Restriction of Hazardous Substances (RoHS)

Environmental Compliance

By Brian Baisden
Why Environmental Compliance

- This year consumer electronic discards will reach over 300 Million units per year!
- The USA discards 30 million computers each year!
- Mobile phones alone are projected to be discarded at the rate of 100 million per year creating in excess of 65,000 tons of waste.
WANTED

Lead
A.K.A.: Pb
Atomic Weight: 207.2
Usually Found In: Batteries, Batteries, Pipes,
Dispenser Parts, Paints, Sealers.
Remarks: Lead is a soft, malleable and corrosion resistant metal.
CAUTION: Lead has been linked to Arterial, Kidney and Reproductive damage.

WANTED

Mercury
A.K.A.: Hg, Liquid Silver
Atomic Weight: 200.59 g
Usually Found In: Thermometers, Barometers, Alternators, Solvents, Soldering铝合金.
Remarks: Nearly half of the world's mercury production is used in the production of mercury.
CAUTION: Mercury is poisonous, deadly and can enter the body through the digestive system, respiratory tract or skin.

WANTED

Hexavalent Chromium
A.K.A.: Cr(6+), Chromium Tetroxide, Lead Chrome, Iron Chromate, Stanniferous Chromate.
Atomic Weight: Unknown
Usually Found In: Spray Paint, Chrome Plating, Coatings, Stainless Steel.
Remarks: Hexavalent Chromium and its compounds present a hazard in many applications and present one of the most toxic forms of chromium.
CAUTION: Hexavalent Chromium in a known carcinogen and has been linked to a significant increase in lung cancer and permanent eye damage.

WANTED

Cadmium
A.K.A.: Cd
Atomic Weight: 112.41 g
Usually Found In: Batteries, Alloys, Hi-Ci Batteries, TV Tubes, Semiconductors.
Remarks: Cadmium is a known carcinogen in some forms, including fuses, granules, pellets, wire and paint.
CAUTION: Cadmium is Highly Toxic.

WANTED

Polybrominated Biphenyls
A.K.A.: PBDEs
Atomic Weight: Unknown
Usually Found In: Plastics, Computer Monitors, TVs, Textiles, Food products.
Remarks: Adding PBDEs to plastics makes them difficult to burn. UK manufacture of PBDEs stopped in 2008.
CAUTION: Exposure to PBDEs has been linked to Neurotoxic effects, such as thyroid damage, liver damage, Mercury & Learning Impairment, Memory Loss, System & Sertolii Development.

WANTED

Polybrominated Diphenyl Ethers
A.K.A.: PBDEs
Atomic Weight: Unknown
Usually Found In: Air, Soil, Water & Wildlife samples.
Remarks: PBDEs are a class of organic compounds used in a wide variety of products, including rubber, plastics, and paints.
CAUTION: There are 209 different types of PBDEs and all are produced by only 8 manufacturers. PBDEs are suspected of causing cancer, Thyroid damage, Mercury & Learning Impairment, Memory Loss, System & Sertolii Development.
RoHS (2002/95/EC) Directive

- July 1, 2006, electrical and electronic equipment “put on the market” may not contain Lead, Mercury, Cadmium, Hexavalent Chromium. Polybrominated Biphenyls (PBBs) and Polybrominated Diphenyl Ethers (PBDEs) in amounts exceeding the set Maximum Concentration Values.
RoHS Material Limits

- Lead (Pb)
- Mercury (Hg)
- Hexavalent Chromium (CrVI)
- Polybrominated Biphenyls (PBB) or (C\textsubscript{12}H\textsubscript{4}Br\textsubscript{6})
- Polybrominated Diphenyl Ethers (PBDE)
  0.1wt% per (1000ppm) “homogeneous material”

- Cadmium (Cd)
  0.01wt% per (100ppm) “homogeneous material”
Material “Where Used”

- **Lead (Pb)**
  - Printed Wiring Boards
  - Solder
  - Cable insulation, Jacketing, Color concentrates
Material “Where Used”

- Mercury (Hg)
  - Switches
  - Relays
  - Mercury Discharge Lamps
Material “Where Used”

- **Hexavalent Chromium (CrVI)**
  - Paints
  - Toners
  - Corrosion Inhibitor

Pacific Gas and Electric
Hinkley, California
Material “Where Used”

- **Polybrominated Biphenyls (PBBs)**
- **Polybrominated Diphenyl Ethers (PBDEs)**
  - Plastic Connectors and Housings
  - Cables
  - Capacitors
Material “Where Used”

- **Cadmium (Cd)**
  - Cables
  - Semiconductors
  - Batteries

![Pie chart showing material usage]
Complying with RoHS is Required

Failure to comply with the requirements of RoHS Regulations will result in the removal of the manufacturers products from the market place.
RoHS Decision Tree

