*Adaptation to scientific and technological progress under Directive 2002/95/EC*

# Joint response from EICTA, AeA Europe, EECA ESIA and ZVEI, to the general and specific questionnaires relating to exemption 14

"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 80% and less than 85% by weight"

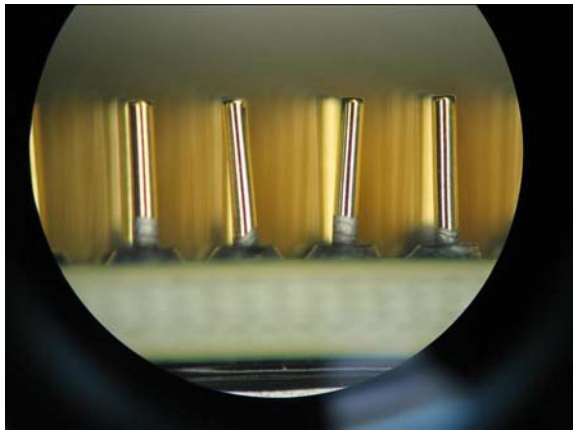
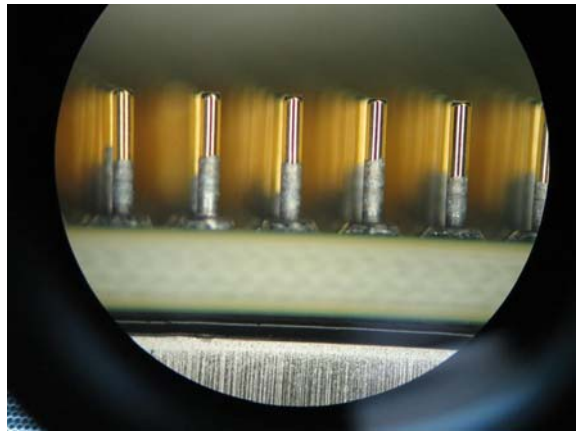
31 March 2008

Content

# General questionnaire

| | |
|---|---|
| 1. For which substance(s) or compound(s) should the requested exemption be valid? | 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 80% and less than 85% by weight. |
| 2. What is the application in which the substance/compound is used for and what is its specific technical function? | This is used in a microprocessor application with a high number of pins (e.g. a desktop microprocessor having more than 900 pins). The solder is specifically used to connect the pins to the substrate providing both electrical connectivity and mechanical stability. The large number of connections between the pin and the substrate requires very high reliability per individual connection, as the probability for package failure grows with the number of pins. Pin counts have been increasing over time and will continue so, as microprocessors will provide more functionalities, their packages will become larger and require an increased number of pins. |
| 3. What is the specific (technical) function of the substance/compound in this application? | The solder serves to connect the pins to the substrate. It provides an electrical connection and also mechanically holds the pin to the package. The pins serve as interconnect between the microprocessor and the motherboard through a socket. |
| 4. Please justify why this application falls under the scope of the RoHS Directive (e.g. is it a finished product? | Microprocessors are used in desktop, servers, embedded applications, mobile and handheld devices, which are covered by the RoHS Directive. |
| - Is it a fixed installation? | No. |
| - What category of the WEEE Directive does it belong to?). | Microprocessors are used in end products of the following WEEE categories<br>3. IT and telecommunications equipment<br>4. Consumer equipment |
| 5. What is the amount (in absolute number and in percentage by weight) of the substance/compound in: | |
| i) the homogeneous material[1] | The lead content in the homogenous material is between 80% and 85% (typically 82%, or equal to 0.5gms per microprocessor) |
| ii) the application, and | The total lead content per application (end product) is 0.5 g, the percentage by weight depends on application (end product) such as desktop, laptop or servers. |
| iii) total EU annually for RoHS relevant applications? | Total amount of lead brought into the EU market with applications using exemption No. 14 was nearly 6940 kg in 2007.<br>(Source for volume of units shipped to the EU in 2007: IDC and Gartner statistics). |
| 6. Please check and justify why the application you request an exemption for | Not applicable |

| | |
|---|---|
| does not overlap with already existing exemptions respectively does not overlap with exemption requests covered by previous consultations. | |
| 7. Please provide an unambiguous wording for the (requested) exemption. | 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 80% and less than 85% by weight. |
| 8. Please justify your contribution according to Article 5 (1) (b) RoHS Directive whereas: | |

