AeA
Advancing the Business of Technology

EICTA
European Industry Association
Information Systems Communication Technologies Consumer Electronics

ANNEX

Question 3

LEAD IN SOLDERS FOR SERVERS

A. No feasible substitutes currently exist for broadly replacing lead-based solders in server products. Each of the lead-free solder substitutes that are being evaluated have numerous known reliability risks (details are discussed in the Server Exemption Annex). Much of the needed reliability learning for servers will come from analyzing the field performance of similar, but much simpler non-mission critical lead-free electronic products (e.g. desktop and notebook PCs) which will be introduced with the July 2006 EU RoHS Directive. Based on these requirements, we have developed a proposed definition of "server" to encompass the unique technical and functional design characteristics of servers and urge the TAC adopt this definition and retain the server exemption until at least 1 January 2010 (see this AeA Europe/EICTA Consultation Response Document)

B. To our knowledge, legal restrictions do not apply to the lead-free solders that are being considered for use in server applications. However, the leading lead-free solder candidates for server applications have not yet been tested adequately to ensure that they meet the stringent reliability requirements to enable organizations such as hospitals, municipalities, airports, banks and other large and small businesses to operate without interruption. The 2010 implementation date for servers and storage systems should be adequate to ensure completion of the required reliability demonstrations for these products.

C. Each of the lead-free solder candidates has associated cost/benefits and advantages/disadvantages. For example, if SnAgCu were eventually determined to be a viable substitute some disadvantages would include: 1) higher production costs (consumable material cost and new equipment cost), 2) higher energy consumption, 3) higher potential environmental impact from Ag mining, and 4) higher reliability risks.

Server Exemption Annex

Definition of "Solder"

Consistent with the EICTA position on the definition of "solder" previously provided to the TAC, EICTA recommends that the term "solder" is defined in order to provide technical clarity to the scope of the RoHS Annex exemptions.

The term "solder" is defined as alloys used, among other things, to create metallurgical bonds between two or more metal surfaces to achieve an electrical and/or physical connection. The metallic parts must be in proper chemical state to be joined by solder; this state is called "solder-wettable." In the electronics industry, metal component leads or pads and printed circuit board lands are often made solder wettable by applying a thin layer of solder. For example, for tin-lead solder alloys, a tin-lead solder "finish" is typically used. The "finish" material ultimately becomes part of the final solder joint and the electronic component or product. Solder thus includes all materials such as solder finishes on components and boards

as well as solder pre-attached to components and boards that become an integral part of the solder joint in the end.

Thus, EICTA recommends the following definition for “solder”:

Alloys used, among other things, to create metallurgical bonds between two or more metal surfaces to achieve an electrical and/or physical connection. The term “solder” also includes all materials that become part of the final solder joint, including solder finishes on components or printed circuit boards.

Server Reliability Aspects

A server is a complex product consisting of hundreds or thousands of electronic components attached with solder to a printed circuit board (PCB). The PCB is thicker and stiffer than those used in typical desktop or notebook computers (typically > 0.093”) and the components are more densely packed and attached to both sides of the board. A surface mount (SMT) reflow process is used to attach the majority of the components while others are attached with a wave solder process. The reliability impact of both processes should be considered when considering a lead-free solder substitute. Risks associated with lead-free component finishes must also be considered in server applications.

Sn-Ag-Cu Solder

Tin-silver-copper (Sn-Ag-Cu) is the industry leading lead-free solder alloy. The most data has been gathered for this material and it is supported by nearly every industry group. Its primary weaknesses when compared to tin-lead (SnPb) solder are:

- 30°C higher surface mount reflow temperature
- Slower wetting rate
- Double the cost (for raw material)
- Environmental concerns with Ag
- Although it is stiffer and stronger than SnPb, it has lower ductility

Surface Mount

Due to the high thermal mass of a server PCB (and some of the large components mounted on it), when passed through the reflow oven the temperature difference (?T) between the coldest spot on the board (under a large component) and the hottest spot on the board can be as high as 30°C (as reported by Alcatel[1]). Therefore to enable proper reflow of the coldest joints on the PCB, the hottest locations on the PCB along with the smallest components can reach temperatures in excess of 260°C which surpasses the rating of some critical components. A few examples include:

- Aluminium electrolytic capacitors, which can suffer dielectric cracking at temperatures greater than 245°C.[2]
- Large plastic ball grid array packages, which are prone to warping at these higher temperatures resulting in weak solder joints, particularly in server applications.
- Z-axis thermal expansion of thick PCBs can result in weakened or cracked plated through hole vias.[3] An example is shown in Figure 1.
- Blistering, delamination, and/or warping can also result in these PCBs.

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[1] J. Smetana, “Peak Temp Requirements for Lead-Free Components and J-Std-020”, HDPUG Fall Meeting, 2003, Scottsdale, AZ.
[2] J. Primak, “Power on Failures in Tantalum and Al Capacitors”, 2002 Components Tech Inst Conf, Kemet Electronics Corp.
[3] J. Davignon & R. Reed, “Effects of SnAgCu Assembly Reflow on PTH Performance”, SMTA Boston Lead-free Symposia, 2000.

The primary concern is that each of these heat-induced defects is latent in nature (not detected at initial inspection) and thus can result in catastrophic field failures at some point in the future.

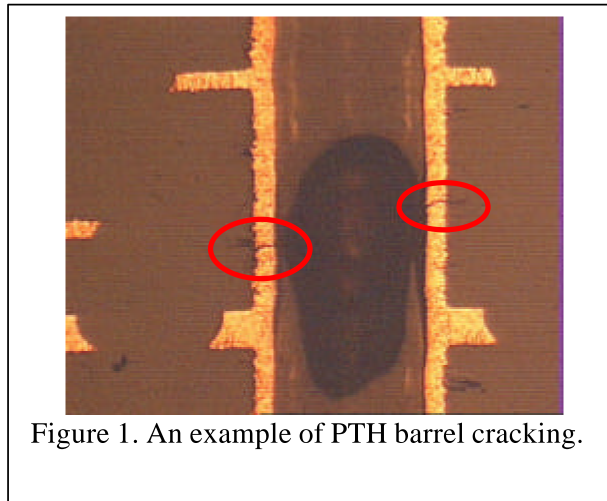

Figure 1. An example of PTH barrel cracking.

Wave Solder

There are several wave solder defects that are unique to lead-free soldering and are exacerbated with the thicker server PCBs. It is widely known that SnAgCu wetting characteristics are not nearly as good as SnPb so when the PCB is passed over the molten solder, it can take considerable time for the through-hole to become completely filled. To correct this problem on thick server boards, the board speed must be significantly reduced which in turn can cause heat damage to the PCB (warping, blistering, via cracking, etc.).

Fillet lifting is another wave solder defect which is exacerbated by the stiffer Sn-Ag-Cu solder and the thicker PCB. Shrinkage of the solder in the Z-axis upon cooling creates stress on the fillet causing it to lift off the pad as shown in Figure 2. The industry recommendation for reducing this defect is to insert a mechanism to cool the PCB more quickly after processing[4] (such equipment has not yet been developed nor its effectiveness proven).

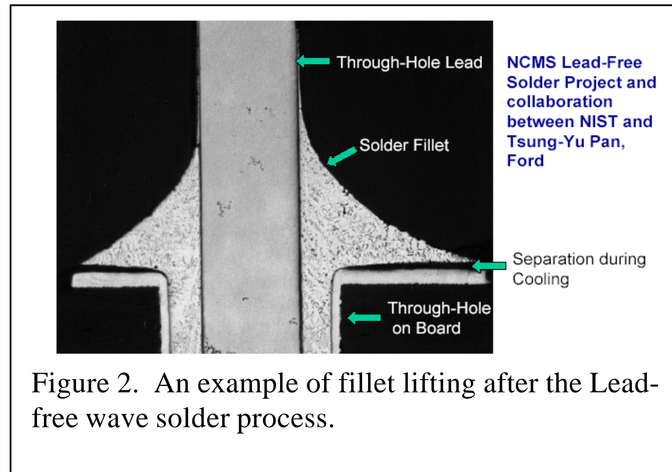

Figure 2. An example of fillet lifting after the Lead-free wave solder process.