Needs electric currents or electromagnetic fields to work?  
Yes 

Less than 1,000V AC or 1,500V DC?  
Yes 

Fits within one of the 8 product categories?  
<table>
<thead>
<tr>
<th>Large Household Appliances</th>
<th>Small Household Appliances</th>
<th>IT &amp; Telecoms Equipment</th>
<th>Consumer Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting Equipment</td>
<td>Electrical &amp; Electronic tools</td>
<td>Toys, leisure &amp; sports Equipment</td>
<td>Automatic Dispensers</td>
</tr>
</tbody>
</table>

Yes 

Covered by a specific exemption?  
| Large-scale stationary industrial tool | Spare parts for repair of EEE placed on market before 1 July 2006 |
| Exemptions listed in Annex C | Spare parts for the capacity expansion or upgrade of EEE placed on the market before 1 July 2006* |

Yes, Not Covered 

No, Not Covered 

Intended for a specific national security and/or military purpose?  
Yes, Not Covered 

No, Not Covered 

Main power source is electricity?  
Yes 

Electricity is needed for primary function?  
Yes 

Forms part of equipment not included in product categories?  
Yes, Not Covered 

No, Not Covered 

Covered by scope of the Regulations
Due Diligence

A person shall not be entitled to rely on the defense provided by reason of his reliance on information supplied by another, unless he shows that it was reasonable in all the circumstances for him to have relied on the information.
Demonstration of Due Diligence

- **Product Category**
  - Review products and accessories to determine RoHS Category
  - Gray products may require 3rd party support
  - Document data used to determine category

- **Exemption review**
  - Materials and their applications
  - Document applicable exemptions

- **Material data and validation**
  - Components
  - Bare board
  - Sub assemblies
  - Housings
  - Plastics
  - Sheet metal
  - Fasteners
Demonstration of Due Diligence

- **Quality Management System**
  - Review all Business and Technical Procedures that may cause a RoHS Non-Compliance.
  - Modify procedures as necessary.

- **RoHS Compliance Auditing**
  - Develop a documented RoHS compliant auditing process.
  - Validate the effectiveness of modified procedures and processes
  - Internal Audit results
  - 3rd Party auditing
  - Auditing must be an ongoing activity not a one time event.
Incoming Material Flowchart

Receiving

Product verified against Purchase Order

Receiving transports to holding area.

Quality - Inspect to print

QA Material Verification and approval

Yes

Place approval tag

Place into inventory

No

Return Material to Supplier

Purchasing to notify vendor or return parts

Return

NMR Tag Applied Non-Conforming Material

Deviate if temporarily acceptable

(CAR) = Corrective Action Report
(NMR) = Non-Conforming Material Report
Vendor Qualification Flowchart.

Company (RoHS) Requirement

Vendor (RoHS) Survey

Review the (RoHS) Survey feedback from Vendor

Qualify/Approve Vendor

Product (RoHS) Approved

Yes

RoHS Approved Vendor

No

Action for Improvement

Vendor Audit / Follow up of improvement

Yes

OK

No

3rd Party Qualification required if compliance Information cannot be obtained.
Corrective Action Flowchart

Detection of Non-Conforming Item

Halt Production

Quarantine/Audit Suspect Product

Verify Part or Document for Compliance

Product Verification

Yes

Document Audit Process (CAR)

Resume Production

No

Supplier

Notification to supplier of non-conformance

(CAR) = Corrective Action Report
Proof of Compliance

- A producer shall, at the request of the EU enforcement authority, submit within 28 days of the date of the request, technical documents or other information showing that electrical and electronic equipment placed on the market complies with the requirements of the regulations.
Proof of Compliance

Due Diligence, simply means that you have systems and procedures in place that work and that you can prove it.
Tools of Enforcement

X-Ray Fluorescence Analyzer

Notification of concern from external parties

Product Knowledge

• Market intelligence
• Products known to contain materials of high concern
• High-volume products
• Consumer products unlikely to be recycled

Documentation Review
One product may contain over hundreds of homogeneous materials.
RoHS (2002/95/EC) Directive

- **Homogeneous Material**
  - A Material that cannot be mechanically disjointed into different materials

- **Mechanically Disjointed**
  - The materials can be, in principle, separated by mechanical actions such as unscrewing, cutting, crushing, grinding.
Material in actual cases?
Investigate Complete System

Security Light

Remote Transmitter

Remote Entrypad

WallStation Transmitter

iDrive Pro
TorqueMaster
Exemptions to the RoHS Directive

- Medical Equipment and Control Instruments.
- Automotive, Defense and Aerospace Industry Equipment.

