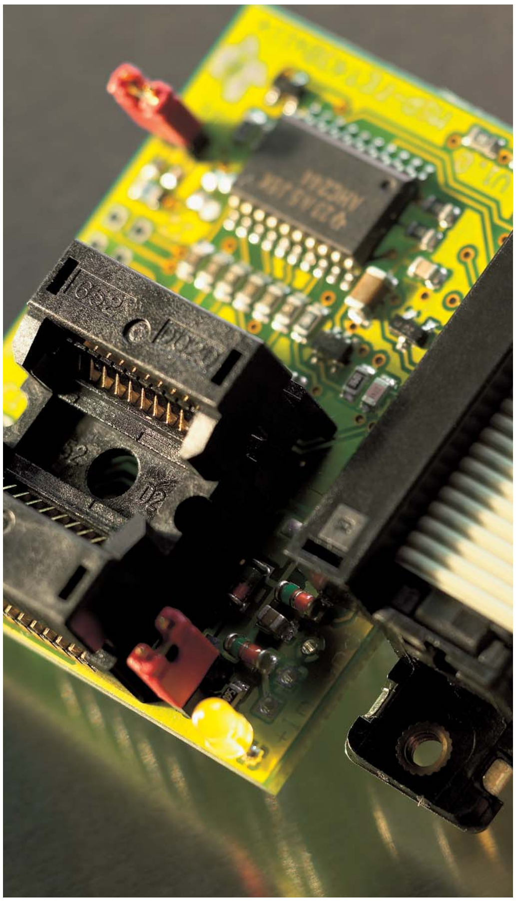
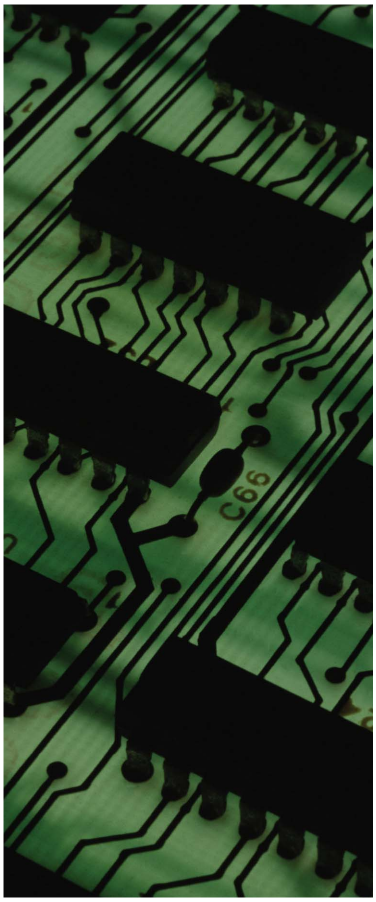
NEWARK inone[SM]

RoHS Legislation and Technical Manual

Step-by-step Guide
(Version 2)





Newark InOne is pleased to present you with this comprehensive guide produced by Farnell InOne, our sister distributor in the UK who has been at the forefront of RoHS compliance.

Visit RoHS Express at **www.newarkinone.com/rohs** frequently, as we are continually updating its content.

FARNELL inone

RoHS Legislation and Technical Manual

Step-by-Step Guide (Version 2)

Contents

Introduction to the requirements of the RoHS Directive 2002/95/EC RoHS

The Restriction of the use of certain Hazardous Substances (RoHS) Directive restricts six substances:-

- Lead - (Pb)
- Mercury - (Hg)
- Hexavalent chromium - (Cr(VI))
- Cadmium - (Cd)
- Polybrominated biphenyl flame retardants - (PBB)
- Polybrominated diphenyl ether flame retardants - (PBDE)

These materials are restricted in equipment that is within the scope of this directive:

The Directive applies to electrical and electronic equipment that is dependent on electric or electromagnetic fields in order to work properly. Also, equipment for the generation, transfer and measurement of such currents and fields falling in the categories listed on page 9 of this guide and designed for use with a voltage rating not exceeding 1,000 volts for alternating current and 1,500 volts for direct current

The scope is eight of the ten categories of the Waste Electrical and Electronic Equipment (WEEE) Directive. These are:

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment (including light bulbs, and luminaires in households)
6. Electrical and electronic tools (except large scale stationary industrial tools)
7. Toys, leisure and sports equipment
10. Automatic dispensers

The RoHS requirements apply to end products that fall within its scope and this means that all the components, and combination of components put together to form sub-assemblies, must not contain any of the restricted substances in levels above the maximum concentration values defined on page 4.

Exemptions

There are certain exemptions:

Lead: In high melting point solders

In glass of CRTs, fluorescent tubes and electronic components

In electronic ceramic parts

In certain alloys at limited concentrations

In solders for servers, storage and storage arrays and telecommunications network infrastructure equipment

Mercury: In fluorescent and other lamps

Cadmium: Plating except where banned by directive 91/338/EEC (Cadmium Directive)

Hexavalent chromium:

Carbon steel cooling systems for absorption refrigerators

Additional exemptions have also been requested which, at the time of going to print, are being assessed by the European Commission.