Reliability Impact

In addition to the reliability risks associated with processing of SnAgCu, there are also risks due to the different mechanical properties of this new material compared to traditional SnPb. As previously stated, SnAgCu has higher modulus, higher yield strength, and lower creep than SnPb, however, it also has lower ductility. As a consequence, compliant components (those with similar or lower elastic modulus than the PCB) or those with an expansion coefficient similar to the PCB tend to perform better in thermal cycling with the SnAgCu solder. On the other hand, large and stiff components with a higher expansion mismatch oftentimes perform worse with the SnAgCu since strain is higher and is concentrated in the joint (not as easily spread throughout the component body). A study by Woodrow showed the characteristic life of a leadless ceramic package was approximately 3500 cycles for SnPb but only 600 cycles for SnAgCu. [5] In another study, cycles required to cause failure in 1% of large 2512 resistors was

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[4] "Lead-free Wave Solder Material Issues", Cookson Electronics. 2003.

[5] T. Woodrow, "The Effects of Trace Amounts of Lead on the Reliability of Six Lead-free Solders", IPC Lead-free conference proceedings, San Jose, 2003.

shown to be 50% less for the SnAgCu solder compared to SnPb.[6] This same tendency with 2512 resistors was described in a study by Rae, et. al.[7] Still another investigator found the thermal cycle crack growth rate in a SnAgCu solder joint on a ceramic component was 1.8 – 2.6 times faster than with eutectic SnPb.[8]

The risk for thermal cycle induced field failures due to SnAgCu solder is significantly greater in a server application where the PCBs are thicker and stiffer and a greater number of large ceramic components are used (due to their superior electrical performance). Although one might argue that servers don't undergo as many on/off cycles, they do undergo many idle to full power cycles in the course of a day (delta T of 40-50C).

Undoubtedly, engineers will eventually find creative solutions that will enable SnAgCu to be reliably used on server products, however, this will likely require a period of time longer than the current July 2006 RoHS implementation date. The risk of failure is too high and the cost of failure too great to justify using SnAgCu solder in server applications before the numerous issues expressed above have been resolved.

Sn-Ag-Bi Solder

A number of Lead-free solder alloys have been proposed with lower melting temperature than SnAgCu thereby reducing the various reliability risks caused by high temperature reflow. Adding a few percent bismuth (Bi) to the Sn-Ag alloy can reduce the melting temperature by up to 10°C (a modest improvement). The resulting alloy tends to be more ductile with better fatigue properties than SnAgCu (and more comparable to SnPb).

The most significant risk of Bi containing alloys is the unfortunate formation of a low melting temperature (96°C) SnBiPb eutectic phase when the alloy is inadvertently mixed with Pb. In severe cases this can result in crumbling of the solder joint and rapid catastrophic failure. In less severe cases it results in a significant decrease in the fatigue life of a joint. Woodrow showed that even small amounts of Pb (0.8%) in a SnAgBi solder joint caused a dramatic decrease in thermal cycle reliability.[5] In the first few years of transition to lead-free, it will not be uncommon for mistakes to be made in placing components with traditional Pb baring lead finish instead of the lead-free finish. Woodrow's work shows that such a mistake will have a significant and detrimental impact on the long term reliability of the solder joints. Worse yet, Pb bearing joints are visually indistinguishable from lead-free joints so these defects will could escape and result in field failures.

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[6] Swan et.al, "Development of Lead-Free Peripheral Leaded and PBGA components to Meet MSL3 at 260C Reflow", IPC APEX 2001, San Diego, CA, Jan. 2001.
[7] A. Rai, et.al, "Real Life SnAgCu Alloy Processing", Cookson Electronics, APEX, Anaheim, March 2003.
[8] Grossman et.al, ECTC Conference, 2002.

Sn-Ag-In Solder

The addition of 4-8% indium (In) to the SnAgCu solder system can also reduce the melting temp 10°C (from 217°C to 207°C), which reduces the risk of heat damage to components and boards.[9] For the most part, the mechanical properties are improved over SnAgCu (except for corrosion resistance). The reason In alloys cannot be seriously considered as a large scale lead-free solder replacement is the limited availability of the material. Approximately 36,000 tons of lead is used yearly in electronics whereas only 100 tons of indium is produced yearly[10]. After taking into account the differing densities of the materials, calculations show that the total yearly supply of indium would be used up if only 0.2% of In were used in a lead-free solder alloy. Indium currently costs 400 times more than Pb. Use of any appreciable amount of Indium in a lead-free solder would cause the price to skyrocket and the alloy would rapidly become prohibitively expensive.

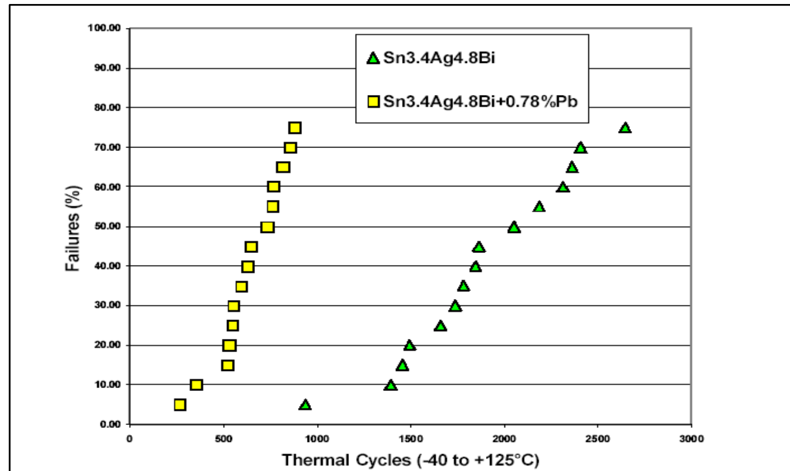

Figure 12. Reliability of Sn3.4Ag4.8Bi Solder (with and without Pb Contamination)

Figure 3. Impact of trace amounts of Pb on reliability of SnAgBi Lead-free alloys[5].

Sn-Zn-Bi Solder

Early lead-free adopters used tin-zinc-bismuth (SnZnBi) alloys to avoid heat damage to components and boards since its melting temperature is 198°C (19°C lower than SnAgCu). However, the Zn is extremely reactive and results in poor paste life, excessive voiding, high dross in wave solder, and most importantly corrosive failures in humid environments. A study by Suganuma from Sony showed the fatigue life of SnZnBi solder joints becoming almost zero after exposure to 85°C/85%RH.[11] The failure mechanism was due to coarsening and oxidation of the Zn as shown in Figure 4.

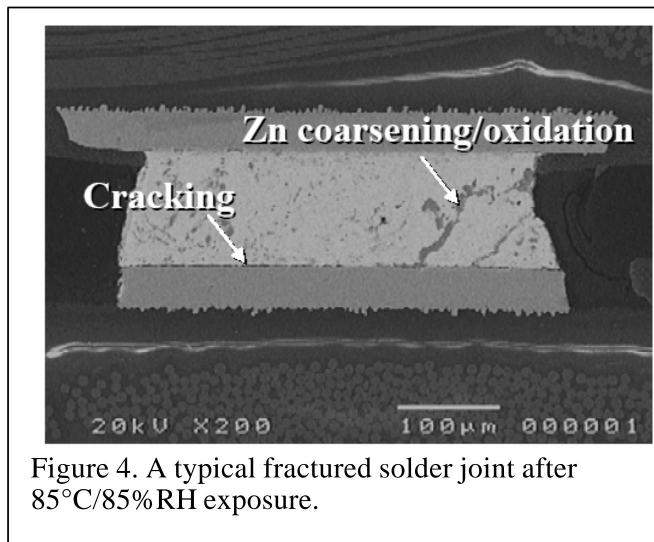

Figure 4. A typical fractured solder joint after 85°C/85%RH exposure.