| | |
|---|---|
| o Substitution of concerned hazardous substances via materials and components not containing these is technically or scientifically either practicable or impracticable; | Alternate materials and pin attach methodologies that exist today do not meet the requestor's product quality, yield and reliability requirements for microprocessors with high pin counts and are therefore impracticable. The large number of connections between the pin and the substrate requires very high reliability per individual connection, as the probability for package failure grows with the number of pins.<br>High pin count results in increased tolerances and variations during pin mounting on the package and eventually lowers process margins in flip chip attach process. Pin counts have been increasing over time and will continue so, as microprocessors will provide more functionalities, their packages will become larger and require an increased number of pins.<br>In the case of alternate solders, the requestor is actively pursuing development of lead free solders as a substitute to the lead containing pin solder.<br>However, studies have shown several issues with the alternate solders even at engineering assessment stages. Some of these issues include:<br>a. Pin movement that moves the pin from its desired location by design to enable socketing and thus affects yield and mechanical reliability;<br>b. Pin solder climb interfering with socketing that affects ability to insert pins in the socket. Even if socketing is possible, the solder would wear off and contaminate the test contacts which may lead to arcing that consequently may lead to damage to the test contactors and the part itself.<br>c. Solder voids that affect pin strength and mechanical reliability;<br>d. A marginal process window to attach the die due to a narrow range of melting temperature between the pin solder and the C4 (controlled collapse chip connection) solder (flip chip solder) on the package. The end results of such issues are high yield loss in assembly and test, difficulty in scaling up to volume production and potential field failures at customers due to loss of pin(s).<br>e. In order to improve the manufacturing process window, alternate flip chip low melting solders were investigated. Solders containing Sn, Ag, Bi, In, Cu were studied and found to be non manufacturable for high volume package fabrication.<br>   |

| | Moving Pin Solder Climb |
|---|---|
| o Elimination or substitution of concerned hazardous substances via design changes is technically or scientifically either practicable or impracticable; | The requestor has also investigated design changes to overcome the use of lead containing pin solder, but the work undertaken has shown that this is currently technically impracticable, especially for microprocessors with high pin counts, that would consequently also require a high number of LGA interconnects.<br>f. Substitution with another Package Design: The requestor has moved to LGA (Land Grid Array) for some products already, but has not extended this transition to all products yet. LGA is an interconnect technology that does not use pins any more and therefore does not need to use the pin solder for which this exemption is needed. However based on customer feedback, transition to all LGA products is not possible due to technically impracticability or lack of infrastructure in the customer application.<br>g. The requestor has pursued alternate interconnect technologies like BGA (Ball Grid Array) with our customers. This involves major infrastructure changes at the customer and also eliminates the flexibility of adding/removing the processor without affecting other components on the motherboard. Other issues related to damage of processor during its assembly onto the motherboard and ownership if such issues were to happen were difficult to resolve. Customers wanted a plug-and-play solution that is proven and reduces risk of ownership on their side. Based on such feedback, the requestor is unable to use this alternate path to PGA (Pin Grid Array) for the majority of products. |
| o Negative environmental, health and/or consumer safety impacts caused by substitution are either likely or unlikely to outweigh environmental, health and/or consumer safety benefits thereof (If existing, please refer to relevant studies on negative or positive impacts caused by substitution). | Elimination of lead content in the pin solder before adequate reliability for microprocessors with high pin count can be proven might result in environmental and safety problems.<br>Poor reliability might reduce the life span of EEE, resulting in increased electronic waste.<br>Elimination of this RoHS exemption might also impact the reliability of communications and control systems which would create a consumer safety problem. |
| 9. Please provide sound data/evidence on why substitution / elimination is either practicable or impracticable (e.g. what research has been done, what was the outcome, is there a timeline for possible substitutes, why is the substance and its function in the application indispensable or not, is there available economic data on the possible substitutes, where relevant, | The requestor has done extensive studies on alternate lead free solders based on their melting point characteristics, such that it allows sufficient manufacturability margin to the flip chip attach assembly process. Alternate package and interconnect designs for microprocessors with high pin count have also been researched.<br>The result of these studies was that substitution and/or elimination through another design are currently not feasible:<br><br>Summary of results:<br>1. Pb free pin solders reduce process margins in high volume manufacturing<br>2. Yield loss in assembly, test and potential customer socketing issues are major concerns |

