# Restriction of Hazardous Substances (RoHS)

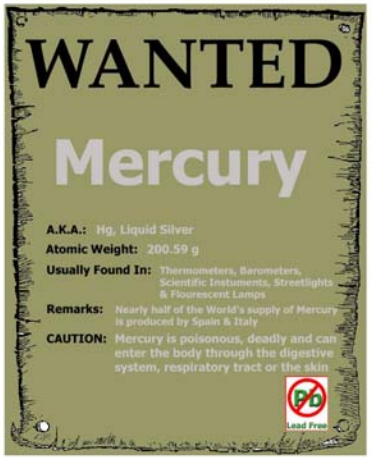
## Environmental Compliance

By Brian Baisden

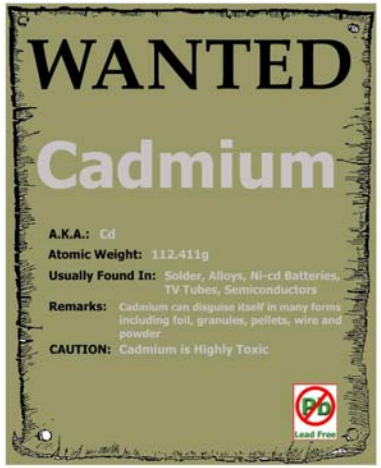
# Why Environmental Compliance

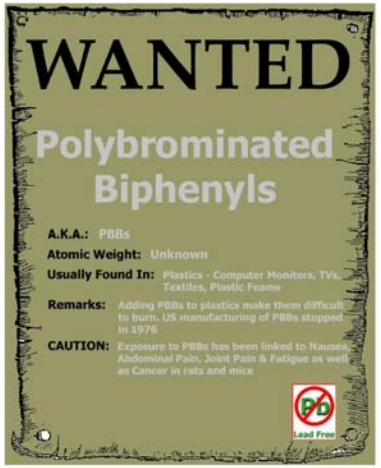
- This year consumer electronic discards will reach over 300 Million units per year!
- The USA discards 30 million computers each year!
- Mobile phones alone are projected to be discarded at the rate of 100 million per year creating in excess of 65,000 tons of waste.

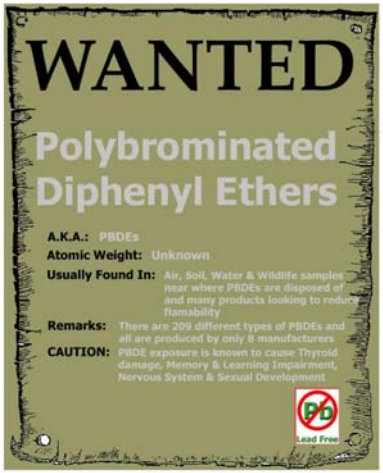

WANTED
Lead
A.K.A.: Pb
Atomic Weight: 207.2
Usually Found In: Solder, PCBs, Batteries, Pipes, X-Ray Shields, Petrol, Paint, Insecticides
Remarks: Lead is a soft, malleable and corrosion resistant material.
CAUTION: Lead has been linked to Anemia, Kidney and Reproductive damage
Pb
Lead Free


WANTED
Mercury
A.K.A.: Hg, Liquid Silver
Atomic Weight: 200.59 g
Usually Found In: Thermometers, Barometers, Scientific Instuments, Streetlights & Flourescent Lamps
Remarks: Nearly half of the World's supply of Mercury is produced by Spain & Italy
CAUTION: Mercury is poisonous, deadly and can enter the body through the digestive system, respiratory tract or the skin
Pb
Lead Free


WANTED
Hexavalent Chromium
A.K.A.: Calcium Chromate, Chromium Trioxide, Lead Chromate, Zinc Chromate, Strontium Chromate
Atomic Weight: Unknown
Usually Found In: Spray Paints, Chrome Plating, Coatings, Stainless Steel
Remarks: Hexavalent Chromium and its compounds are found in many workplaces and present one of the greatest workplace hazards around
CAUTION: Hexavalent Chromium is a known Carcinogen and has been linked to a statistically significant increase in lung Cancer, Ulcers and permanent eye damage
Pb
Lead Free


WANTED
Cadmium
A.K.A.: Cd
Atomic Weight: 112.411g
Usually Found In: Solder, Alloys, Ni-cd Batteries, TV Tubes, Semiconductors
Remarks: Cadmium can disguise itself in many forms including foil, granules, pellets, wire and powder
CAUTION: Cadmium is Highly Toxic
Pb
Lead Free


WANTED
Polybrominated Biphenyls
A.K.A.: PBBs
Atomic Weight: Unknown
Usually Found In: Plastics - Computer Monitors, TVs, Textiles, Plastic Foams
Remarks: Adding PBBs to plastics make them difficult to burn. US manufacturing of PBBs stopped in 1976
CAUTION: Exposure to PBBs has been linked to Nausea, Abdominal Pain, Joint Pain & Fatigue as well as Cancer in rats and mice
Pb
Lead Free


WANTED
Polybrominated Diphenyl Ethers
A.K.A.: PBDEs
Atomic Weight: Unknown
Usually Found In: Air, Soil, Water & Wildlife samples near where PBDEs are disposed of and many products looking to reduce flamability
Remarks: There are 209 different types of PBDEs and all are produced by only 8 manufacturers
CAUTION: PBDE exposure is known to cause Thyroid damage, Memory & Learning Impairment, Nervous System & Sexual Development
Pb
Lead Free

# 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 ($C_{12}H_4Br_6$)
- **Polybrominated Diphenyl Ethers** (PBDE)

  0.1wt% per (1000ppm) “homogeneous material”

- **Cadmium (Cd)**

  0.01wt% per (100ppm) “homogeneous material”

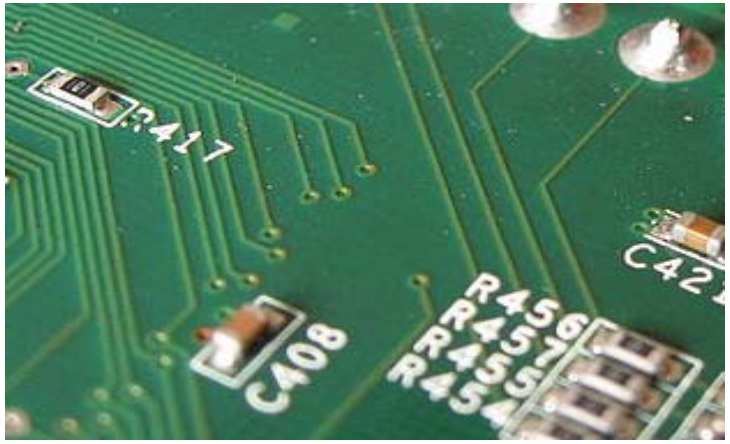
# Material “Where Used”