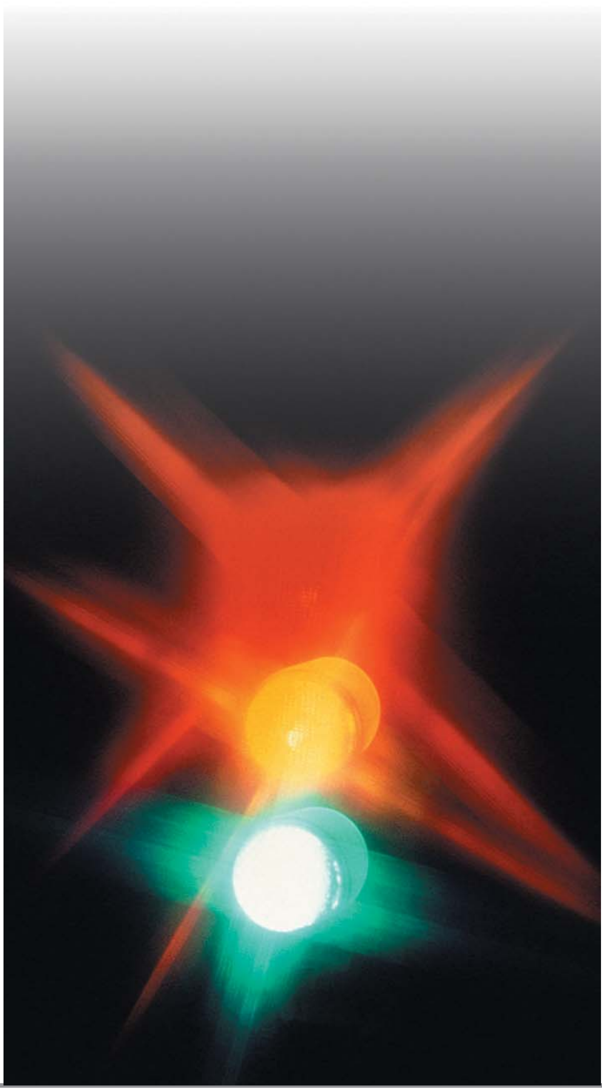
Batteries are not part of the RoHS Directive and are covered by their own legislation.

The UK Government believes that Military equipment is exempt. However, there is no specific exemption for aircraft and some equipment used within an aircraft is within the scope.

Also note that many other substances are banned by the Hazardous Substances Directive. This includes two of the PBDE flame retardants - Penta and Octa-BDE. The sale of these was banned from August 2004. Note however that most other brominated flame retardants are safe to use.

Step-by-Step Guide to Compliance with the RoHS Directive

Pages 3 to 11 represent the Step-By-Step Guide to RoHS compliance compiled by Farnell InOne with ERA Technology and made available to customers at the end of 2004.



1 Does your product need to comply with the RoHS Directive?

- The Directive applies to electrical and electronic equipment that is dependent on electric or electromagnetic fields in order to work properly. Also, equipment for the generation, transfer and measurement of such currents and fields falling in the categories listed in Appendix A on page 9 of this guide and designed for use with a voltage rating not exceeding 1,000 volts for alternating current and 1,500 volts for direct current.

2 Contact suppliers and ask if their materials, parts, components, etc. contain any of the six restricted substances:

- Lead, cadmium, mercury, hexavalent chromium, PBB or PBDE flame retardants.
- Suppliers should provide a declaration which could be in various formats. Some will provide this information on websites.

3 Is there any doubt about the presence of a restricted substance?

- Use the decision tree that appears on page 7 of this guide to decide if analysis is advisable.
- The frequency of analysis will depend on many factors, including your relationship with suppliers.
- Analysis frequency also depends on the potential environmental impact from inadvertent use of a restricted substance. The authorities will expect more frequent analysis of parts in products sold in very large quantities than in those sold in relatively small numbers.

4 Some suppliers may not change their part numbers so separation of RoHS compatible and RoHS incompatible parts will be needed.

5 Keep supplier declarations and analysis data in a technical file

- The authorities will expect to see this in case of a suspected infringement.

6 Your customers may ask about RoHS compliance and expect you to provide a declaration.

Introduction to the RoHS Directive

The Restriction of the use of certain Hazardous Substances (RoHS) Directive comes into force on 1st July 2006. From this date, producers of certain categories of electrical and electronic equipment (see page 9) will not be able to place on the market products that contain six banned substances unless specific exemptions apply (see page 10). This much is clear, but what will producers be expected to do by the authorities?

What is a compliant product?

The RoHS Directive applies to equipment that is within the scope of the Directive (see page 2). None of the "homogeneous materials" within compliant products must contain the six restricted substances at concentrations above the "maximum concentration values".

Who is responsible?

Producers of equipment are held responsible for ensuring that their products do not contain the six restricted substances. The Directive does not cover components or sub-assemblies and so the equipment producers will have to take their own steps to ensure that all parts and materials used in their products do not contain restricted substances.

"Producer" means any person who, irrespective of the selling technique used:

(i) manufactures and sells electrical and electronic equipment under his own brand;

(ii) resells under his own brand equipment produced by other suppliers; or

(iii) imports or exports electrical and electronic equipment on a professional basis into a member state.

It is clear from this that there will be circumstances in which it is not the actual manufacturer of a product who will assume the "producer" responsibilities.

What are the maximum concentration values (MCV)?

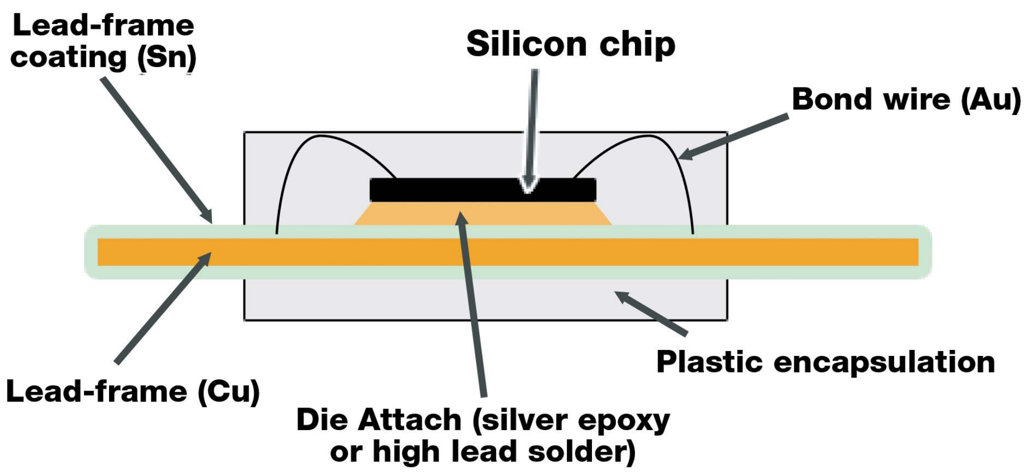
These have not been formally agreed, but are likely to be 0.1 weight percent of lead, mercury, hexavalent chromium, PBB and PBDE and 0.01 weight percent cadmium in homogeneous materials.

What is a homogeneous material?

The definition of homogeneous materials has caused some confusion in the past, but has been clarified in draft guidelines published by the European Commission.