| | |
|---|---|
| etc.). | 3. Use of low melting alternate flip chip attach solders that improve the manufacturing margins were found to be non-manufacturable in high volume<br>4. Higher solder voiding and solder climb observed with lead free pin solders may result in reliability exposure to the requestor's products.<br>5. Several DOE (Design of Experiments) are still in progress; however, results are discouraging so far.<br>6. A move to alternate infrastructure (LGA, BGA) poses significant technical and economic risk at the customer and is not a viable solution<br><br><u>More details of the stated summary above:</u><br>Extensive repeated studies showed pin movement and pin solder climb after pin and flip chip attach reflow. This affects yield in assembly and the pin strength is compromised which impacts reliability. The requestor's product test involves multiple socket insertions (as many as 30x) to ensure product performance, quality and reliability before a part is shipped to customers.<br>In case there is partial pin movement observed that passes our internal test, there is still a high potential for pins detaching from the package in the customers' assembly process.<br>This poses a serious quality and reliability issue. Significant DOE (Design of Experiments) were conducted to optimize the pin geometry, solder composition, solder volume and assembly process. Results continue to show pin movement and solder climb that do not meet product requirements. In certain situations such as to repair defects, the flip chip attach process goes through multiple reflows which exacerbates the above stated issues. The requestor continues to work internally and with our partners on non-traditional ideas, novel pin attach techniques and other potential changes to the pin material and geometry.<br>The requestor has also worked with customers and socket partners on alternate infrastructures such as socketed LGA and surface mounted BGA. Even though some of the server products were successfully converted to LGA, a full conversion in desktop and laptop products was not possible due to major infrastructure and technical impractibility issues at customers. Same issues were prevalent for the BGA solution. |
| 10. Please also indicate if feasible substitutes currently exist in an industrial and/or commercial scale for similar use. | As of today it is known that a substitute is used for some microprocessors.<br>However, alternate substitutes do not exist today that meet the requestor's product quality and reliability requirements for microprocessors with high pin count, as the large number of connections between the pin and the substrate requires very high reliability per individual connection as the probability for package failure grows with the number of pins.<br><br>It should also be considered that different sets of conditions influence the determination of product reliability requirements. |
| 11. Please indicate the possibilities and/or the status for the development of substitutes and indicate if these substitutes were | Research for substitutes to this exempted application has been ongoing since 2001.<br>A number of studies were conducted to optimize pin geometry, solder composition, solder volume and assembly process since then and continuing into the future until a substitute will have been found. |

| | |
|---|---|
| available by 1 July 2006 or at a later stage. | Attached schedule (Annex 1) shows development work completed until today and our roadmap showing the steps planned for the future. |
| 12. Please indicate if any current restrictions apply to such substitutes. If yes, please quote the exact title of the appropriate legislation/regulation. | The alternative pin solder material constituents that are under investigation are not currently restricted for the intended use. |
| 13. Please indicate benefits / advantages and disadvantages of such substitutes. | See question 8c) |
| 14. Please state whether there are overlapping issues with other relevant legislation such as e.g. the ELV Directive that should be taken into account. | The requestor is not aware of overlapping issues with the ELV. |
| 15. If a transition period between the publication of an amended Annex is needed or seems appropriate, please state how long this period should be for the specific application concerned. | As indicated in the answers to the questions above, industry is working towards elimination of lead in the exempted application (No. 14) over time.<br>However, since no substitutes have been identified yet, the exemption is still needed.<br>In any case though, a transition period would be required for any change to this exemption as presently defined. |
| 16. Additional comments | |