- **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

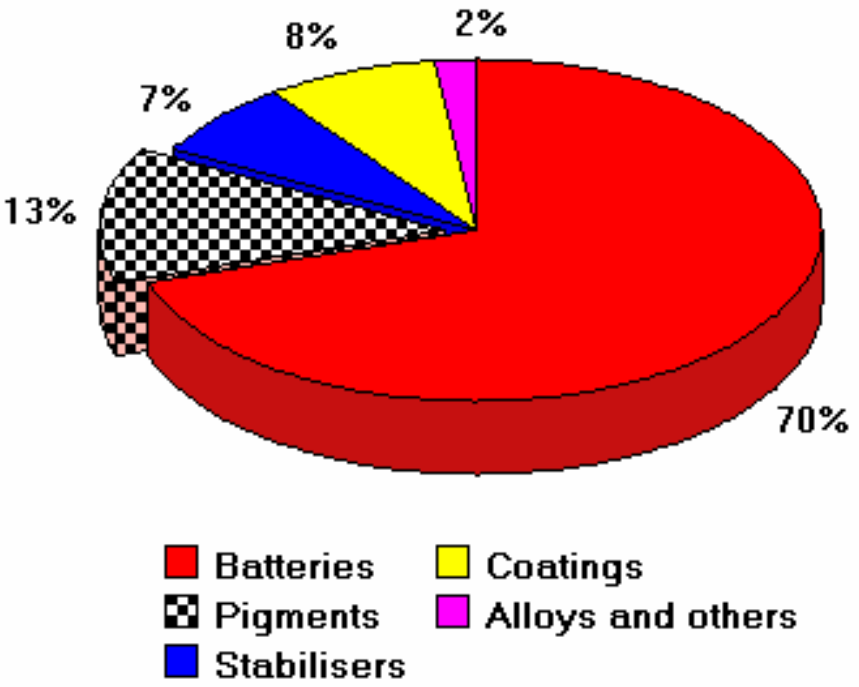
# Material “Where Used”

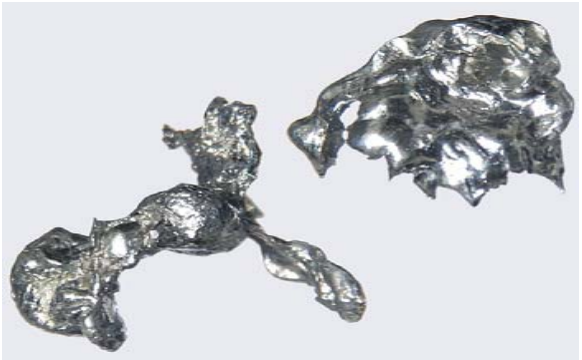
- **Cadmium** (Cd)