A homogeneous material is a single substance such as a plastic, for example the PVC insulation on insulated copper wire. Components such as capacitors, transistors and semiconductor packages are not "materials" but will contain several different materials. For example, a semiconductor package will contain at least six as shown below.

Homogeneous material – semiconductor package example



Introduction to the RoHS Directive

What will producers be required to do to comply with RoHS legislation?

By placing their products on the market, producers are declaring that these comply with RoHS legislation. This is the basis for "self-declaration" which is used for several other European Union directives. There are no requirements for the application of a specific mark or testing by independent third parties. However, the authorities within each Member State will carry out market surveillance and conduct checks on products. If they find that a product does not comply with RoHS legislation, the producer will be asked to show that due diligence has been used and he has taken "reasonable steps" to comply. This legal defence is used for other legislation, but what constitutes "reasonable steps" has not been defined.

Producers will be expected to use two approaches to comply:

- Obtain declarations of compliance for materials, components and other parts from suppliers.
- Selected analysis.

Where authorities find non-compliant equipment, they will audit the producer's records, which should be in the form of a "technical file". These files must be kept for at least four years.

Compliance Declarations

Equipment producers will need to obtain materials declarations or certificates of compliance from their suppliers. At present there are no standard formats for these, although several are being developed. The minimum that these need to state is that the materials, parts or components may be used to produce RoHS compliant equipment. This confirmation must be for individual materials, not for whole components (due to the homogeneous material requirement mentioned on page 4).

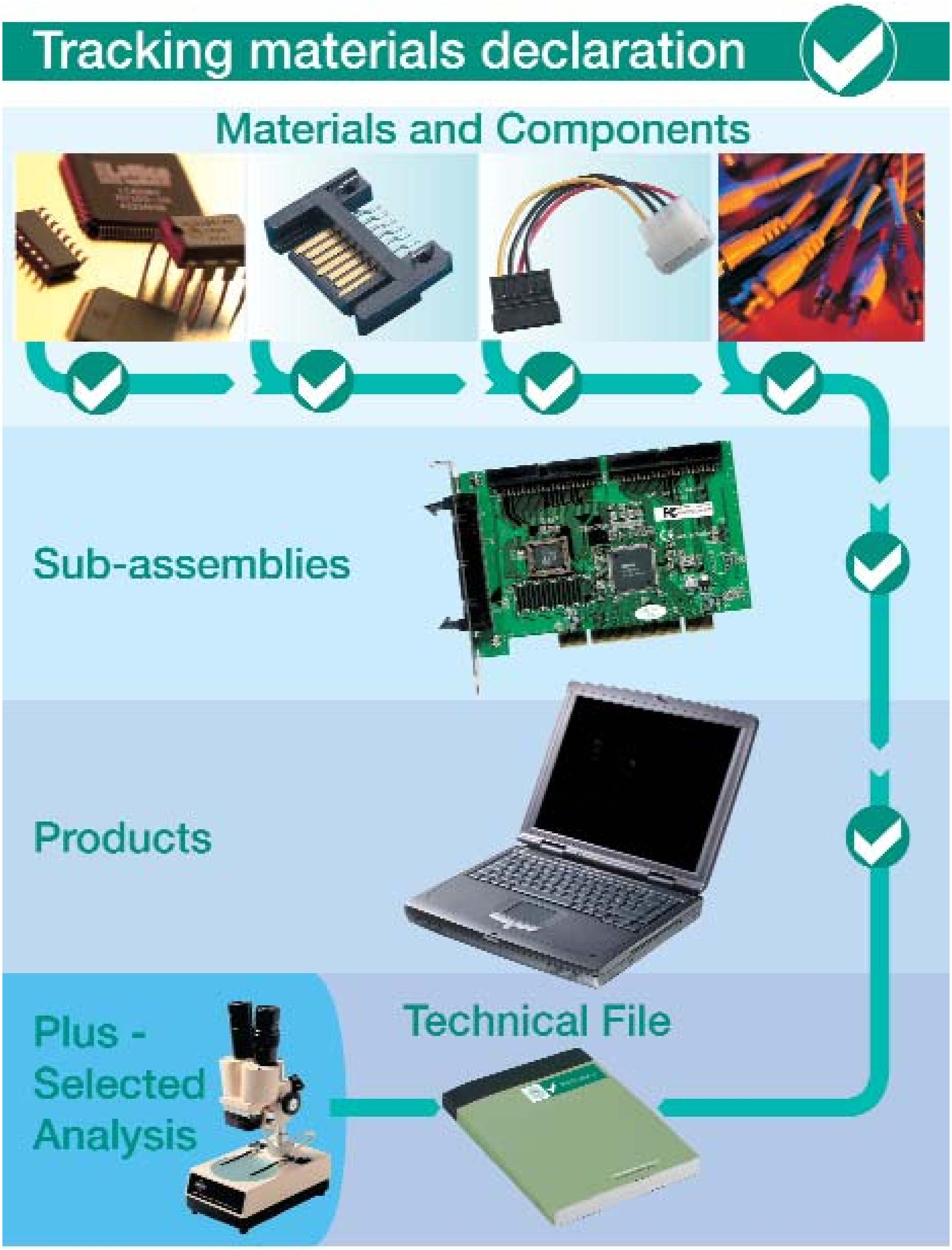
Some component manufacturers produce materials declarations for ranges of products, for example one declaration for all types of Quad Flat Pack (QFP) packages. This is reasonable because all of these would consist of the same materials and so a declaration for one part number would be identical to one for another part in the same range, and because the composition of all of the materials is identical.

Equipment producers often obtain a part on a regular basis from a supplier and these can, over a period of time, be from a number of batches. Separate declarations for each batch should not be necessary unless the manufacturer has made a change to the production process. However, equipment producers need to be aware that batch-to-batch variation may occur.

Tracking materials declaration for RoHS Compliance

The absence or presence of the six restricted substances is tracked throughout the supply chain. For example, a notebook PC manufacturer will obtain declarations on individual components and sub-assemblies, as well as carrying out selected analysis.