# Specific questions exemption 14

## "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 80% and less than 85% by weight"

The following specific questions should be answered in your stakeholder contribution if you support exemption 15 to be continued / amended / discontinued:

| | |
|---|---|
| 1. Please state the **amount of lead** used per application, the lead content in the homogeneous material, the annual production volume as well as the number of applications related to exemption 14 put on the EU market annually. | The lead content in the homogenous material is more than 80% and less than 85%, or equal to 0.5gms per microprocessor.<br><br>Total amount of lead brought into the EU with applications using exemption No. 14 was nearly 6940 kg in 2007 (Source for volume of units shipped to the EU in 2007: IDC and Gartner statistics). |
| 2. Please explain the status of lead-free material use in this application (Where is substitution feasible? Where is substitution in progress? Where has research resulted in an unfeasibility of substitution? …). | The requestor has done extensive studies on alternate lead free solders for microprocessors with high pin count based on its melting point characteristics, such that it allows sufficient margin to the flip chip attach assembly process. Also alternate package and interconnect designs have been researched.<br>The result of studies was that substitution and/or elimination through another design are currently not feasible:<br><br>Summary of results:<br>1. Pb free pin solders reduce process margins in high volume manufacturing<br>2. Yield loss in assembly, test and potential customer socketing issues are major concerns<br>3. Use of low melting alternate flip chip attach solders that improve the manufacturing margins were found to be non-manufacturable in high volume<br>4. Higher solder voiding and solder climb observed with lead free pin solders may result in reliability exposure to the requestor's products.<br>5. Several DOE (Design of Experiments) are still in progress; However, results are discouraging so far<br>6. Move to alternate infrastructure (LGA, BGA) poses significant technical and economic risk at the customer and not a viable solution<br><br>Details of the stated summary above:<br>Extensive repeated studies showed pin movement and pin solder climb after pin and flip chip attach reflow. This affects yield in assembly and the pin strength is compromised which impacts reliability. The requestor's product test involves multiple socket insertions (as many as 30x) to ensure product performance, quality and reliability before a part is shipped to customers.<br>In case there is partial pin movement observed that passes our internal test, there is still high |

| | |
|---|---|
| | potential for pins detaching from the package at the customers assembly.<br>This poses a serious quality and reliability issue. Significant DOE (Design of Experiments) were conducted to optimize the pin geometry, solder composition, solder volume and assembly process. Results continue to show pin movement and solder climb that do not meet product requirements. In certain situations such as to repair defects, the flip chip attach process goes through multiple reflows which exacerbates the above stated issues.<br>The requestor continues to work internally and with partners on novel pin attach techniques and other changes to the pin material and geometry.<br>The requestor has also worked with our customers and socket partners on alternate infrastructures such as socketed LGA and surface mounted BGA. Even though, some of the server products were converted to LGA, a full conversion in desktop and laptops was not possible due to major infrastructure and technical impractibility issues at customers. Same issues were prevalent for the BGA solution. |
| 3. The previous evaluation in 2004 stated that design changes would make this exemption obsolete by 2010. The exemption should therefore be limited to 31 December 2009. Is such a **phase out** still possible until the end of 2009? If the exemption is needed beyond 2009, please justify and provide a detailed **roadmap** with activities, milestones and timelines towards the replacement of lead in this application. Name an **expiry date** that you think is technologically feasible for industry. | The requestor has worked on **design changes**, i.e. the possibility to move to alternate infrastructures than PGA (Pin Grid Array).<br>The requestor has moved to LGA for some products already, but has not extended the transition to all products yet, even though the requestor has strived to do so.<br>LGA is an interconnect technology that does not use pins any more and therefore does not need to use the pin solder for which this exemption is needed.<br>However based on customer feedback, a transition to LGA for ALL products is not possible due to cost or lack of infrastructure in the customer application.<br><br>A **roadmap** with activities, milestones and timelines towards elimination of the use of lead in the exempted pin solder can be found in Annex 1.<br>It needs to be emphasized should be noted that the roadmap relies on **inventing** a substitute solder in 2008. The roadmap is only valid if there is an invention done in 2008, with an invention being something that cannot be predicted with absolute certainty.<br><br>A manufacturable solution suitable for high volume production of microprocessors with high pin counts is not likely to be available by 2010.<br>An **expiration date** for the exemption applicable to microprocessors with high pin counts is therefore **not** possible to name at this time. |

# Annex 1 Exemption 14

## "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 80% and less than 85% by weight"

Roadmap with activities, milestones and timelines towards elimination of the use of lead in pin solder exempted in exemption No 14
It should be noted that the roadmap relies on inventing a substitute solder in 2008. The roadmap is only valid if there is an invention done in 2008, which cannot be predicted with absolute certainty. If an invention could not be made within 2008, the roadmap will be subject to change.