  Cables

  Semiconductors

  Batteries

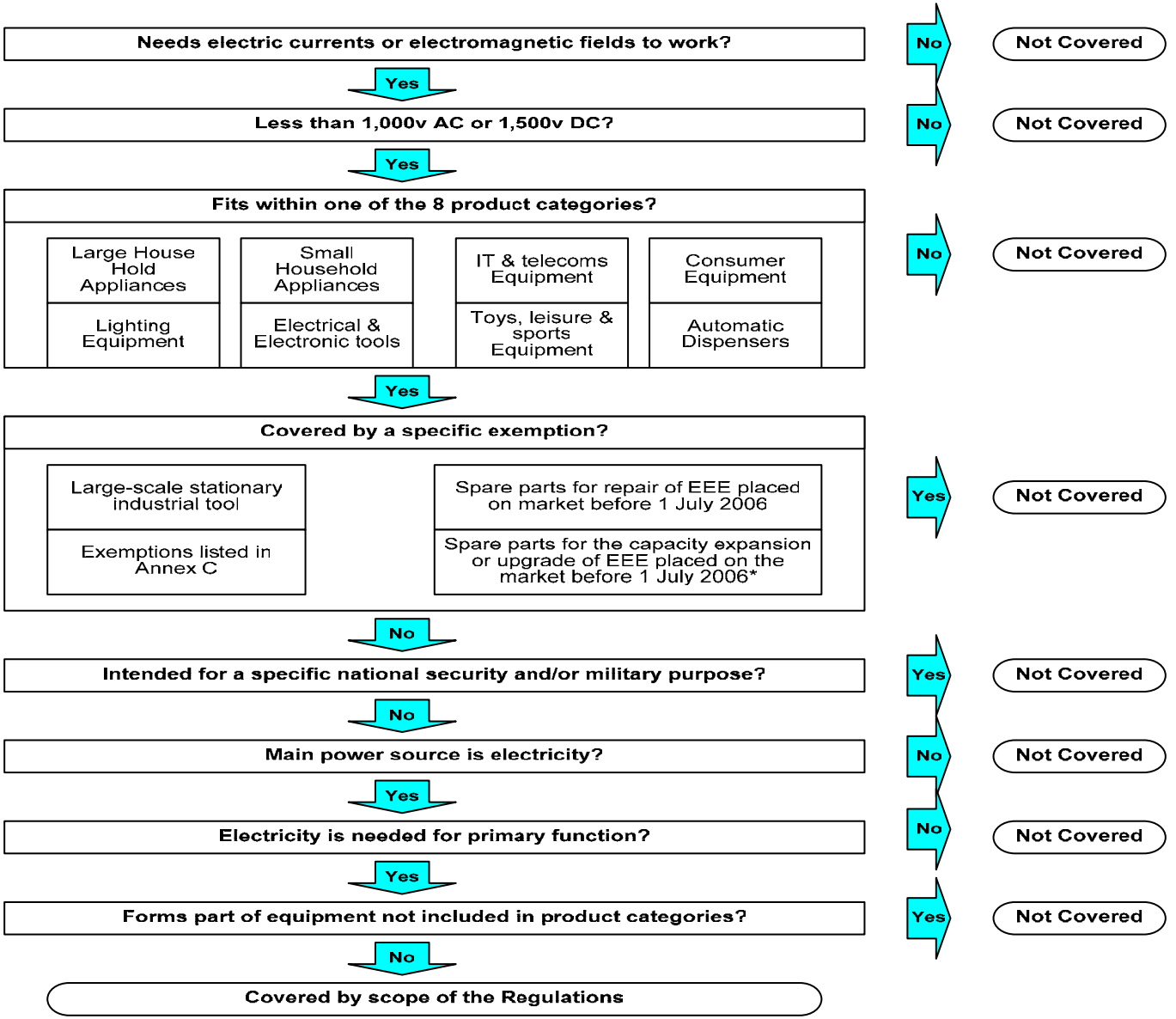


# Complying with RoHS is Required

- 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



# 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

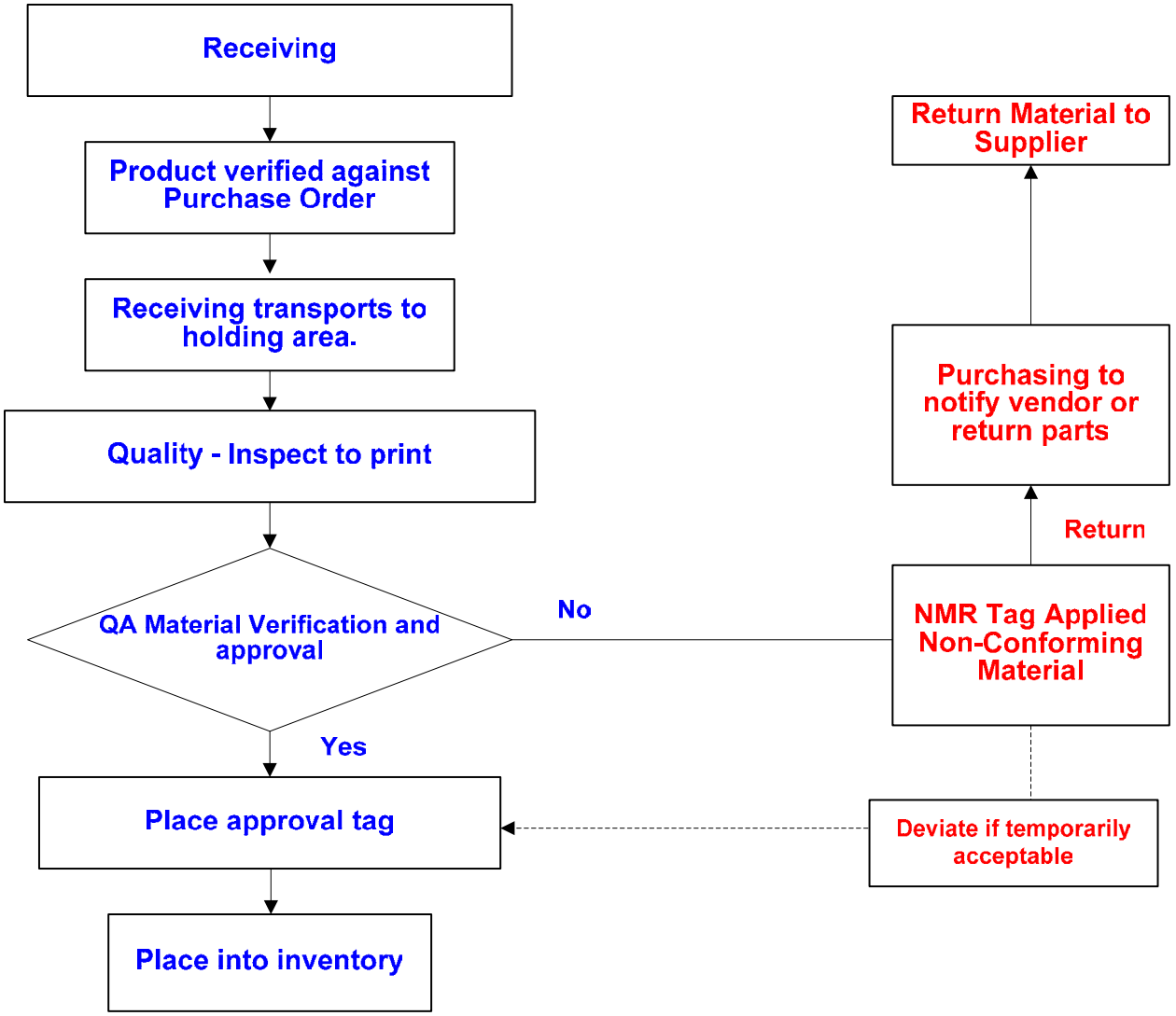
- **Product Category**
  - Review products and accessories to determine RoHS Category
  - Gray products may require 3rd party support
  - Document data used to determine category
- **Exemption review**
  - Materials and their applications
  - Document applicable exemptions
- **Material data and validation**
  - 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.