Materials declarations may be in paper or electronic format

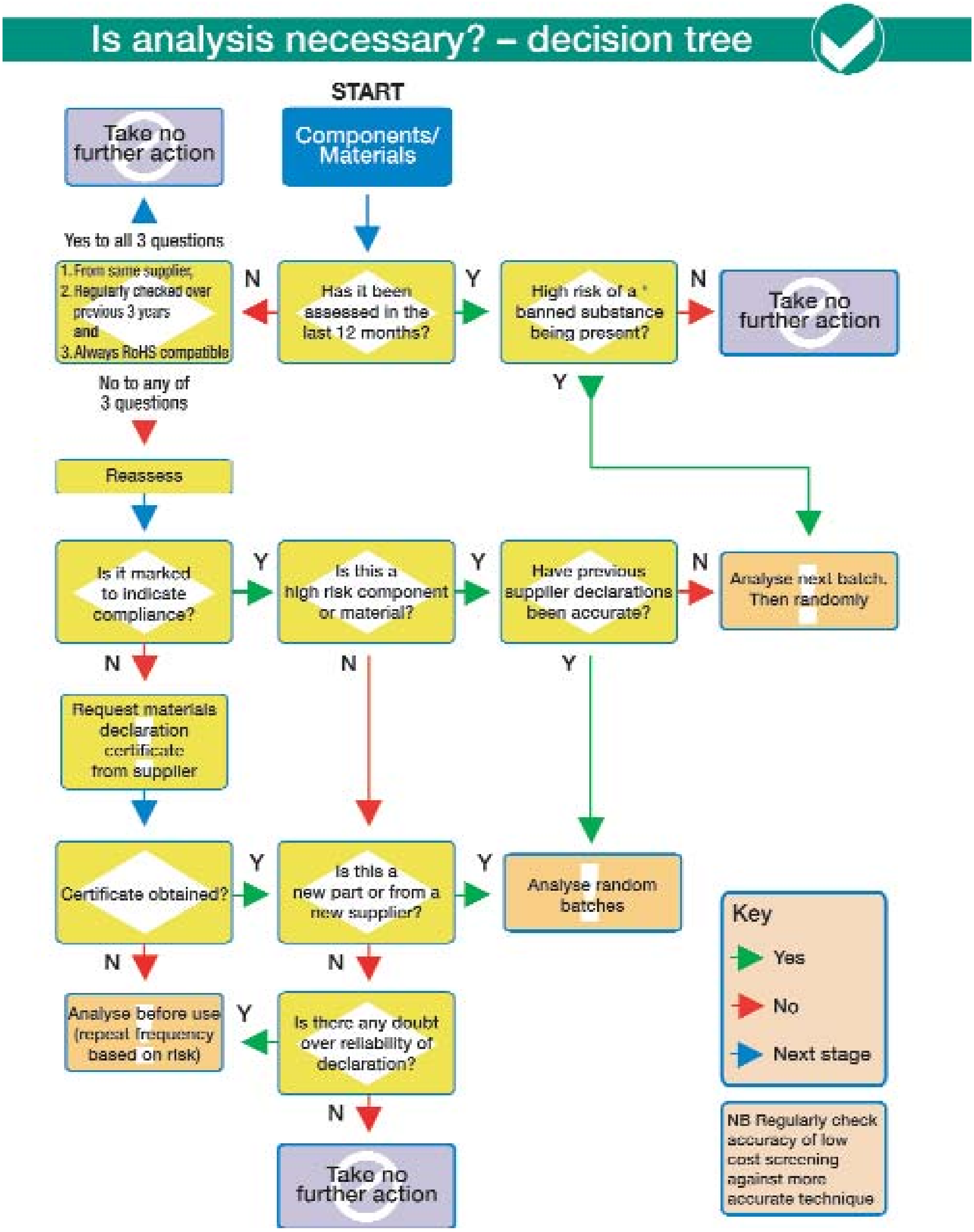


6

Selected analysis –
when to analyse?

There may be occasions when it will be advisable for a producer to carry out analysis to determine whether a restricted substance is present. There are various reasons why this might be necessary, but the decision whether to analyse is left to the equipment producer.

ERA Technology developed an example of a decision tree to help producers decide whether analysis is necessary and this was included in the Government's Proposed Guidance Notes on the UK RoHS legislation. A modified version is included here:



*There are certain materials that have a relatively high risk of containing a restricted substance. For example, PVC obtained from the Far East often contains lead and cadmium and these are occasionally found in other types of plastics.

In addition, there may be significant variation between different batches and therefore an equipment producer using multiple batches should be aware of this issue.

Selected analysis – when to analyse?

To a significant extent, the decision whether to analyse will depend on the relationship with the supplier. Analysis will be needed less often for items from well-established suppliers with proven reliability than from new "unknown" suppliers. In some cases, a producer may never need to analyse.

How and what to analyse

It is clearly unnecessary and far too costly to analyse every material. Only materials that are likely to contain a restricted substance need be checked. For example, in the case of the semiconductor package shown on page 4, the only location where a restricted substance may occur is in the tin plated termination coating as an impurity or because tin/lead alloy was used instead of tin. Connectors may contain restricted substances both in the plastic parts (lead, cadmium or PBDE) and in electroplated tin coatings.

The recommended procedure for routine analysis to check components and materials is a two-step approach. In all cases a producer should ensure that the analyst has expertise in the analysis of electronic components.

Step 1 – Routine screening.

The first step is to use a screening technique such as energy dispersive X-ray analysis (EDXRF). This has sufficient accuracy to determine:

- If no Pb, Cd, Cr, Hg or Br are present; or
- If Pb, Cd, Cr, Hg or Br are present at "significant" concentrations.

This technique gives approximate values only, unless the machine is pre-calibrated with suitable standards. Where no standards are available, analysis by a different technique may be required when the result is close to the MCV. The detection limit for lead in tin is about 0.03% if optimum analysis conditions are used.

Two types of EDXRF are available. Handheld equipment is quick and easy to use but not as accurate as desktop machines. Both types have limitations that should be clearly understood by the analyst. There are other routine screening methods available.

Step 2 – More accurate analysis

This will be necessary under the following circumstances:

- Pb, Cd or Hg was found at "borderline" concentrations – additional, more accurate, analysis would be needed. The method used will depend on the material.
- Cr was detected.
- Br was detected.