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[9] J. Hwang et.al, "Lead-free Implementation - Drop In Manufacturing", IPC Printed Circuits Expo, APEX, 2004.

[10] N. Socolowski, Alpha Metals, "Lead-Free Alloys and Limitations for surface mount assembly", SMT, 1995.

[11] Suganuma, et.al, "Current Technology of Low Temp Lead-free Soldering", JIEP project paper, Soldertec/IPC conference, Brussels, 2003

Component Lead Plating

One last risk area to address when considering the exemption of servers is the component lead finish. The vast majority of component suppliers are turning to Sn based lead finishes upon converting to lead-free (matte Sn, Sn-Cu, or Sn-Bi). All these finishes are known to grow whiskers to varying degrees. The industry is gaining a better understanding of the growth mechanisms behind Sn whiskers, however, the fact remains that there is no known way to accelerate the growth process. Therefore, there is no way to know if any particular finish will grow whiskers in the use application/environment over the course of the product life. For this reason, companies who require highly reliable electronics (such as Boeing and Raytheon) forbid the use of Sn plated components. Servers would be more prone to whisker failures due to their finer pitch components and longer expected life.

More fundamental study on Sn whiskers is needed and is ongoing at NEMI, CALCE, and in academia. Perhaps conformal coatings will be a requirement for highly reliable lead-free products in the future. These and other potential solutions are currently being investigated but are far from being proven effective.

Summary

Engineers industry wide are working to resolve the wide range of manufacturing and reliability issues associated with the rapid conversion from SnPb to lead-free solder in consumer electronic products. Even so, once a large number of lead-free products are released into the market it will take years to quantify the field return rates of these products, perform root cause analysis and implement corrective actions. Due to the added complexity of servers, higher probability of failure, and higher societal cost of failure, it would be extremely risky to force the switch to lead-free in these high end products until the many lead-free issues are resolved with consumer electronics.

Question 5

Lead used in compliant-pin VHDM (Very High Density Medium) connector system

Compliant-pin connectors are widely used in the electronics industry. In many applications compliant pin connectors provide significant advantages over soldered connector alternatives. These advantages include:

1. Higher signal density can be achieved within the connector itself.
2. Higher connector density can be achieved on the electronic assemblies.
3. Connectors can be attached to both sides of the PCB, using the same PTH directly opposing each other, or tightly spaced, staggered front to back on the assembly. This provides better signal integrity in high signal density applications.
4. A reliable connection can be achieved without soldering, which allows assembly and field reworkability.
5. Heat is not required to attach a compliant pin connector, thus avoids damage and degradation of the circuit boards, surrounding components, and their interconnections.

Role of Lead-Tin (Pb-Sn) Compliant Pin Coatings

The tin-lead coating on a compliant-pin tail provides a number of important functions:

1. It provides a good, reliable electrical connection between the compliant-pin tail and the PTH.

2. It acts as a lubricant between the compliant-pin tail and the PTH. Without sufficient lubrication the insertion and removal forces are too great causing damage to the PTH, connector, or

surrounding components or their attachments. See figure 2.

3. Its metal oxides are easily displaced upon insertion into the PTH, providing a good metal-to-metal, gas-tight connection. Metal oxides, typically do not conduct electricity so result in a poor electrical connection.

4. A gas-tight seal is formed upon inserting a compliant-pin tail into a PTH. The pin's tin-lead coating "creeps" slightly conforming to the surface of the PTH creating the seal which prevents reoxidation and corrosion due to the ambient environment from occurring at the metal-to-metal interface, resulting in electrical open circuit conditions.

5. The presence of lead prevents tin whisker formation in pin coatings consisting of pure tin or solders with high tin concentrations. Tin whiskers are fine hair-like filaments that grow from the surface that can cause electrical shorts between pin contacts. See figure 3.

Other Coatings Evaluated

Work is underway to identify a suitable replacement compliant-pin coating.

Gold over nickel used in the contact interface region has excellent electrical properties, corrosion resistance and acceptable lubricity. However, when normal forces are increased to the level required for integrity of the compliant-pin to PTH connection, the friction between the PTH and the compliant-pin becomes too great and damages the PTH, PCB and connector. Thus, this alternative is not currently feasible.

Tin coating has favorable electrical properties as well. However, additional research and development is required to resolve known problems with tin. Tin coating without lead, like gold over nickel, has an increased friction where PTH, PCB and connector are damaged. Additionally, more research is required to find acceptable methods to prevent tin whiskers formation.

Question 6
Lead as a coating material fora thermal conduction module c-ring

Thermal Conduction Modules (TCMs) are critical to the operation of some mainframe servers. State of the art, high performance Central Processing Unit (CPU) chips are extremely complex and include hundreds of millions of built in transistors that are interconnected to the "deck" of a TCM surface with hundreds of thousands of fragile solder interconnections.

When these chips are present in close proximity to one another to optimize signal integrity and high frequency performance, they generate a significant amount of heat during system operation which must be dissipated to ensure reliable performance throughout an extended system lifetime. Thermal Conduction modules with lead-plated C-ring seals are a key element of hardware designs that yield an effective removal of heat generated by a massive integration of high power, high performance devices present in these server products.

Thermal Conduction Module Seal Requirements

TCMs must meet several key design requirements. They must:

1. Be easily reworkable.
2. Hermetically encapsulate the package. This is to protect the flip chip solder connections, ceramic chip carrier and chips' metal circuits from oxidation and corrosion by the ambient environment. This also prevents drying or degradation of the thermal paste used inside the TCM.
3. Reliably withstand the thermally-induced stresses caused by the temperature differences and the expansion mismatch between the ceramic chip carrier and the metal cap.
4. Provide adequate cooling to meet performance and reliability requirements.
5. Securely position and retain the chip carrier relative to the alignment hardware for reliable actuation onto the board connector.

6. Be a field replaceable unit (FRU).

It is important that TCM structures are reworkable because the high complexity of chip devices typically drives very low functional yields when multiple chips are attached and tested. A low yield condition dictates that essentially all TCMs must undergo multiple chip attach, module assembly, module disassembly, and chip removal operations before a fully functional TCM is manufactured. In fact, some TCMs may require multiple reassembly and test sequences in excess of 5 times depending on overall functional complexity.

When a functional TCM is produced, the TCM sealing process and structure must provide a seal that sustains a high internal vacuum level for a time period in excess of 10 years. Although other module sealing technologies exist and are used in some server products, these alternate module sealing technologies do not provide for the combined and required assembly, disassembly, reworkability, and resultant vacuum levels necessary to ensure reliable module functions. This is particularly true for modules used in high-end mainframe servers which include an essentially zero allowed TCM failure rate.

Multiple Roles of the Lead-Coated C-Ring

In order to meet these requirements, several technologies were adapted for use in this application. For ease of reworkability, a mechanical design involving clamping to a perimeter flange is employed. Early versions of the TCM utilized a metal frame that was brazed to the perimeter of ceramic chip carrier. A lead (Pb) plated C-Ring sealed the metal frame to the metal cap. Eventually, the metal frame was eliminated by sealing directly to the ceramic chip carrier. To seal the assembly, in either case, required a mechanical seal with a C-shaped cross-section and a square or rectangular overall shape, made of a malleable metal, that is compressed between the chip carrier flange and the metal hat. The C-Ring seal has characteristics that meet the requirements of items 1, 2, 3, and 5 listed above. This sealing design is the key enabler of TCMs used in many main frame servers.