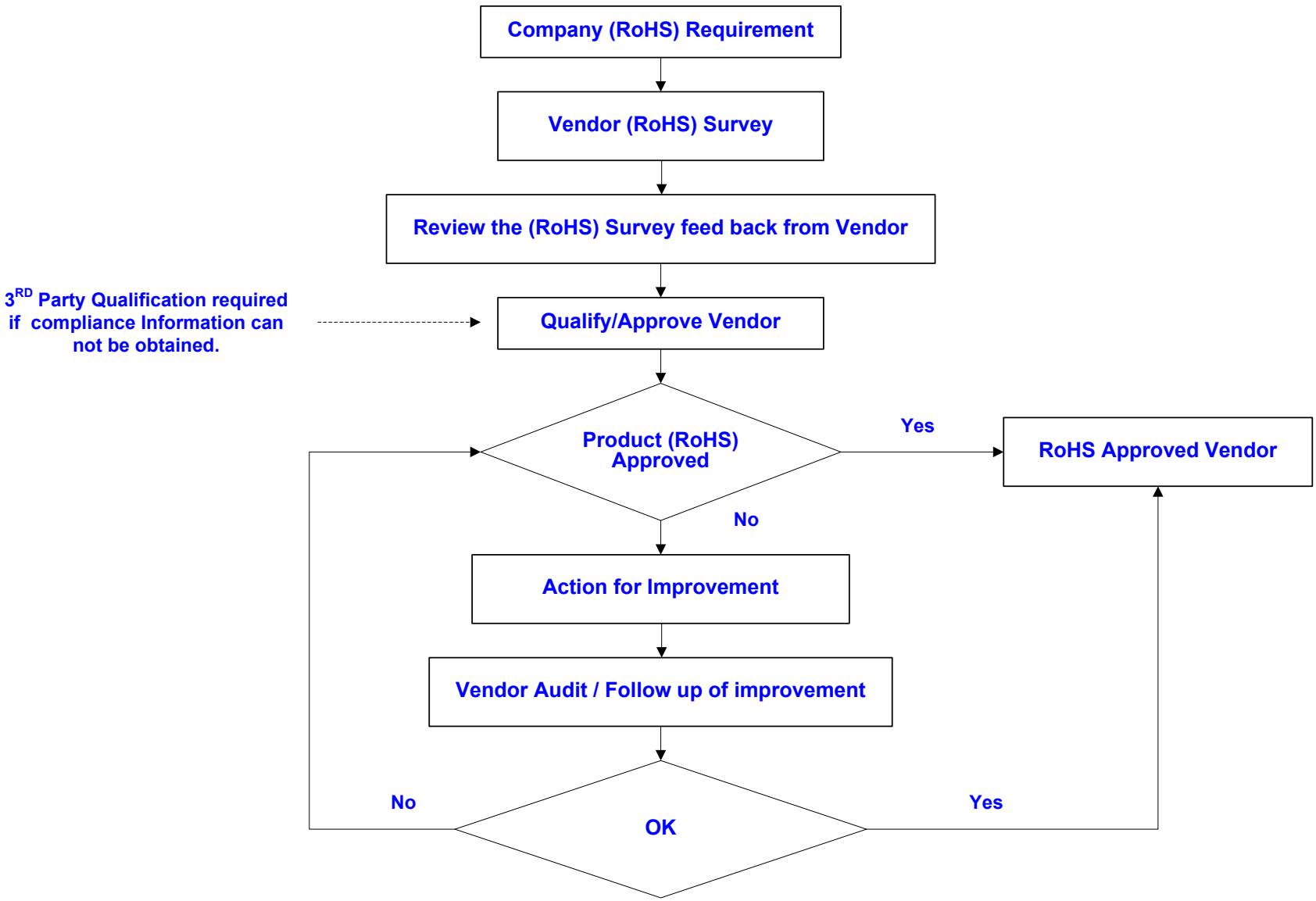
- **RoHS Compliance Auditing**
  - Develop a documented RoHS compliant auditing process.
  - Validate the effectiveness of modified procedures and processes
  - Internal Audit results
  - 3rd Party auditing
  - Auditing must be an ongoing activity not a one time event.