Under these circumstances, it would be advisable to ask a professional analytical laboratory to analyse suspect materials.

Appendix A

List of categories of equipment that will need to comply with RoHS legislation

The list of products below each category heading is illustrative and not exhaustive.

1. Large household appliances
(Such as large cooling appliances; refrigerators; freezers; other large appliances used for refrigeration, conservation and storage of food; washing machines; clothes dryers; dish washing machines; cooking; electric stoves; electric hot plates; microwaves; other large appliances used for cooking and other processing of food; electric heating appliances; electric radiators; other large appliances for heating rooms, beds, seating furniture; electric fans; air conditioner appliances; other fanning, exhaust ventilation and conditioning equipment)

2. Small household appliances
(Such as vacuum cleaners; carpet sweepers; other appliances for cleaning; appliances used for sewing, knitting, weaving and other processing for textiles; irons and other appliances for ironing, mangling and other care of clothing; toasters; fryers; grinders, coffee machines and equipment for opening or sealing of containers or packages; electric knives; appliances for hair-cutting, hair drying, tooth brushing, shaving, massage and other body care appliances; clocks, watches and equipment for the purpose of measuring, indicating or registering time; scales)

3. IT and telecommunications equipment
(Such as centralized data processing; mainframes; minicomputers; printer units; personal computing; personal computers, including the CPU, mouse and keyboard; laptop computers, including the CPU, mouse and keyboard; notebook computers; notepad computers; printers; copying equipment; electrical and electronic typewriters; pocket and desk calculators; other products and equipment for the collection, storage, processing, presentation or communication of information by electronic means; user terminals and systems; facsimile; telex; telephones; pay telephones; cordless telephones; cellular telephones; answering systems; other products or equipment of transmitting sound, images or other information by telecommunications)

4. Consumer equipment
(Such as radio sets; television sets; video cameras; video recorders; hi-fi recorders; audio amplifiers; musical instruments; other products or equipment for the purpose of recording or reproducing sound or images, including signals or other technologies for the distribution of sound and image than by telecommunications)

5. Lighting equipment, (including electric light bulbs and household luminaires)
(Such as luminaires for fluorescent lamps; straight fluorescent lamps; compact fluorescent lamps; high intensity discharge lamps, including pressure sodium lamps and metal halide lamps; low pressure sodium lamps; other lighting equipment for the purpose of spreading or controlling light)

6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
(Such as drills; saws; sewing machines; equipment for turning, milling, sanding, grinding, sawing; cutting; shearing; drilling; making holes; punching; folding; bending or similar processing of wood, metal and other materials; tools for riveting, nailing or screwing or removing rivets, nails, screws or similar uses; tools for welding, soldering or similar use; equipment for spraying, spreading, dispersing or other treatment of liquid or gaseous substances by other means; tools for mowing or other gardening activities)

7. Toys, leisure and sports equipment
(Such as electric trains or car racing sets; hand-held video game consoles; video games; computers for biking, diving, running, rowing, etc.; sports equipment with electric or electronic components; coin slot machines)

8. Automatic dispensers
(Such as automatic dispensers for hot drinks; automatic dispensers for hot or cold bottles or cans; automatic dispensers for solid products; automatic dispensers for money; all appliances which deliver automatically all kind of products)

Appendix B

Exemptions

The RoHS legislation does not apply to: -

- large-scale stationary industrial tools. (This is a machine or system, consisting of a combination of equipment, systems or products, each of which is manufactured and intended to be used only in fixed industrial applications).
- spare parts for the repair of Electrical and Electronic Equipment (EEE) placed on the market before 1st July 2006 and to replacement components that expand the capacity of and/or upgrade of EEE placed on the market before 1st July 2006.
- the reuse of EEE placed on the market before 1st July 2006.
- the specific applications of mercury, lead, cadmium and hexavalent chromium set out on page 12.

Applications of lead, mercury, cadmium and hexavalent chromium, which are exempted from the requirements of the RoHS Directive.

1. Mercury in compact fluorescent lamps not exceeding 5 mg per lamp.
2. Mercury in straight fluorescent lamps for general purposes not exceeding:
   – halophosphate 10 mg.
   – triphosphate with normal lifetime 5 mg.
   – triphosphate with long lifetime 8 mg.
3. Mercury in straight fluorescent lamps for special purposes.
4. Mercury in other lamps not specifically mentioned in this Appendix.
5. Lead in glass of cathode ray tubes, electronic components and fluorescent tubes.
6. Lead as an alloying element in steel containing up to 0.35% lead by weight. aluminium containing up to 0.4% lead by weight and as a copper alloy containing up to 4% lead by weight.
7. Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85% lead).
8. Lead in solders for servers, storage and storage array systems (exemption granted until 2010).
9. Lead in solders for network infrastructure equipment for switching, signalling, and transmission as well as network management for telecommunication.
10. Lead in electronic ceramic parts (e.g. piezoelectronic devices).
11. Cadmium plating except for applications banned under Directive 91/338/EEC (1) amending Directive 76/769/EEC (2) relating to restrictions on the marketing and use of certain dangerous substances and preparations.
12. Hexavalent chromium as an anti-corrosion of the carbon steel cooling system in absorption refrigerators.

Note – The Commission will further evaluate the applications for:

– Deca BDE.
– mercury in straight fluorescent lamps for special purposes.
– lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signalling, transmission as well as network management for telecommunications (with a view to setting a specific time limit for this exemption), and
– light bulbs, as a matter of priority in order to establish as soon as possible whether these items are to be amended accordingly.

Possible future exemptions

The European Commission is currently reviewing the status of two of the exemptions mentioned above and of light bulbs, as well as seven new cases for further exemptions and one clarification of the existing exemptions.

The seven new cases for possible exemption are: -

- Lead used in compliant-pin VHDM (Very High Density Medium) connector systems.
- Lead as a coating material for a thermal conduction module c-ring.
- Lead and cadmium in optical and filter glass.
- Lead in optical transceivers for industrial applications.
- Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 85% in proportion to the tin-lead content *(proposed exemption until 2010).*
- Lead in solders to complete a viable electrical connection internal to certain Integrated Circuit Packages ('Flip Chips') *(proposed exemption until 2010)*.
- Lead in lead-bronze bearing shells and bushes.