The square shaped, lead-plated metal C-Ring was selected because of its excellent sealability, reliability and reworkability. The resultant seal provides a leak rate of less than 10-8 atm-cc/sec of Helium. It also has excellent wear characteristics necessary to meet the on-off and intermediate operational requirements of mainframe servers. Thermal cycling due to operational conditions results in differential expansion across the C-Ring that in turn results in a relative motion between the metal hat and the ceramic carrier. This causes a rolling or bending of the seal cross-section. The lead plating has the requisite material properties that allow it to remain in intimate contact with all the sealing surfaces while these events occur over a minimum 10 year period. Its excellent wear characteristics allow it to remain hermetic over thousands of such cycles. C-Rings in these assemblies have been successfully stressed to over 3,000 thermal cycles in accelerated reliability tests.

A lead-plated C-ring seal also provides the frictional force needed to prevent the ceramic carrier from moving during thermal cycling and actuation of a TCM into its connector on the circuit board. In early versions, this actuation involved a motion along one of the centerline axes of the ceramic carrier. The C-Ring compression force, which is always present after assembly, provides a retention force equal to the frictional force between the ceramic carrier and C-Ring on one side, and the ceramic carrier and a cushion on the other side. This prevents the ceramic carrier from moving laterally.

As stated earlier, the hermetic seal used in TCMs is square shaped with tight radius corners and has a C-shaped cross section. Forming of corners in the base material results in a non-uniform surface in these corner areas. The lead plating covers over and fills in these areas, exhibits excellent bonding to the base metal, and provides a soft, compliant interface material for sealing to the mating surfaces. In addition, the seal must exhibit low yield stress at the contact surfaces to conform to the surface topography, but have high overall elastic compliance to take up component

thickness tolerances and thermal-cycling induced deflections. Another desirable feature of the C-Ring is its curved, or radiused, sealing surface which ensures a circumferential line contact (i.e. only making contact at the top and bottom of the C-Ring). This feature makes it an ideal candidate for the application of soft plating materials. The forces are very high at the C-Ring contact points deforming the plating into any surface irregularities.

Other Solutions Evaluated

A silicone adhesive module sealing technology to package a variety of single chip modules and multichip modules is common throughout the computer industry. However, modules which use this sealing technology are in general less complex, run at lower powers, and do not possess the assembly and rework requirements of their mainframe server module counterparts. They also typically require a reliable life span of approximately 5-7 years based on maximum stress or use conditions.

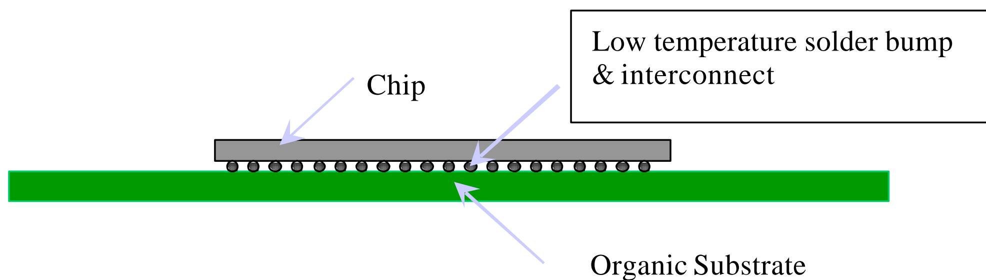
Over the past approximately 25 years since TCMs were first utilized for mainframe computers, many other potential TCM seal solutions were evaluated. Elastomer and metal O-Rings, gaskets made of metals, elastomers and composites, and plated elastomers were all investigated. The C-Ring was the only seal that met all the requirements. Various coatings were evaluated: gold, silver, indium, lead-tin, lead (Pb). All alternative solutions investigated exhibited either poor seal reliability with thermal cycling, poor time zero yield, high leakage, or some combination of these problems. These studies were quite extensive and comprehensive and were performed over a long period of time, consuming scores of man-years of effort. Many variations of the C-Ring design were also investigated. The only material that provided all the required attributes noted, including long-term reliability, is a lead (Pb) coating.

Question 11
Outline of the problem and substantiation of the necessity for the exemption:

Certain integrated circuit (IC) packages are currently manufactured with low temperature solder for the internal electrical connection. These IC packages are commonly referred to as "flip chip". Organic substrates require low melting temperature solder to connect the chip to the substrate. Low temperature (eutectic lead-tin (PbSn) solder, lead content less than 40%) solder has been used for many years and provides a product, which is suitable for many mainstream electronics applications. The amount of lead in the solder joint is less than a half compared to the high temperature lead solders which are currently exempted from the requirements of Article (4) of the RoHS directive. This new exemption request is for a even narrower application – lead-bearing solder required to complete a viable electrical connection internal to the integrated circuit package.

Today flip packages are used extensively in computing applications, in hard disc drives, handsets and portable electronic devices (e.g. cameras, radios, personnel digital assistants (PDA's), in cars (ABS systems and engine control unit (ECU) microcontrollers.

Figure 1 Diagram of a Flip Chip Package with Internal Connection Technology



In flip chip packages, tiny amounts of tin lead solder are used to connect the chip to the substrate. These bumps (internal to the package) for state of the art flip chips are about the same size as the diameter of a human hair and may contain less than 0.002 mg lead per bump. Replacing the tin-lead solder balls (outside the package) with lead-free solder balls eliminates more than 97-99% of the lead from the finished package.

The connection between the chip and the substrate forms the heart of the integrated circuit package. After the flip chip connection is formed, the gap between the die and the substrate is filled for mechanical and environmental protection. At this point, the die can be encased in a plastic mold compound or covered with a lid, or the package can be installed directly into an electronic assembly with no further processing.

Explanation of the delay in information after the adoption of the RoHS Directive:
The industry began in the nineties to consider alternatives to tin lead solders and today entire product lines are available lead-free.
In the case of flip chip packages, lead-free test units using several different alloys passed reliability testing at lab level but just recently field experience with these circuits has identified reliability issues not apparent during the development phase.

Flip chip interconnects have two significant advantages over wire bond interconnects. First, flip chip interconnects can enable smaller die (devices). In flip chip interconnects, the entire chip area can be used for I/O interconnection, whereas traditional wire bond chips are limited

to interconnection only at the edges. Second, flip chip interconnects provide superior electrical performance compared to wire bonds, with lower resistance, capacitance and inductance. The result of these advantages is smaller, lighter and faster products with improved electrical performance and less power consumption. This, in turn, reduces the material required with its resultant environmental benefits.

Range of producers:

Manufacturer spectrum for flip chips, divided by regions:

Region	Market share flip chip
Germany	<3.3%
EU	6.9%
Non-EU	>89.9%

All numbers based on list of top 30 worldwide semiconductor companies.

Market segment of flip chips in relation to other chips worldwide:

2002	about 2.8% of total packages are/may be FC
2004	about 4.6% of total packages may be FC
2006	about 6.5% of total packages may be FC

Relevance for the environment

Material balance accounting: How much heavy metal is used for the application in question? Which amounts can be expected within the scope of the RoHS Directive? (rough estimate)

3 – 5 µg lead per flip chip results in an imported lead volume to the EU:

Year	*2004*	*2005*	*2006*	*2007*
Worldwide lead in internal package bumps in kg	1086	1175	1379	1376
Lead imported to EU in package bumps in kg	326	352	414	413

Environmental Relevance of low temperature Flip Chip Bumps:

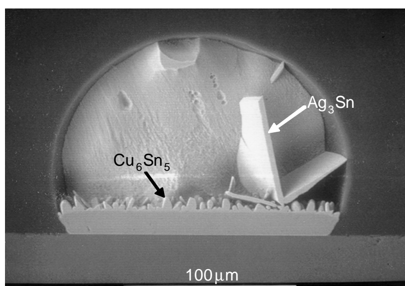
The amount of lead in the solder joint is less than a half compared to the high temperature lead solders which are currently exempted from the requirements of Article (4) of the RoHS directive. Due to the lack of lead-free alternatives for this application, the current RoHS Directive would require manufacturers to switch to a higher lead alternative for all flip chip applications. In this case the additional exemption of low temperature solder needed to complete the connection would be needed (see point 10: lead in high melting temperature type solders and any lower melting temperature solder required to be used with high melting temperature solder to complete a viable electrical connection).
This request for a new exemption would allow the continued use of low lead concentration solder until lead-free alternatives are found and evaluated. It would be counterproductive for the environment to change to high-lead solders within flip chip packages in order to get coverage by the existing exemptions and the clarification to this existing exemption.