# Incoming Material Flowchart

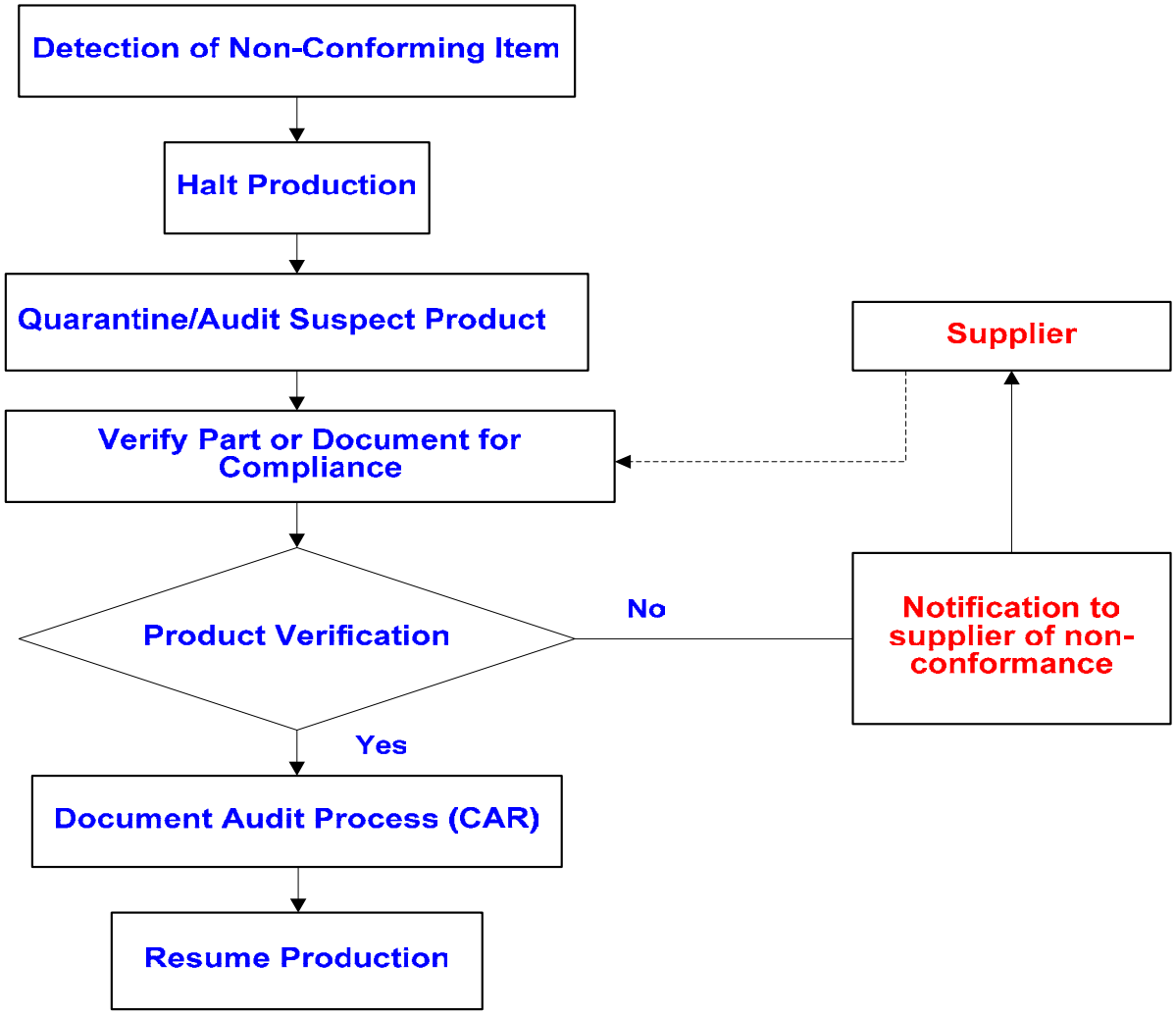



(CAR) = Corrective Action Report
(NMR) = Non-Conforming Material Report

# Vendor Qualification Flowchart.



# Corrective Action Flowchart




(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

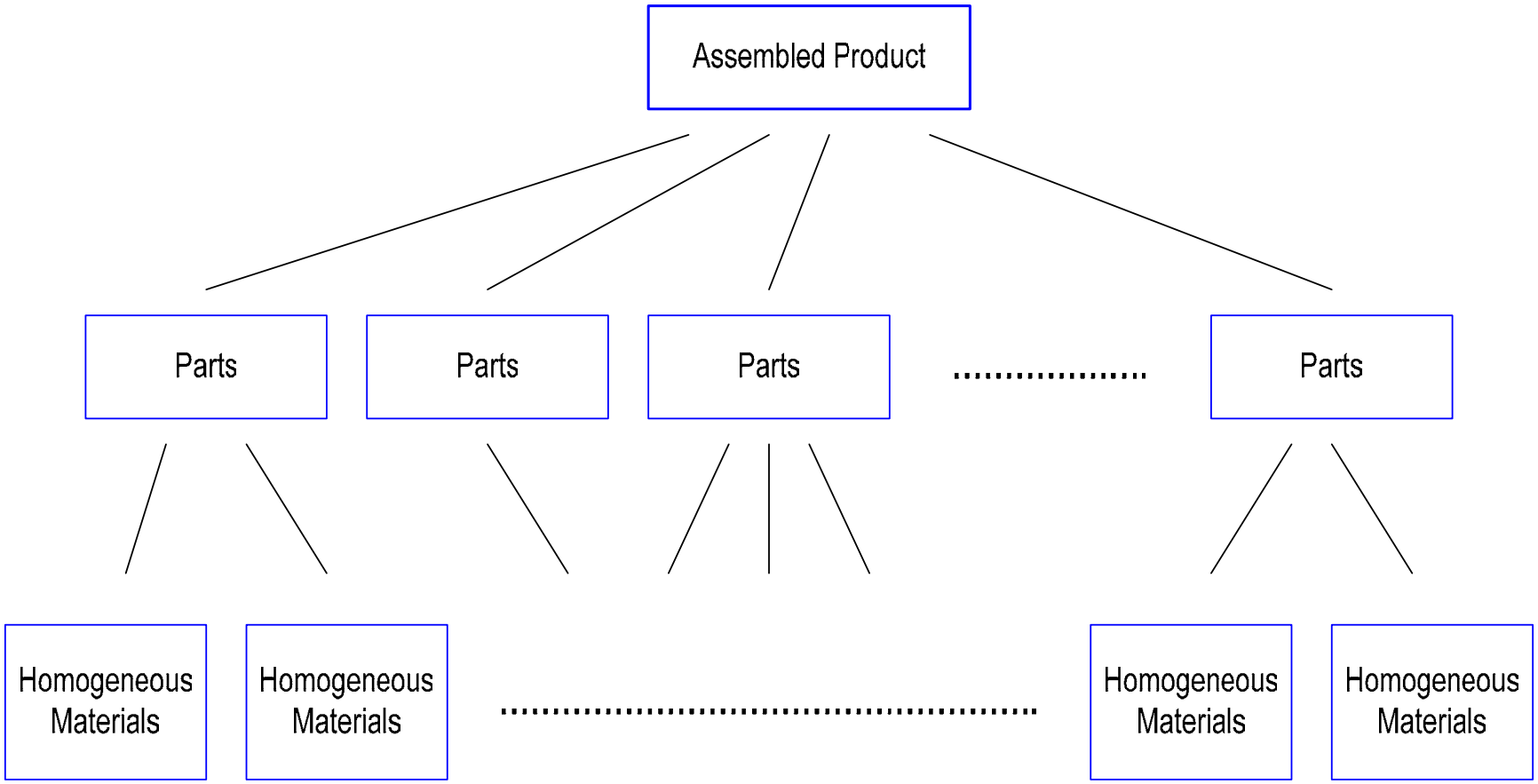
Notification of concern from external parties