The existing exemption that is being reviewed for possible clarification and extension may be amended as follows: -

- Lead in high melting temperature type solders (i.e. tin-lead solder alloys containing more than 85% lead) and any lower melting temperature solder required to be used with high melting temperature solder to complete a viable electrical connection.

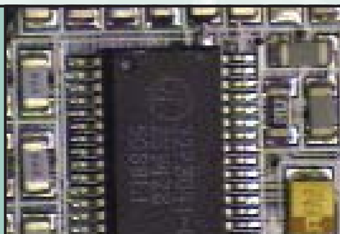
In addition, the Commission is reviewing the status of Deca BDE. At the moment, Deca BDE is included within the scope of the Directive. A study, undertaken on behalf of the Commission, has recently concluded that the risk assessment on the use of Deca BDE should be closed without restrictions for any applications. The study also concluded that questions relating to the environmental findings of Deca BDE in Europe should be addressed by the initiation of a monitoring programme and complemented by a further voluntary programme of industrial emissions controls in partnership with the Deca BDE user industries in Europe.

The Commission is currently considering how these conclusions should apply in respect of the scope of the RoHS Directive.

Restricted substances - where they might be found

Substance	Application
Lead	Solders
	Termination coatings on components
	Paints as pigments and as driers
	PVC as a stabiliser
	Batteries (not covered by RoHS Directive)
Cadmium	Electroplated coatings
	Special solders (e.g. in some types of fuse)
	Electric contacts, relays, switches
	PVC stabiliser
	Plastics, glass and ceramic pigments
	In some glass and ceramic materials
Mercury	Lamps
	Sensors
	Relays
Hexavalent chromium	Passivation coatings on metals
	In corrosion resistant paints
PBB and PBDE	Flame retardants in plastics.

Potentiometer, may contain cadmium internally



Lead in solder or termination coating

Lamp, glass and solder may contain lead

Plastic housings, PBB, PBDE, cadmium and lead

Plastic connector and cable insulation may contain lead or cadmium

Electrolytic capacitor; lead in termination coatings and in plastic cover if PVC

MLCC, lead in ceramic is exempt but lead in termination is banned

Cadmium or lead in plastic and lead in electroplated coatings

Limitations of alternatives

Material or component	Alternative	Limitations of alternative
Tin/lead solder	Lead-free solders	All different to tin/lead, see next section
Silver/cadmium oxide contacts	Silver/tin oxide	OK at low voltage, wears faster at high voltage
Chromate passivation	Various	Most are less effective as corrosion inhibitors on bare metals.
Mercury switches	Gold contacts	Only mercury gives bounce free contact and life is significantly longer
Tin lead electroplated terminations	iTn, tin alloys	Risk of tin whiskers. Wetting characteristics different
PBDE flame retardants	Other flame retardants	Characteristics may be different. Need to comply with fire regulations

Note that manufacturers may request exemptions for some of these applications. Where alternatives are available, in some cases they may be more expensive.

Lead Free
Soldering

Glossary of terms

What are Tin-Whiskers?

Tin-whiskers are single crystal, electrically conductive, hair-like structures that grow from lead-free, pure tin surfaces.

What are Dendrites?

Dendrites are fern-like or snowflake-like patterns growing along a surface (x-y plane) rather than outward from it, like Tin-whiskers. The growth mechanism for dendrites is well understood and requires some type of moisture capable of dissolving the metal (e.g., tin) into a solution of metal ions that are then redistributed by electro-migration in the presence of an electromagnetic field.

What is SIR?
Surface Insulation Resistance

Metal migration between isolated conductors on a completed assembly may produce electrical shorts. These occur when the space between the conductors is bridged by dendrites formed by re-deposited metal ions

What is a "popcorn" reaction?

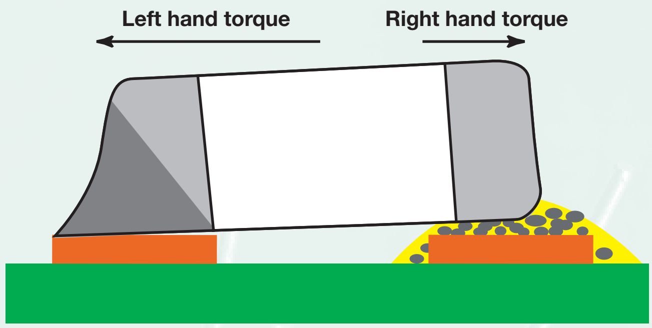
When heat is rapidly applied to moulded components moisture can gather. Above 100°C it expands, turns to gas and tries to escape and when it can't it tends to break or “pop” the moulded compound like a “popcorn effect”

What is Wetting?

The ability of a liquid to flow across a surface as opposed to sticking to itself. Wetting occurs when the attractive surface energy of the pad, or lead, is greater than the surface energy of the solder drawing a molecularly thin layer of solder across itself. Heating solder adds to the surface energy in the solder, so the cooler the solder the better the wetting.

What is Tomb-stoning?

Defined as the raising of one end, or standing up, of a leadless component from the solder paste. This phenomenon is the result of an imbalance of the wetting forces during reflow soldering.



Initial stages of tomb-stoning due to the force of imbalance caused by temperature differences

What is Kneading?

The process of mixing solder powder to solder flux to form solder paste

What is Drossing?

The formation of oxides and other contaminants upon molten solder.