See Directive for complete listing of exemptions.
Can your company afford to be shut out of any major market?
HARDWARE
Design and Manufacturing

- Component Identification
- Component Selection
- PCB designs from the perspective of electing solderable coatings.
  - Immersion Gold
  - Immersion Silver
  - Immersion Tin
  - OSP (Organic Solder Preservative)
Design and Manufacturing

- **Higher heat profiles**
  - Laminates
  - Number of thermal cycles

- **Compatibility of those components to the new thermal profiles.**
  - Bake cycles and double sided mounting on assemblies

- **Reflow processes**
  - Higher temperatures and longer dwell times
Component Identification

- RoHS does not specify any labeling requirements.
- Industry driven labeling for identification.
- The RoHS label does include all banned materials rather than concentrating on just lead.
Component Identification

SCHURTER
Sub-miniature fuse-link
IEC/EN 60127-3/4

PIECE 1000  TYPE: USF 1206
T 800 mA 250V

PART NO 3413.0112.26
IR 100 A /250V AC

BATCH 11111
DATE 0440
Swiss made

BARCODE

(01) 97611908294017 (30) 001000
(10) 0000000111110440

RoHS Compliant 2002/95/EC

CE
Laminates

- Must have lead free solderable coatings.
- Must comply with list of identified RoHS materials.
- Must be able to meet new thermal excursion temperatures.
- 5X Thermal shock at 260°C results are a key indicator of material performance in higher temperature lead free assembly applications.
Manufacturing process changes

- Lead free components will require:
  - Training of material handling personnel.
  - Identification of parts and Inspection.
  - Providing proper storage and environments.
  - Awareness of moisture sensitivity of components. (MSL)
Moisture Sensitivity Level (MSL)

<table>
<thead>
<tr>
<th>Level</th>
<th>Floor Life</th>
<th>Cond degC/%RH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>unlimited</td>
<td>&lt;=30/85%</td>
</tr>
<tr>
<td>2</td>
<td>1 year</td>
<td>&lt;=30/60%</td>
</tr>
<tr>
<td>2a</td>
<td>4 weeks</td>
<td>&lt;=30/60%</td>
</tr>
<tr>
<td>3</td>
<td>168 hours</td>
<td>&lt;=30/60%</td>
</tr>
<tr>
<td>4</td>
<td>72 hours</td>
<td>&lt;=30/60%</td>
</tr>
<tr>
<td>5</td>
<td>48 hours</td>
<td>&lt;=30/60%</td>
</tr>
<tr>
<td>5a</td>
<td>24 hours</td>
<td>&lt;=30/60%</td>
</tr>
<tr>
<td>6</td>
<td>TOL</td>
<td>&lt;=30/60%</td>
</tr>
</tbody>
</table>

1) TOL means 'Time on Label', or the time indicated on the label of the packing.
Component Issues for Reliable Pb-Free Assembly

- Moisture/Reflow Sensitivity
  Effect of Peak Reflow Temperature

- Solderability
  Backward & Forward Compatibility
Moisture/Reflow Sensitivity

Plastic packages absorb moisture from humidity in the air.
Reflow of Surface Mount Plastic Package

High temperature solder reflow causes condensed internal moisture to vaporize & delaminate weak interfaces.

If internal vapor pressure exceeds strength of plastic, a crack can form.
“Popcorn Effect” Type I Crack
“Popcorn Effect” Type II Crack
Bond Wire Damage
Moisture/Reflow Results

<table>
<thead>
<tr>
<th>MSL</th>
<th>Peak Reflow Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>225°C</td>
</tr>
<tr>
<td>2a</td>
<td>Pass  (9 units)</td>
</tr>
<tr>
<td>3</td>
<td>Pass  (9 units)</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

General Rule-of-Thumb: a 15-20 °C change in peak temperature, will affect moisture sensitivity by one MSL Level.
Lead Free Process Compatibility

<table>
<thead>
<tr>
<th>Components</th>
<th>No Lead (no Pb) Components</th>
<th>Lead (Pb) Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solder Method</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>250~260 deg C</td>
<td>230~240 deg C</td>
</tr>
</tbody>
</table>
Solderability

- Pb-free solders will require longer wetting times and higher reflow temperatures.
  - Recommended times above 235°C >30 sec.
  - Peak reflow temperatures > 240°C needed.
  - Temperatures must be less than 260°C due to max temp limitations for both components & PWBs.
Life Cycle Testing

- Based on complexity of design, further testing may prove valuable to avoid product failures.

- **HALT (Highly Accelerated Life Testing)**
  - Identifying the weak points in a design

- **HASS (Highly Accelerated Stress Screening)**
  - Designed to only fail production units that have incipient flaws
Summary

- RoHS Requires new understanding of product materials & compliance risks.

- RoHS will drive expanded compliance requirements through supply chain.

- Compliance Tools: Education/Testing/Auditing
  Screening products during development can be beneficial.
Special Thanks To:

CRI - CONTROL RESOURCES INCORPORATED

STR - Specialized Technology Resources, Inc.

Quality, Safety and Compliance Experts
Providing Solutions to Improve Product Success in the Marketplace

AMI

sti electronics

ANALYTICAL LAB

Imagineering Inc.

Kester®
Reference

- http://www.rohs.gov.uk
- http://www.strquality.com
- http://www.rohsguide.com
- http://www.pcbnet.com
- http://www.stielectronicsinc.com
- http://www.ul.com
THANK YOU!