Product Knowledge

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

Documentation Review

# Challenge to Industry

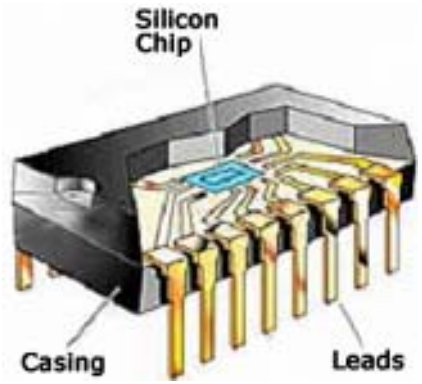



**One product may contain over hundreds of homogeneous materials.**

# 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?

# Transmitter Assembly

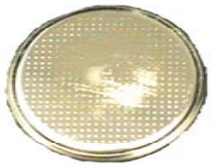
Complete Assembly

Front Cover

Buttons

Back Cover

Light Pipe



Battery

Visor Clip

PCBA

# Investigate Complete System

Security Light


iDrive Pro
TorqueMaster

Remote
Transmitter

Remote Entrypad

WallStation
Transmitter

# 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)

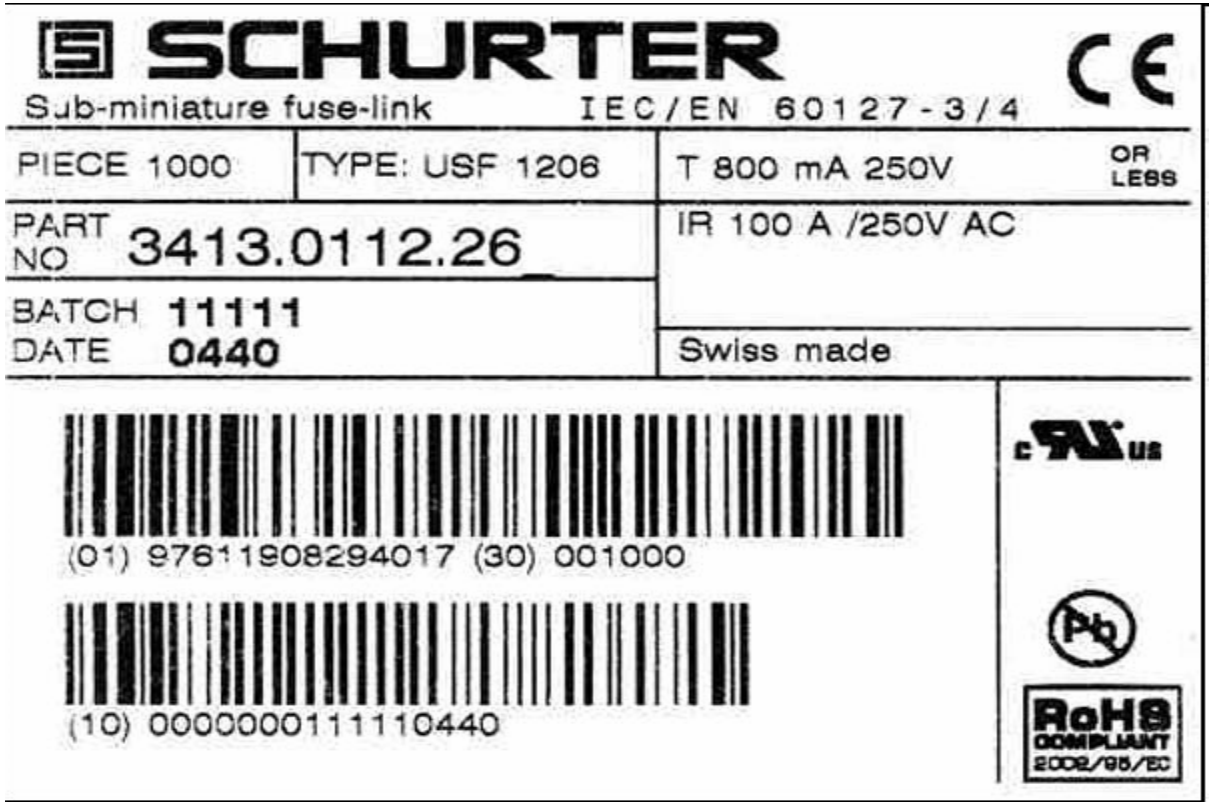
# Design and Manufacturing

- **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



# 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)

| | Floor Life | |
|---|---|---|
| Level | Time | Cond degC/%RH |
| 1 | unlimited | <=30/85% |
| 2 | 1 year | <=30/60% |
| 2a | 4 weeks | <=30/60% |
| 3 | 168 hours | <=30/60% |
| 4 | 72 hours | <=30/60% |
| 5 | 48 hours | <=30/60% |
| 5a | 24 hours | <=30/60% |
| 6 | TOL | <=30/60% |

1) TOL means 'Time on Label', or the time indicated on the label of the packing.