Replacements for Standard solder

Despite extensive research, there is no "drop-in" replacement for standard tin/lead solder. All lead-free alloys are different. (M.pt. = melting point)

Alloy composition	M.pt. °C	Comments
Eutectic tin/lead solder	183	Included for comparison. Good wetting and low melting temperature
Sn0.7Cu	227	Used for wave soldering applications (known as 99C), high melting temperature and wetting inferior to SnAg
Sn3.5Ag	221	Used as high temperature solder, wetting inferior to SnAgCu
Sn3.5Ag0.7Cu (and variations on this)	217	Most widely used lead-free alloy. Various percentages of silver and copper are used. Melting temperature 34°C higher than tin/lead and inferior wetting
SnAgBi alloys (some with Cu)	Ca. 210 -215	Better wetting properties than SnAgCu but must not be used with lead. Mainly used as solder pastes but has been used for wave soldering, mainly in Japan. Wire not available
Sn9Zn	198	Needs special flux and is susceptible to corrosion
Sn8Zn3Bi	Ca. 191	Used by several Japanese manufacturers where heat sensitive components are used. Difficult to use
58Bi42Sn	138	Low melting point, hard, brittle alloy

Reliability issues with lead-free solders:

The main differences between lead-free and tin/lead alloys that need to be understood to avoid reliability issues are:

Higher melting temperature

Lead-free alloy soldering temperature is higher (30°C - 40°C), which can lead to a variety of defects such as:

- Thermal fatigue of solder joints - not well understood, research is on-going
- Tin-whiskers from electroplated tin termination coatings - not fully understood, research is on-going
- Delamination of multi-layer PCBs
- Damage to plated through holes - especially with narrow holes in thicker laminate
- PCB warping - can damage components, cause open circuits, misalignment
- IC packages are more susceptible to "pop-corn" failure. The IPC/JEDEC-020B Moisture Sensitivity Level for components with lead-free soldering can be 1 or 2 levels lower.
- Damage to heat sensitive components
  Check upper temperature limit in manufacturers datasheet

Wetting

of most lead-free solders is inferior to tin/lead.

- Tin coatings behave differently to tin/lead, even with tin/lead solder
- Correct choice of flux important.
- It is more important with lead-free that component terminations and solderable surfaces are clean and oxide-free
- Use the correct temperature profile. If the temperature rises too slowly due to poor temperature control or insufficient power, surfaces will oxidise making solder wetting more difficult. Beware of too rapid temperature rise as this can damage some components and PCBs due to thermal shock.
- The surface tension of lead-free solders is higher than tin/lead solders. This limits solder spread as well as increasing the risk of "tomb-stoning".

Example of tomb-stoning

Tomb-stoning can be prevented by alignment of the component perpendicular to the direction of the conveyer, using a paste with a wider pasty range, ensuring all surfaces have good solderability

Components: Typical maximum temperatures	
Aluminium electrolytic capacitor - max. temp. depends on size	240°C -250°C
Tantalum capacitor - various types	220°C -260°C
MLCC ramp rate more important	240°C -260°C
Film capacitor	230°C -300°C
Surface mount relay	226°C -245°C
Crystal oscillator	235°C -245°C
Connector - depends on type of plastic used	220°C -245°C
LED - may function but light output affected	240°C -280°C
Ball Grid Array & Chip Scale Packaged devices	220°C -240°C
Other ICs	245°C -260°C

Equipment and processes

Hand soldering

- This is relatively straightforward and trials with samples of wire are easy to carry out.
- Greatest difficulty is with large thermal mass components.
- Many lead-free SnCu, SnAgCu, SnAg wire products available.
- Alloys with bismuth not generally available as it is brittle and difficult to make into wire (can be made as "specials" but more expensive).
- Need slightly higher soldering iron tip temperature.
- More aggressive solders and fluxes will shorten tip life - 10°C rise could halve tip life.
- Longer pre-heat needed and wetting will take longer unless very high temperature is used (this will reduce productivity).
- Older style soldering irons have poor temperature control - can result in overheating (large temperature cycle).
- New soldering iron equipment has much better temperature control
- "Lead-Free" iron tips being developed.
- Frequently too-high a temperature is used with SnPb for fast wetting - operators in these cases may be able to use the same temperature with lead-free wire.
- To find optimum tip temperature:- start at 350°C, reduce temperature until poor results occur then increase by 10°C (or increase until good results are obtained).

Wave soldering

- Lead-free solders can damage steel parts - contact machine supplier for advice.
- Higher temperature required.
- Need to choose suitable flux.
- Some components may be damaged if they pass through the wave.
- Drossing rate higher - consider using nitrogen over wave.
- Check bath composition initially, especially if some tin/lead terminated components used.

Surface mount

- Forced air convection heating needed for better temperature control.
- Minimise peak temperature with good temperature control and many heat zones. Ovens may need to be longer with throughput lower to achieve good results.
- A controlled cooling rate is advisable as some component coatings can crack if cooled too slowly. Too rapid cooling can damage certain brittle components such as MLCCs.
- Nitrogen helps but is not essential.
- Choose optimum paste by comparative testing with realistic test PCBs. Test each paste over an eight-hour shift. This can be carried with 12 PCBs:
- Print 4 (no kneading), then place components, measure tack on 2 of these.
- 1 PCB wait 1 hour then reflow.
- 1 PCB wait 3 hours then reflow.
- Wait 6 hours, then place components, measure tack, then reflow.
- Repeat with 4 more after 1 hour.
- Repeat tests.
- Repeat with 4 more after 1 hour.
- Repeat tests.

PCB coatings

- traditional tin/lead hot air level (HASL) coatings cannot be used.

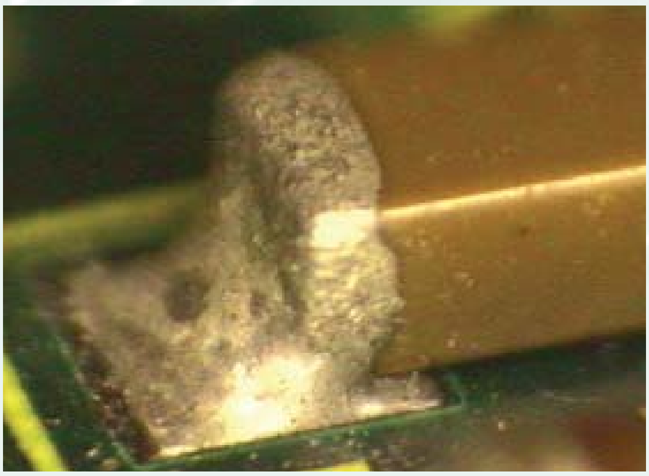
Alternatives include:

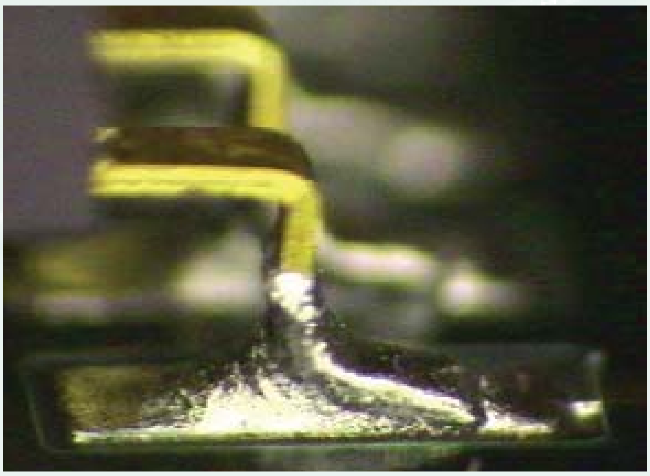
PCB Coating	Limitations
Lead-free HASL	Need new equipment, pre-bake boards
Nickel/gold (ENIG)	Gives good protection and solderability for up to 1 year but most expensive option
Organic solderability preservative	Low cost option, protection for up to 6 months, very easily damaged
Immersion silver	Good compromise but tarnishes (sulphides)
Immersion tin	Good compromise but deteriorates in warm or humid conditions

Inspection

Lead-free solder joints appear different to tin/lead and therefore training may be required so that operators can recognise good and poor solder joints. The criteria in IPC - 610C, although originally written for tin/lead should also apply to lead-free solder

Examples of tin lead solder joints





Examples of Tin/Silver/Copper solder joints

Rework and repair

Spare parts for the repair of equipment put onto the market before 1st July 2006 are not within the scope of the RoHS Directive. Therefore these spares may legally contain the six restricted substances. By inference therefore, spare parts used for the repair of equipment put onto the market after this date, must not contain restricted substances.

The same types of rework tools that are used for tin/lead can be used for lead-free solders. It is advisable however to avoid mixing alloys so wherever possible, repair using the same solder as was originally used. Some combinations can give very poor reliability, in particular lead and bismuth.

The temperature will need to be high so there is a greater risk of damage to heat sensitive components and the PCB, including high aspect ration plated through holes.

More aggressive fluxes may be required. These can cause SIR, corrosion and dendrites problems.

Trouble shooting guide

No.	Defect	Cause	Solution
1	Poor wetting	i. Unsuitable flux ii. Surfaces oxidised or contaminated iii. Poor temperature control	i. Use different flux ii. Ensure surfaces are clean and oxide free - do not use parts beyond their use-by dates Rotate stocks of components and PCBs iii. Use equipment with better temperature control
2	No wetting	Part not hot enough Insufficient heating power for part to reach solder melting temperature in a short enough time.	Use equipment with good temperature control and sufficient power
3	PCB delamination	Moisture within laminate and incorrect temperature profile	Increase pre-heat time/temp. to dry PCB before reflow
4	PCB warping	High reflow temperature	Reduce reflow temperature Use high Tg laminate Re-design to eliminate stresses during reflow
5	Pop-corning of ICs	Moisture within package	Check moisture sensitivity level of component for lead-free processes. May need to store in dry environment or bake before use.
6	Cracked PTH	Stresses on copper due to high TCE of laminate. Drilling defects increase risk	Re-design with thinner laminate, larger diameter PTH, increase copper thickness, use low z-axis TCE laminate. Replace drill bits more frequently
7	Damaged components	Exceeded maximum temperature	Use alternative components if available Re-design to avoid heat sensitive components Use lower reflow temperature (may need new equipment)

Rework and repair

Trouble shooting guide continued

No.	Defect	Cause	Solution
8	Shorts on PCB (bridging)	Lead-free solders have higher surface tension than lead solder	Use hot-air knife after reflow Increase time above solder melting temperature Use different flux
9	Excessive number of solder balls	Incorrect solder reflow profile, incorrect flux	Modify profile, use more active flux
10	Voids in solder joints	Trapped gas from coatings or flux	Increase time of pre-heat and time above solder melting temperature.
11	Solder bonds fracture easily after reflow	Thick and brittle intermetallic layer formed	Decrease maximum temperature and time above solder melting temperature. Use nickel barrier layer under solderable coating
12	Short circuits occur in field	i. Tin whiskers form after period in service ii. Dendrites	i. Specify coatings with low susceptibility to tin whiskers ii. Use less active flux or clean to remove flux residues.
13	Open circuits occur in field due to thermal fatigue	i. High strain on solder joints ii. Poor solder wetting	i. Redesign to minimise joint strain. ii. Improve wetting - see 1.

Environment

Environmental issues

The main aim of the RoHS Directive is to prevent hazardous materials entering landfill sites. The EU is restricting the use of six substances on the basis of the precautionary principal, as it is known that these six substances are classified as harmful or toxic.

Equipment manufacturers will see little impact from the change to alternative materials. For example, fume extraction should be used for soldering processes but this is to remove flux vapour. Lead-free fluxes are chemically similar to those used with tin/lead solders and so this requirement will not change. The chemicals used to produce hexavalent chromium coatings are toxic and carcinogenic and so users of these chemicals will benefit because the alternatives are much less hazardous. There is currently no evidence however that the thin hexavalent chromium coatings that are produced pose a risk to human health during normal use.

Global status

Europe: RoHS Directive comes into force 1st July 2006.

Japan: No lead ban at present but many Japanese manufacturers already changing to lead-free technology as a result of recycling laws. Lead solder ban is planned.

China: Planning legislation that will be similar, but not identical to EU RoHS directive. Likely to come into force 1st July 2006.

USA: Plans for legislation in California and other States.

15 states have active, or pending, WEEE-like product take-back laws.

5 states dictate that manufacturers provide advance notice of mercury content and a further 5 insist on a special label.

Rest of world - likely to follow.

Please note:

The information contained in this guide is of a general nature and is not intended to address the circumstances of any particular individual or entity. Although we endeavour to provide accurate and timely information, there can be no guarantee that such information is accurate as of the date it is received or that will continue to be accurate in the future. No one should act on such information without appropriate professional advice after a thorough examination of the particular situation.

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