Flip chips are used in applications that serve the environment. They reduce the fuel consumption of cars by effective motor control and contribute to road safety by supporting ABS systems.

Measures taken until now by the industry to prepare for the conversion of the substance ban of the RoHS Directive

Lead-free solder research is widespread across industry, universities, institutes and national laboratories in all regions of the world. We will work with interested parties, if desired. Lead-free solder flip chip interconnections are successfully used today in many applications. Industry believes lead-free solders can eventually be used for most flip chip applications. Our research shows that lead-free alternatives to low temperature tin lead bumps are currently not universally available because:

1. In lead-free solutions, the formation of intermetallic alloys in this tiny bump constitute a high percentage of the joint volume and greatly reduces the resistance to impact (e.g. drop) and thermo-mechanical stresses normally found in the use environment, especially in flexible circuit applications; failure of the joint renders the integrated circuit useless;
2. Lead-free solders with a melting point sufficiently high for mainstream products are much stiffer than eutectic lead-tin solders. This stiffness increases stress on the chip, and can cause premature failure of the chip circuitry.
3. The equipments and materials required for fabricating lead-free bumps are still in the development stage. For example, fluxes for lead-free solder flip chip connections are just now being developed.
4. The industry is still learning the full impact of lead-free solder flip chip interconnect on manufacturability and reliability. For example, it is well known that lead-free solders do not wet (coat) metal terminals as well as lead-tin solders. In order to obtain adequate wetting, new fluxes are being developed. However, the nature of these fluxes impacts other assembly steps and product reliability, and the full extent of the impacts are still being determined.
5. In high temperature (high lead) flip chip solutions, attachment to the organic substrate still requires a low temperature lead-containing solder interface;



Undesirable intermetallic alloys make up a significant portion of the experimental lead-free solder bump.

Current technology for the connection between the package and the PWB will not work for interconnect bumps with small dimensions.

A variety of reliability problems have surfaced and no broadly applicable reliable alternative has been identified. To ensure no disruptions in flip chip applications, it is critical to provide a new narrow exemption for low temperature lead-containing solder for these tiny internal connections.

Time frame for finding potential substitutes:
The ITRS (International Technology Roadmap for Semiconductors) provides an industry identification/assessment of future technical challenges. Alternatives to flip chip connection may be optical interconnects or bumpless area arrays (direct copper to copper bonding). These solutions may find their way into products by the end of the decade, but their use will be limited to certain niche applications until the cost is reduced. In the meantime, international chipmakers are in active development and are seeking lead-free alternatives to eutectic PbSn solders at high speed.

Support from industry associations and competitors:
The proposal is actively supported by the ZVEI, ESIA, EICTA; JBCE and AEA Europe. The two market leaders and key competitors in flip chip applications, Texas Instruments Inc. and ST Microelectronics (of European and US origin), support this request for a new exemption.

Additional Requests for exemptions (not part of the European Commission's questionnaire):

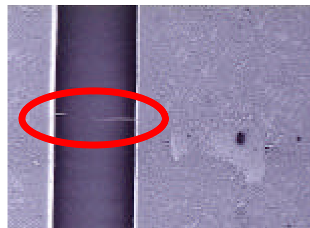
Tin-lead plating in Fine Pitch Flexible Applications

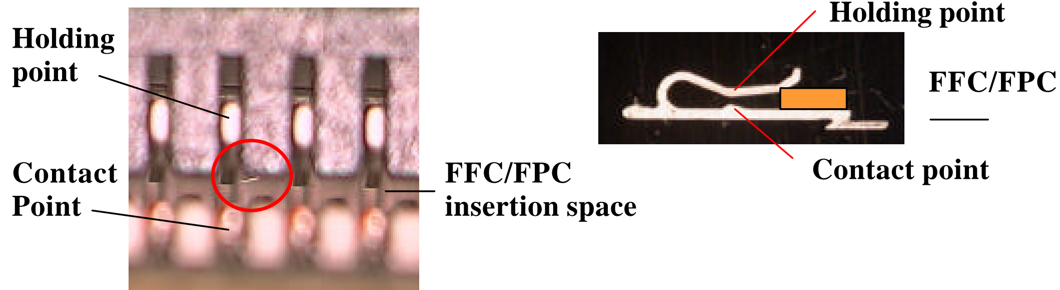
- Do feasible substitutes currently exist in an industrial and/or commercial scale?

No alternative technology exists than using lead as whisker suppresser in electroplated tin coating for Flexible Printed Circuit (FPC), Flexible Flat Cable (FFC), and their connecters.

- Do any restrictions apply to such substitutes?

Searching for substitutes, "accelerated" tests were done with pure tin plating and a tin-copper alloy:
Sn-Cu: The whisker growth saturates. Final length frequently exceeds 500 µm
Sn: The whisker growth saturates. Final length is usually 200- 500 µm
Comparison with Sn-Pb: The whisker growth saturates within a length below 20-40 µm
Critical Whisker Length: For a pitch of 500 µm already a whisker length of 250 µm is critical, as the whiskers can grow from both sides of a device.





Where lead-free tin plating is used, an unusual, but dangerous phenomenon occurs: growth of tin whiskers. These whiskers are tiny, crystalline structures that are electrically conductive. Numerous electronic system failures have been attributed to short circuits caused by tin whiskers that bridge closely spaced circuit elements maintained at different potentials. The mechanisms that cause tin whiskers to grow have been studied for many years now, but a clear, generally acceptable explanation has not yet been established. External stress that is occurring at flexible connections is one of the reasons identified being responsible for the growth of whiskers.

- What are the costs and benefits and advantages and disadvantages of such substitutes?

It takes a few years to confirm that the length of the growing whiskers have no impact on product quality (reliability).

Conclusion

As no alternative technology exists than using lead as whisker suppresser in electroplated tin coating for Flexible Printed Circuit (FPC), Flexible Flat Cable (FFC), and their connecters, the use of tin-lead alloys for these flexible fine pitch applications with a pattern-pitch <500 µm should be excluded.

Lead (Pb) in Plating of Iron-Nickel Alloy Fine-Pitch Electronic Components

1. Introduction

The purpose of this document is to describe the technical issues regarding "tin whiskers" and to request consideration by the European Commission and the EU's Technical Adaptation Committee on the RoHS Directive (2002/95/EC) of an exemption for tin-lead (Sn-Pb) platings on electrical terminations for iron-nickel (alloy 42) alloy-based metal "fine-pitch" electronic components. This exemption is necessary to ensure the reliability of products that use these types of electronic components. Without such consideration, products will become WEEE prematurely, placing an undue burden on both consumers, and the recovery and recycling infrastructure in the European Union.

2. Background

The electrical terminations of virtually all-electronic components must be plated with a thin layer of metal to make them capable of being soldered to the printed circuit board. Today, these terminal platings are most commonly comprised of a tin-lead (Sn-Pb) alloy. Substitutes for these Pb-bearing platings are usually nickel/palladium/gold alloys or pure tin or dilute alloys of tin with copper, silver, or bismuth. While many components have been qualified using Ni/Pd/Au alloys, there are segments of the industry that have not yet completed the technology development required to provide sufficient components to meet the industry demand. This continuing research is centered in tin based platings. The main problem with these Pb-free tin based platings is that filaments of metal, known as "tin whiskers," may form and create electrical short circuits between closely spaced component terminals (see Figure #1). Pb is the only alloying element of tin electroplatings that is known to eliminate the risk of tin whiskers. These whiskers can cause functional failure of electronic products once they grow long enough to create short circuits between adjacent electrical terminations. Fine-pitch parts are the most susceptible to such failures because the distance between the conductive leads is small (as little as 125 micrometers).

