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Mat'l 3b</td>
<td>Hardener</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Mat'l 3n</td>
<td>Epoxy formulation(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Mat'l 4a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Mat'l 4b</td>
<td>Colorant formulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Example 1: Mold Compound Homogeneous progression**

* Mold Compound
IC subcomponents to IC

Homogeneous 4  ||| Homogeneous 5? Transition  ||| Non Homogeneous

Not Disjointable  Not Disjointable  Disjointable

Assembly Process, Sub-products & Products...

Example 2 (continued): Mold Compound Homogeneous progression
Other Possible Solutions

• China RoHS
  – Has 3 categories for electronic information products (EIP)

<table>
<thead>
<tr>
<th>Structural Unit</th>
<th>Definition of basic structural unit or material</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIP-A</td>
<td>Homogenous substances of electronic information products</td>
</tr>
<tr>
<td>EIP-B</td>
<td>Coating materials of parts in electronic information products</td>
</tr>
<tr>
<td>EIP-C</td>
<td>Small parts in electronic information products, i.e., small or non-homogeneous parts that cannot be further disassembled and are 4 mm³ or less in volume</td>
</tr>
</tbody>
</table>

• If <= 4 mm³ in size, then the component is considered homogeneous
• For lead frame devices, the main body must be disassembled from the exposed leads and each tested separately as ‘homogeneous’
• For ball grid array packages, the main body must be disassembled from the solder balls and each tested separately as ‘homogeneous’
China RoHS in practice

• Minimum test sample mass of 6.9 grams (see slide for Test Methods) for the RoHS 6 substances would take
  – Over 800 units of a 14 pin SOIC package to gain enough exposed lead samples
  – Over 100 units and over 17,000 solder balls for a 173 ball BGA package

• Neither of these package strategies are practical
  – Both package types require many more units than what would be within a given finished product usually available for test
  – Removal of BGA solder balls would require extensive time, equipment and additional units beyond reasonable capability to perform
  – Removal of exposed leads, though less difficult than solder balls would require time, equipment and additional units beyond reasonable capability to perform on a continuing basis

• In practice, the idea of components < 4 mm³ are considered homogeneous could be expanded to any complex electrical component that cannot be disjointed, regardless of size.
  – The component would be homogenized by following IEC 62321
Summary

• Compliance for EU RoHS regulatory requirements is at the homogeneous level
  – All other legislative requirements are at the component / product / Article level

• Alignment of these regulations for components would greatly reduce the supply chain burden for proving due diligence
  – Full alignment would be: Component = product = Article = homogeneous

• Testing is dependent on a component supplier’s business model
  – Test the finished component - or -
  – Test the subcomponents of the finished component

• This approach would
  – Fully meet RoHS due diligence
  – Clarify the requirements being pushed through the supply chain
  – Reduce the burden of proof volume costs
    • Time, manpower, reporting and tracking systems
    • Testing costs (materials, lab tests, shipping, tracking)

• The question remains, can component and homogeneous be aligned?
Homogeneous Suggestions

Suggested amendment of the RoHS recast proposal:

Insert in place of the definition of homogeneous material in article 3 (l) the following:
(l) "Homogeneous material" means any of the following:
1. A material of uniform composition throughout that can be mechanically disjointed, or
2. A protective metallic layer surface coating, or
3. A heterogeneous material that cannot be mechanically disjointed into different materials (not including protective metallic layer surface coatings)

Add a separate definition for the term “mechanically disjointed” to read as follows:
• “Mechanically disjointed” means that the materials can be separated in practice by common mechanical tools such as unscrewing, cutting, crushing, grinding and abrasive processes.
•
Questions?
Back-up Information
Bio – Mark Frimann
Texas Instruments

- Mark Frimann – SC Product Stewardship
- He has worked at Texas Instruments since 1990 with various roles within an IC Fab, Product Engineering and Quality. He has been addressing RoHS and substance reporting issues since 2001. During this time he:
  - Led the TI team to develop the product content website (www.ti.com/productcontent), answered customer questionnaires, developed & trained the team for this growing requirement, and continues to support automation processes in this area
  - Monitors industry regulations
  - Reviews & responds to customer specifications surrounding RoHS and related legislative requirements
  - For new environmental requirements, he works with internal teams to understand current capabilities and changes that may need addressed
  - Industry Standards participation: He is currently co-chair of the iNEMI / IPC 2-18 committee for the 175x series on Material reporting and participates in the JIG-101 and TC111 WG1 (IEC 62474) standards groups covering substance declarations and the latest Halogen Free IPC/JEDEC J-STD-709 draft.
Homogeneous across all IC components

- Blow-up of 10 Cent Euro with ICs on it
- Same homogenous info for all sizes required
Further Disjointment information – In Practice

see IEC/PAS 62596 for further details

The term “mechanically disjointed” means that the materials can, in principle, be separated by mechanical actions such as: unscrewing, cutting, crushing, grinding and abrasive processes.

• When separated from other components, individual components can be tested as a whole
  – Separation of its materials can not be completely accomplished
  – Through the use of expensive equipment, advanced techniques and time, “close” material estimations could be accomplished
    • An impractical approach

• From a standpoint of recycling, components may be
  – Separated from the products they are installed
  – Left within the printed circuit board
  – Left with the final product
  – No attempt is made to mechanically disjoint components into their previous separate material sets
IEC PAS 61906
Description of components in printed Circuit Board

• IEC PAS 61906 Procedure for the declaration of materials in products of the electrotechnical and electronic industry

• 3.3
  – Product subpart: Subunit(s) of a product part
  – Note 1: A product part, such as an assembled printed circuit-board, consists, for example, of the product subparts bare printed circuit-board and components.
Electronic Component Definition, IEC 62542

3.15 electronic component
electrical or electronic devices that cannot be taken apart without destruction or impairment of design use

EXAMPLE Resistors, capacitors, diodes, integrated circuits, hybrids, application specific integrated circuits, wound components and relays.

NOTE They are sometimes called electronic parts, or piece parts.

• Reference: INTERNATIONAL ELECTROTECHNICAL COMMISSION, IEC 62542 (Draft) ENVIRONMENTAL STANDARDIZATION FOR ELECTRICAL AND ELECTRONIC PRODUCTS AND SYSTEMS, Standardization of environmental aspects under Glossary of terms