# Component Issues for Reliable Pb-Free Assembly

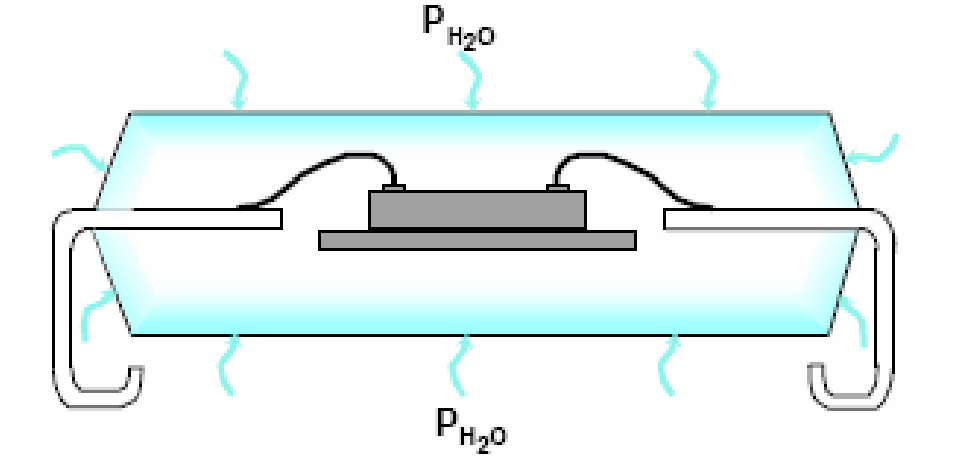
- **Moisture/Reflow Sensitivity**

  **Effect of Peak Reflow Temperature**

- **Solderability**

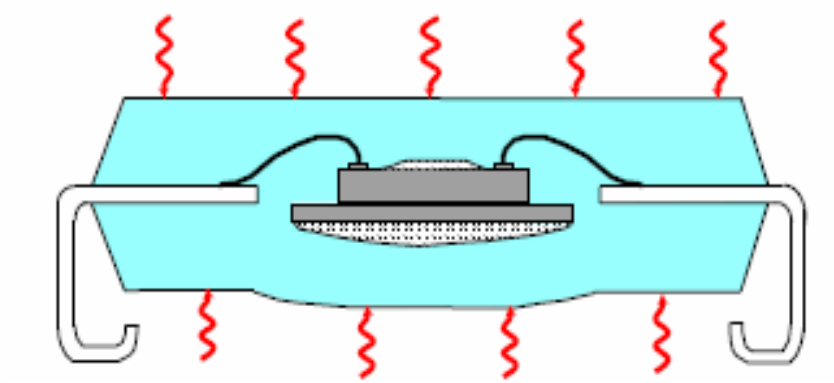
  **Backward & Forward Compatibility**

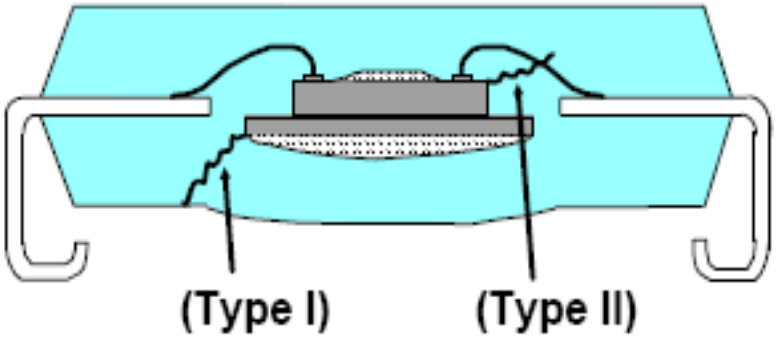
# Moisture/Reflow Sensitivity




**Plastic packages absorb moisture from humidity in the air.**

# Reflow of Surface Mount Plastic Package



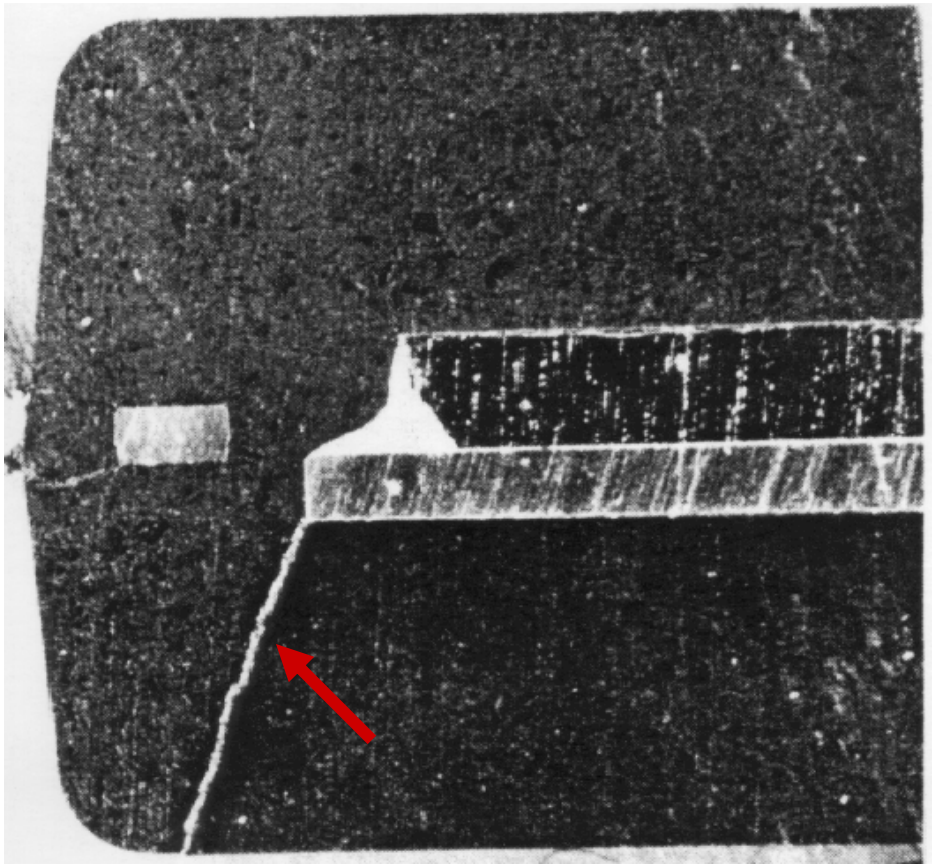


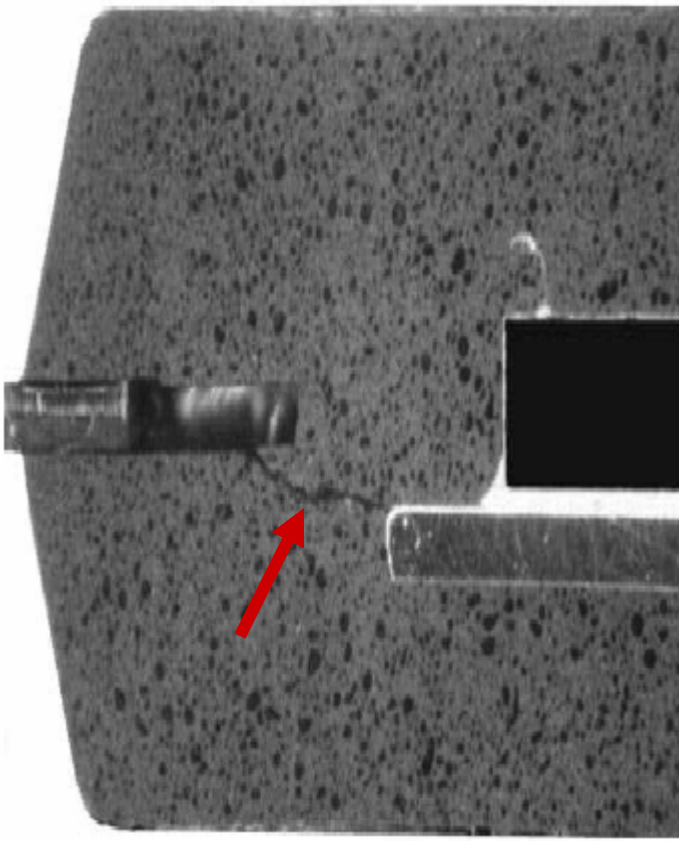

"POPCORN" CRACKS

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

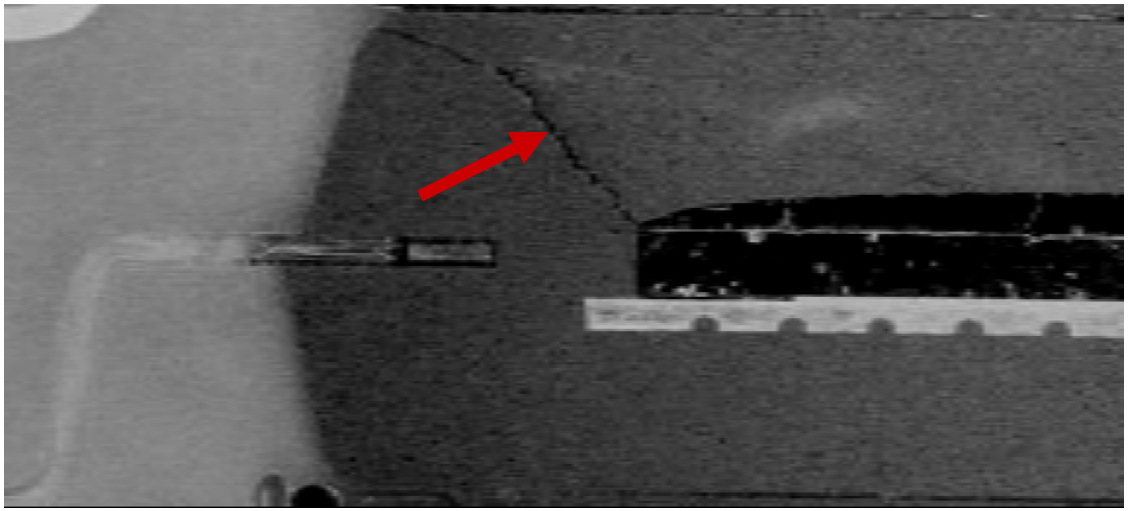
**If internal vapor pressure exceeds strength of plastic, a crack can form.**