Tin whisker failures can be catastrophic. This risk of failure exists for all product applications, including mission critical ones. For example, NASA has reported the loss of satellites due to tin whisker failures (http://nepp.nasa.gov/whisker/failures/).

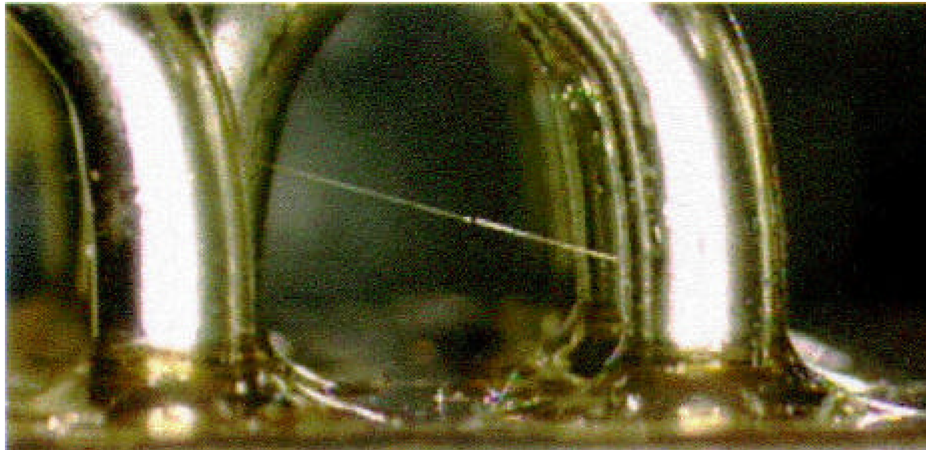


Figure #1.
Magnified photograph of a tin whisker growing from the electrical termination front right toward the termination front left. Taken from the NASA tin whisker web site: http://nepp.nasa.gov/whisker/.

Another result of tin whisker failures is that affected products are likely to be prematurely discarded for recycling. This impact is potentially very significant because the number and variety of products that contain fine-pitch components and, therefore, can be affected by tin whisker failures, spans the entire spectrum of electronic products: from electronic cameras and mobile phones, to PCs and office equipment, to large servers and telecommunications equipment. Of course, such failures will cause customer dissatisfaction and increased costs as well.

The industry does not have a reasonable technical understanding of tin whiskers. First, the fundamental reasons why tin whiskers form and grow is still being researched and debated, even after several decades of investigation. There are many conflicting claims and much conflicting data in the industry, with no clear consensus emerging that provides a quantitative understanding, or a reliable technical alternative that is commercially feasible. For example, the National Electronics Manufacturing Initiative (NEMI) consortium has three separate groups currently working on the tin whisker problem, including one focused on the fundamentals of whisker formation and growth. While these groups have been operating for several years, the group comprised of companies expecting to use tin-plating technology recently attempted to reach consensus on the best methods to mitigate tin whisker formation. As evidence of how far the industry is from a solution, no such consensus could be reached.

Careful control of the electroplating process is one ofthe areas under investigation to reduce or eliminate tin whisker formation. Unfortunately, the necessary details of what variables to control and the precise process limits to impose are not known at this time. Thus, batch-to-batch variations in tin whisker response result, impairing the industry's capability to ensure that tin whiskers will not form and cause product failures. No one has yet been able to show which process variables are actually at issue or how to control them. It is far from clear that the industry will gain the necessary process understanding any time soon.

A critical impediment to finding a commercially viable technical solution is that it is difficult to obtain technical data from which to quantify tin whisker risk for particular plating solutions

and particular products. Whiskers may form and grow rather slowly, even under laboratory conditions, necessitating long test times. There is currently no quantitative way to assess the risk of product failures due to tin whiskers based on "accelerated" laboratory data collected over a period of a few months or less. Just because whiskers do not form or grow to dangerous lengths in a two-month test does not validate that they will not grow and cause failures in a product intended to function for two years, five years, or longer. Furthermore, development of an accelerated test may never be possible because the conditions under which many electronic products operate are very similar to those that promote the most rapid tin whisker growth. In other words, the most accelerated test would still need to last nearly as long as the product is intended to function in order to validate that tin whiskering is under control.

Leading electronics manufacturers have been working with their supply chain partners to find alternative solutions for Pb-free terminal platings that do not contain tin (and are therefore not at risk for tin whisker problems). One solution being examined is the use of layered nickel/palladium (Ni/Pd) and nickel/palladium/gold (Ni/Pd/Au) platings. From a technical standpoint, these platings are acceptable, and indeed have been used in certain applications for many years. Unfortunately, at present these platings are not widely available on components using iron-nickel (Alloy 42 based metal) alloy terminations (for example, memory devices). Considerable time and effort will be needed to convert a sufficient fraction of this component supply base to this solution in order to assure uninterrupted supply of electronic products into Europe.

3. Request for RoHS Exemption

We request an exemption to the RoHS legislation for the use of lead (Pb) as an alloying element in tin-based platings on electrical terminations for iron-nickel (Alloy 42-based metal) alloy "fine-pitch" electronic components. For the purpose of this exemption, fine-pitch components are defined as those with electrical terminations spaced with centers 0.65 mm or less apart. For components with terminations spaced more widely than 0.65 mm, the risk of product failure due to a tin whisker growing long enough to span the distance between adjacent terminals, thus causing an electrical short circuit, is judged to be minimal during the intended lifetime of most products.

This exemption would expire on January 1, 2010. The period covered by this exemption will provide the electronics industry the time required to resolve the tin whisker issues and/or to convert to palladium based (Ni/Pd and Ni/Pd/Au) platings.

4. Impact of Exemption

The impact of this exemption on the environment would be low because the amount of Pb tin-lead electroplating on component terminal connections is small. The concentration of Pb in the terminal plating alloys is typically below 10%, and the thickness of the plating is only about 10 micrometers. In fact, a typical electronic component using tin-lead electroplated terminations contains less than 0.1% Pb as a fraction of the mass of the component.

The exemption would have an impact on product performance and lifetime. It would reduce product failure risk from tin whiskers for devices ranging from electronic cameras and mobile phones, to PCs and office equipment, to large servers and telecommunications equipment. Therefore, this exemption could reduce the number of electronic products prematurely discarded into the recycling stream due to premature loss of functionality.

Lead solder used to create a viable connection between aluminium wire and copper in high performance voice coil applications in hard disc drives.

A. Voice coils utilized in high performance hard disc drives use an aluminium voice coil, due to its unique properties, and operate at high temperatures. Currently, solder containing approximately 80% lead is used to create a viable connection between the aluminium voice coil wire and copper in high performance voice coil applications. Lead-free substitutes for the application of solder described above do not currently exist. Additionally, lead solder containing more than 85% lead will not work for this application.

B. Substitutes for lead solder in the above application have experienced catastrophic failures in laboratory tests. Substitute solders would not provide a reliable high-performance product.

C. The amount of solder used in such an application is extremely small. There is no guarantee that substitutes, if identified, would come at a lower cost to the environment in terms of eco-toxicity. At the current stage of technological development, however, such substitutes would, in any event, result in product failures.

Conclusion: This exemption is critical for the electrical connection between Aluminium and Copper in high performance applications.

Position Paper-Implications of the RoHS Directive for the Manufacturing of New E&E Equipment Containing Re-Used Parts: (27 January 2004)

XEROX and OCE wish to draw the attention of the Commission and the Member States to the fact that article 2(3) of the ROHS Directive limits the ability of certain manufacturers to re-use certain equipment parts due to an artificial distinction between "old" and "new" equipment, and in spite of the clear environmental advantages of such practices. Optimising re-use is one of the priorities of the WEEE and ROHS Directives, whose objectives we fully support. However, according to the Commission's interpretation[12], the ROHS Directive as it currently stands would prevent certain established manufacturing practices aimed precisely at this objective. In particular, manufacturers will not be able to continue to market or envisage to market products containing re-used but non-ROHS compliant parts.

Paradoxically, while new non-compliant parts may be manufactured and put on the market for the purposes of repairing old equipment, the re-use of certain recovered parts would not be allowed in equipment if it is put on the market with a new serial number. Whole assemblies could thus be sent to scrap prematurely even though they contain only small amounts of restricted substances.

Article 5 of the ROHS enables the TAC to exempt materials and components of E&E equipment *"where the negative environmental, health and/or consumer safety impacts caused by substitution are likely to outweigh the environmental, health and/or consumer benefits thereof"*. We contend that the re-use of parts in new equipment fulfils these conditions:

- By eliminating the need to manufacture new parts, it reduces consumption of raw materials, energy consumption, greenhouse gas emissions, and other emissions to air and water.
- There is no increase in the use of restricted substances since the recovered equipment provides enough spare parts to ensure that manufacturers do not need to manufacture new non-ROHS compliant spare parts to service the equipment.
- The quantity of controlled substances entering the waste stream does not increase; only the timing of their disposal and treatment would change.
- The premature disposal of parts that are fit for re-use yields no environmental benefit.

Further, the Directive already permits extending the lifetime of non-compliant old equipment by allowing re-use of equipment and the manufacturing of spare parts. “New” equipment containing re-used non-compliant parts would not enter the waste stream any later than such equipment.

Therefore, in contrast to what is claimed by the Commission, these practices would *not* prolong the existence of hazardous substances in the waste stream and limit increased recycling efforts.

Moreover, re-use of parts would *not* make the enforcement of the Directives difficult as long as it were only allowed for manufacturers operating documentated and verifiable closed-loop systems, which provide sufficient guarantees as to traceability.

We therefore call on the TAC and the European Commission to amend the Annex of the Directive so as to enable parts containing ROHS-restricted substances recovered from used equipment to be re-used in new equipment put on the market after 1 July 2006 (provided the

[12] Commission reply of 11 September 2003 to written question E-2356/03 of 8 July 2003 **by** Ria Oomen-Ruijten, Caroline Jackson, Johannes Blokland, Alexander de Roo and Karl-Heinz Florenz

parts are re-used in a closed-looped system by the original manufacturer of the equipment). We suggest that such an exemption could be limited to a period of five years given that parts from equipment put on the market before 1 July 2006 will have become obsolete within this timescale.

***

I. The re-use of components is a priority for EU policy on EEE waste

Excluding the reuse of components containing ROHS-restricted substances would contradict the spirit of the WEEE and ROHS Directives, which, like the EU's Waste Management Strategy, give priority to the re-use of waste equipment.

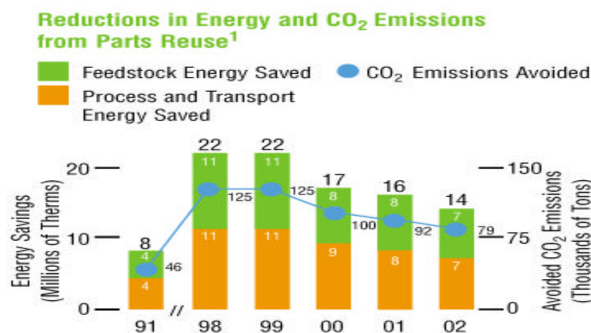
Indeed, article 4 of the WEEE Directive states:

> "*Member States* ***should encourage the design of EEE*** *which take into account and facilitate dismantling and recovery, in particular the re-use and re-cycling of WEEE, their* ***components*** *and materials".*

Furthermore, since the ROHS Directive can be extended to other substances in the future, its application in a manner that prevents the re-use of parts will **undermine manufacturers' confidence in the value of designing equipment for re-use and extension of life**.

II. There are substantial environmental benefits to the use of recovered parts in new equipment

- Re-using parts essentially eliminates the need to manufacture new parts from raw materials**.** This approach effectively results in avoiding resource depletion, energy consumption, greenhouse gas emissions, and other emissions to air and water.

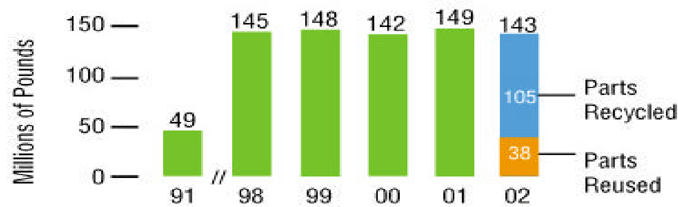


[1] Energy savings represent the difference between the energy required to build new parts and the energy required to process parts for reuse, assuming an average machine composition of 60 percent plastic and 40 percent steel. Energy savings calculations encompass "feedstock energy" (the energy content of the petroleum and coal raw materials converted to plastic and steel, respectively) and energy required to process and transport materials throughout the life cycle. Life cycle energy data was obtained from Franklin Associates, Ltd. Energy savings were converted into avoided emissions of carbon dioxide using a U.S. energy profile and emissions factors calculated by the U.S. Environmental Protection Agency and Department of Energy. Feedstock energy was excluded from this conversion.

Figure 1 (Source: Xerox)

- **The premature disposal of used equipment and components that are perfectly suitable for re-use is avoided.** Under the end-of-life Directives, the quantity of controlled substances entering the waste stream therefore would not increase; only the timing of their disposal and treatment would change.

Waste Diverted from Landfills through Parts Reuse/Recycle



Note: Data cover the remanufacture and reuse/recycle of Xerox equipment and parts at Xerox facilities and those of our contract office equipment manufacturer, Flextronics.

Figure 2 (Source: Xerox)

- Moreover, the recovered equipment provides enough spare parts to ensure that manufacturers do not need to manufacture new non-ROHS compliant spare parts to service the equipment thus manufactured.

In essence, the environmental advantages of re-use obviously outweigh any perceived environmental benefits of early disposal.

III. A restrictive interpretation of the ROHS Directive would penalise leading practices in eco-design:

Several manufacturers who strongly support the objectives and requirements of the electronic waste Directives have long realised that the re-use of returned parts yields a double dividend, i.e. significant environment benefits coupled with the cost reductions, and are manufacturing new equipment **containing up to 70-90% of re-used parts, of which a limited but essential portion may be non-ROHS compliant.**

These producers supply information technology equipment, primarily copiers, printers and multifunctional devices for professional users other than private households. Reuse of components in new equipment takes place mainly in the case of high-value items of equipment in the business-to-business market in the context of **closed-loop processes**. These items remain the property of the manufacturer, or are subject to other contractual arrangements, and are taken back either when the contract expires or at end-of-life.

This type of equipment is undergoing rapid changes in the nature of the functional interface with the user and with other types of office equipment, although the underlying marking technology is basically unchanged. In this situation, the pace of technological innovation has shortened product life cycles to the point where it is increasingly important to be able to reuse parts across product generations.

Thus products are designed for ease of disassembly, to ensure integrity of parts, and parts are designed for durability over multiple product life cycles. Product families are designed around modular architectures with common sets of core components. As a result, there are multiple options for extending the useful life of components by re-using them for the purpose for which they were originally conceived: not only as spare parts for existing equipment, but particularly as components for new products of the same model, or in the next generation of models.

Such re-use is dependent on the availability of a reliable flow of sufficient volumes of end-of-life equipment, in suitable condition. These flows can primarily be realised with business-to-business equipment, where the producer retains a relationship with the customer, enabling the return of the end-of-life equipment to the manufacturing plant through a reverse logistics process. Thus the re-use of parts is fully integrated into the normal design, manufacturing and logistics processes, provided that tests and analysis have confirmed that the parts are fit for re-use.