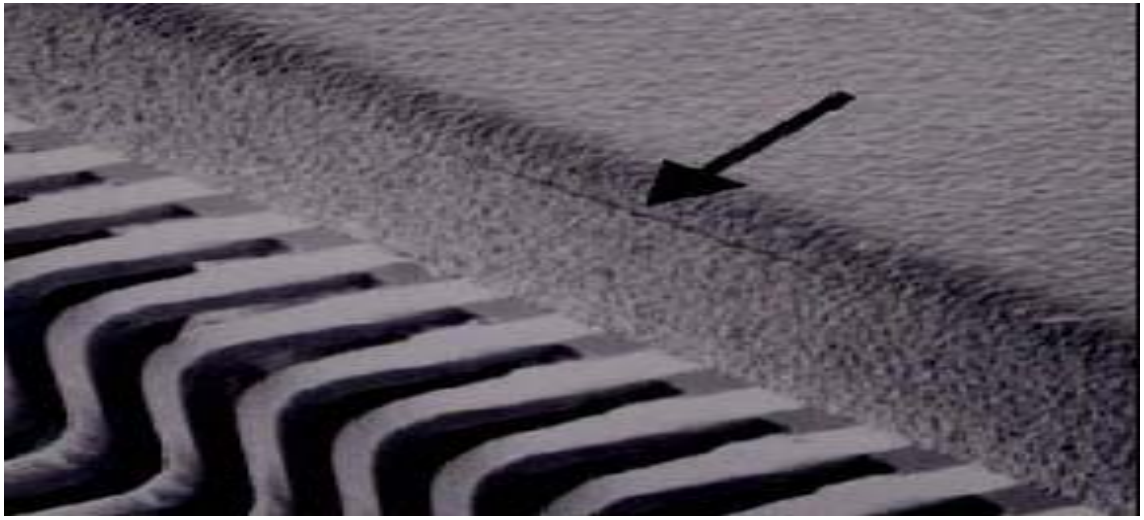
# “Popcorn Effect” Type I Crack



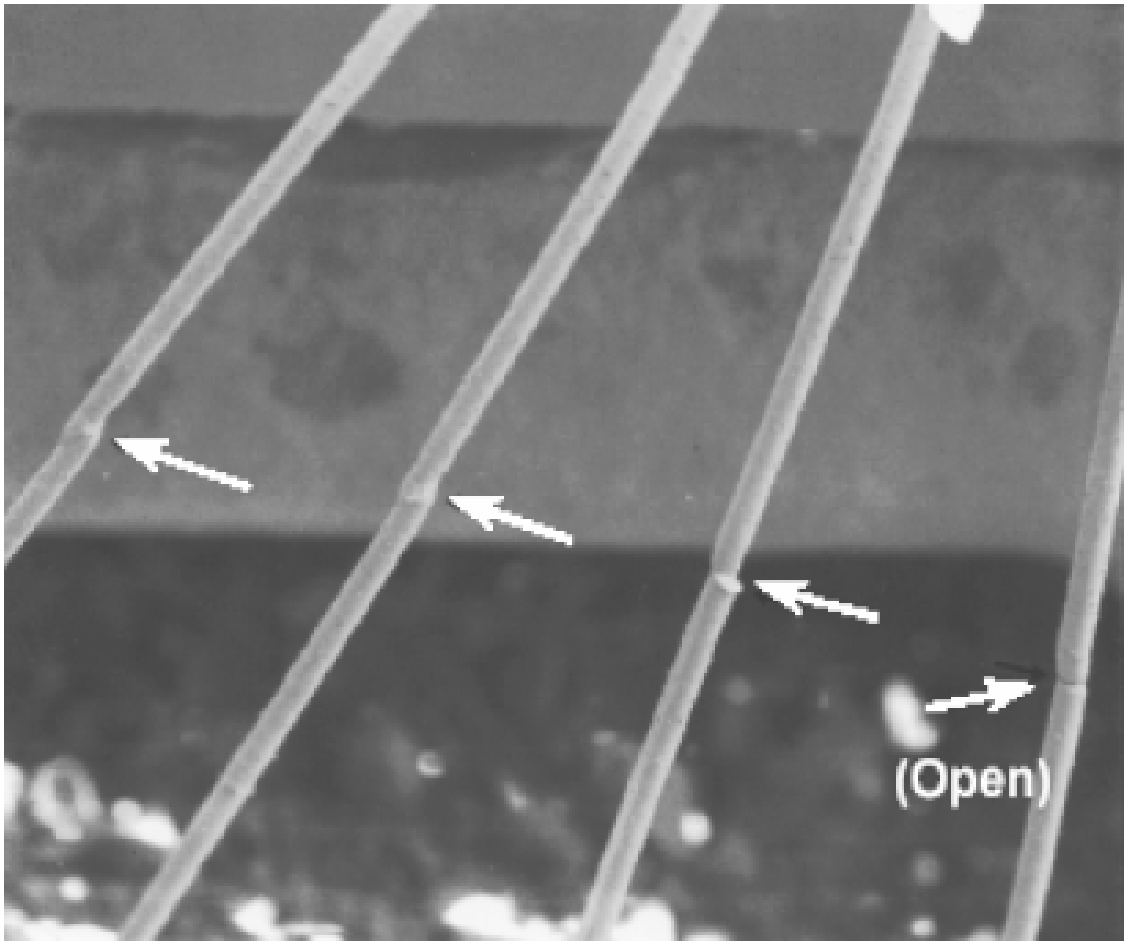


# “Popcorn Effect” Type II Crack





# Bond Wire Damage



# Moisture/Reflow Results

| MSL | Peak Reflow Temperature | | |
|---|---|---|---|
| | 225°C | 250°C | 260°C |
| 2a | Pass (9 units) | Fail (9/9 popcorn) | Fail (9/9 popcorn) |
| 3 | | Pass (9 units) | Fail (2/9 small areas of substrate delam. ) |
| 4 | | | Pass (9 units) |

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

# Lead Free Process Compatibility

| Components | No Lead ( no Pb ) Components | Lead ( Pb ) Components |
|---|---|---|
|  | | |
| Solder Method | Yes / No | Yes / Yes |
|  | No Lead ( no Pb ) Solder<br>250~260 deg C | Lead ( Pb ) Solder<br>230~240 deg C |

# 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:





# Reference

- **http://www.rohs.gov.uk**
- **http://www.strquality.com**
- **http://www.rohsguide.com**
- **http://ec.europa.eu/environment/waste/weee/index_en.htm**
- **http://www.pcbnet.com**
- **http://www.stielectronicsinc.com**
- **http://www.ul.com**

# THANK YOU!