IV. Components so re-used must be traceable

Traceability can be ensured by one of the following:

(a) Manufacturers' and/or suppliers' declarations: These can be used to state as of what date and with what batch number (the only identification for a batch of components) components have become ROHS-compliant.

(b) Administrative measures: Manufacturers can keep records of non-ROHS compliant components that are to be reused in new equipment, and can attribute a unique identification number to these components. The list of components of a new piece of equipment would also contain a list of components containing substances forbidden by the ROHS taken from used equipment.

(c) Technical measures: Non-compliant parts can be marked and will only be used in equipment guaranteed through arrangements with customers to be collected by the manufacturer at end of life.

Conclusion

Those companies that apply the above principles are at the vanguard of environmental policy and eco-design, and the results achieved are clearly in line with those of the WEEE and ROHS Directives. They have clearly demonstrated the feasibility of setting-up systems for the re-use of parts in new equipment without the risk of jeopardising the environmental objectives of the ROHS Directive, and shown that closed loop systems can be set up that guarantee that parts will be returned to the equipment manufacturer and will not end up in collective recycling schemes.

Restricting parts re-use will result in significant unintended environmental consequences, and contradicts the spirit of the legislation. We thus strongly encourage the Commission and the Member States to open a dialogue with manufacturers in order to enable them to optimise re-use through closed-loop schemes and meet the objectives of both the WEEE and ROHS Directives.

Performance upgrade of long life equipment

Servers, storage and storage array systems and network infrastructure equipment all have a long life during which the equipment may be subject to repairs, and very often, to performance improvements (upgrades). These performance upgrades are often necessary to ensure that systems stay competitive and allow the customer to grow the business without the purchase of entirely new systems.

It is important for the mentioned and other similar hardware, that the original components and system building blocks produced (spare parts) may be used to make upgrades and thus guarantee the full useful life of the equipment. According to Article 2 paragraph 3 of the RoHS directive, non-conforming (RoHS) spare parts can be used for repair. However the use of spare parts for performance improvements (upgrades) is not clear. We therefore urge the TAC to give precise guidance on Article 2 paragraph 3 regarding spare parts. If the interpretation does not allow the usage of spare parts for these purposes, we urge the TAC to grant an exemption to expand the use of non-conforming spare parts for performance improvements (upgrades) on equipment originally put on the market before 1 July 2006.

In keeping with the intent of the Directive, this action would not generate any additional waste but would extend the useful life of the equipment upgraded and simply delay the scrap of non-compliant spare parts.

Industry Standard Processes for the Repair of EEE Products

1. Introduction

The purpose of this document is to describe the Industry Standard Processes for the repair or replacement of non-functioning EEE products and to request consideration by the European Commission and the EU's Technical Adaptation Committee on the RoHS Directive (2002/95/EC) on certain aspects of these processes in the post-July 1, 2006, environment. This is necessary to ensure that there is a common understanding regarding the authorized movement of repair and replacement inventory, and to ensure that sufficient provisions are made for the repair or replacement of products placed on the market in the European Union prior to July 1, 2006, to extend their effective life. Without such consideration, products will become WEEE prematurely, placing an undue burden on both consumers, and the recovery and recycling infrastructure in the European Union.

2. Background

There are two standard approaches used by industry to provide warranty and repair support for EEE products.

Part exchange is the approach typically used for high-end products such as servers and storage systems. The non-functioning part is removed from the host product and a replacement part is installed. The non-functioning part is sent to a repair facility, where it may be repaired for further use.

Whole product exchange is the typical approach used for smaller consumer and business products such as personal computers, laptops, printers, handheld PCs and monitors. A replacement product is sent to the customer and the non-functioning product is returned to a repair facility. The replacement product provided to the customer may be a refurbished unit or a unit that has not previously been used.

The timing of the product exchange will vary depending on the repair approach used. Examples of these are:

1. Advance exchange where the replacement is sent to the customer prior to the return of the non-functioning product
2. Standard exchange where the replacement is sent to the customer after receipt of the non-functioning product,
3. On-site exchange where the product is replaced at the customer site.

The facilities where repair or refurbishments are completed may be located within the European Union or outside the European Union. These facilities may accept returned product for repair from both within and outside the European Union. These returned units, once repaired and refurbished, may then be placed into the repair inventory to be used for future repair exchanges, as required.

3. Authorized Inventory Movement After July 1, 2006

Industry believes that it is recognized that refurbished products are used and therefore not subject to RoHS. The inventory movement practices which industry believes will be clearly authorized after the implementation of the RoHS Directive for repaired or refurbished products after July 1, 2006 are as follows.:

- A customer with a non-RoHS compliant product purchased that was placed on the market in the European Union prior to July 1, 2006, experiences a failure after July 1, 2006, sends the non-functioning product to a Refurbish Facility located either within the European Union or outside of European Union. The customer is provided a refurbished, non-RoHS compliant replacement product, which was placed on the market within the European Union prior to July 1, 2006.
- The unit which was returned by the customer is first repaired and then reused within the European Union as either:

A. Replacement: A refurbished product replaces another customer's broken product, or

B. Resale: The refurbished product is sold as refurbished (i.e. as previously used) equipment to another customer.

4. Current Industry Practice

Whole product exchange is critical to the ability of industry to meet the warranty and repair needs of its customers. It is, for example, the process through which 90% of laptop computer repairs are conducted on an industry-wide basis. As repair/refurbishment facilities support worldwide markets, timely replacement would be difficult to maintain without provisions to allow for a worldwide flow of repaired/refurbished products.

Customer satisfaction surveys have demonstrated that business and household consumers rank the ability to get an immediate replacement unit as their top service demand of an EEE supplier. In addition, customers have come to expect a timely one-to-one replacement with the same model. An upgrade replacement with a newer version is often not acceptable, particularly for commercial businesses which have a large installed base of a single model, all of which have been identically configured. Consequently, repair facilities must maintain extensive inventories of different parts and equipment, including supplies of new equipment which have been transferred to the repair facility for use as replacement units. To attempt to meet these repair/replacement needs on a regional basis (I.E., supplied solely from within the European Union) would lead to inefficiency, material delays and significantly increased costs.

5. Key Considerations

The use of non-RoHS compliant products manufactured prior to July 1, 2006, for the whole product exchange of products put on the market in the European Union before this date, maximizes the reuse of whole products, minimizes the number of products being discarded prematurely and reduces the impacts and pressures on reco very and recycling facilities in the European Union. There should be no net increase in the volume of non-RoHS compliant products in the European Union, as every new or refurbished product that enters the European Union replaces a product that was originally placed on the market in the European Union prior to July 1, 2006. It should be noted that the scope of this type of product exchange is restricted by both the number of products already on the market in the European Union prior to July 1, 2006 and the warranty period for these products (typically 2-5 years). As new RoHS compliant products are introduced into the market, the need for non-RoHS compliant whole product exchange is reduced and will eventually become unnecessary.

6. Requested Inventory Movement After July 1, 2006

Given the extremely large volumes and the diversity of parts and products which EEE manufacturers are required to maintain in their inventory for warranty and repair support, the supplies of parts, components and whole appliances are held in centralized service facilities, industry believes that both new and refurbished products, sourced from other geographies, should be allowed to move into the European Union beyond the RoHS implementation date, to support the warranty and repair needs of customers in the European Union who require service for products put on the market in the European Union prior to July 2006.

Prior to RoHS it has been an accepted industry practice to replace non-functioning units with new and refurbished replacement units of the same product over world -wide geographies.

- A customer with a non-RoHS compliant product put on the market in the European Union prior to July 1, 2006, experiences a failure after July 1, 2006, sends the non-functioning product to a Refurbish Facility located either within the European Union or outside of European Union and receives a new replacement product or a refurbished replacement product which may have originally been put on the market outside the European Union.
- The unit which was returned by the customer is repaired and then used as a replacement for another customer.