Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

Fraunhofer Institut
Zuverlässigkeit und
Mikrointegration

Adaption to scientific and technical progress under Directive 2002/95/EC

Results previous evaluation

Exemption No. 7 a and b

“a) Lead in high melting temperature type solders (i.e. lead-based alloys containing 85 % by weight or more lead)

b) lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signalling, transmission as well as network management for telecommunications

c) lead in electronic ceramic parts (e.g. piezoelectronic devices)”

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5 Recommendations

5.1 Lead in solders and finishes of electrical and electronics devices (set 6 request no. 15)

The exemption request had in parts already been submitted as stakeholder comment to a former consultation. The consultants revised the stakeholder comment and draw their conclusions within a cross-section evaluation (see http://ec.europa.eu/environment/waste/pdf/rohs_report.pdf, page 12 f).

5.1.1 Description of requested exemption

The applicant requested lead to be exempted for the use in typical solders with 60 % and 63 % lead content (weight-%) respectively, the rest being tin. Typical solders, however, have a lead content of 37 % or 40 % respectively, the rest being tin. The further argumentation in the the exemption request also suggests that the request refers to the typical tin-lead solders with 37 % or 40 % lead. A further inquiry with the applicant confirmed this assumption.

According to the applicant, lead is currently essential for creating a soldering material with the least environmental impact and also claims it has advantages in reliability.

The proposed wording for the exemption is:

“Lead in solders and finishes used to form solder joints in electrical and electronics devices."

The applicant states that, the amount of lead used in solders and finishes globally is 0.49 % of the total annual lead consumption.[1]

The applicant also says that globally 50,000 tonnes of solder were used[2]. For 60/40 solder this would give a global lead content of 20,000 tonnes and for 63/37 solder 18,500 tonnes. The applicant says that according to Harvey Miller, an economist, the electronics used in Europe represents about 20% of all electronics sold. The applicant states that this would give a solder usage number for electronics used in Europe of only 10,000 tonnes of which for 63/37 solder would be 3,700 tonnes of lead, or for 60 /40 solder would be 4,000 tonnes of lead.

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[1] N.–C. Lee “Lead Free Soldering – Where is the world Going,” Advancing Microelectronics, September/October 1999, p. 29

[2] Dr. Ron Lasky, senior technologist of Indium Corporation quoting Prismark in September 2006, source quoted by the applicant

5.1.2 Justification for exemption as submitted by applicant and stakeholders

According to the applicant, lead is currently essential for creating a soldering material which has the least environmental impact and which has other major benefits in the area of reliability.

Following documents were provided as support for the environmental adverse impacts of lead-free soldering materials:

- US environmental protection agency (EPA) report “Solders in Electronics: A Life Cycle Assessment” 3”.
- The University of Stuttgart, Department of Lifecycle Engineering: paper on soldering with and without lead.4

According to the applicant, both the EPA report and the University of Stuttgart report are very clear on the subject that lead bearing solder had the least environmental impact of any currently available soldering material. The environmental impacts of the replacement materials were far higher than the materials they are intended to replace.

The applicant says that no substitutes with the same lack of environmental impact were available, and that no time frames were publicly available for acceptable alternatives that had less impact on the environment.

According to the applicant, the replacements have disadvantages in reliability in addition to the environmental impacts. He attached documents supporting the effect known as “tin whiskering”[5].

The applicant also submitted the publication of Edwin B. Smith III and L. Kristine Swanger, K*Tec Electronics Sugar Land, TX, as a background reference on leaching of the different soldering materials into landfill.[6] . The paper shows that metals used in lead-free solders are at least partially leaching above levels that are allowed according to different guidelines on leachates and drinking water.

[3] File name “lfs-lca-final.pdf

[4] File name “Stuttgartpaper.pdf”.

[5] (“Effects of Lead on Tin Whisker Elimination, Efforts toward Lead-Free and Whisker-Free electrodeposition of Tin” by Wan Zhangz and Felix Schwager, file name “JES00C337.pdf”).

[6] File name “expo99.pdf”

5.1.3 Critical review of information as submitted by applicant and stakeholders

The applicant submitted two studies destinated for supporting his statement that lead-containing solders and finishes are more environment-friendly than the lead-free substitutes.

5.1.3.1 The US-EPA study "Solders in Electronics – A Life Cycle Assessment"[7]

This study is a life cycle assessment comparing environmental and health-related impacts of different lead-free soldering alloys. The study comprises all relevant life cycle stages:

- raw material extraction and smelting of the primary metals
- their processing to solders including recycling of solder wastes in manufacturing
- the application of the solders on PWBs (printed wiring boards)
- and the EoL (end-of-life) phase with different scenarios
  - landfill
  - incineration
  - post-consumer recycling of PWBs in electrical and electronics devices after use by the consumer

The EPA study thus takes into account the entire life cycle. The authors of the study, Geibig and Socolof, besides the detailed version of the study report have also set up a summary of the study (see under GEIBIG, chapter 5.1.5 on page 23).

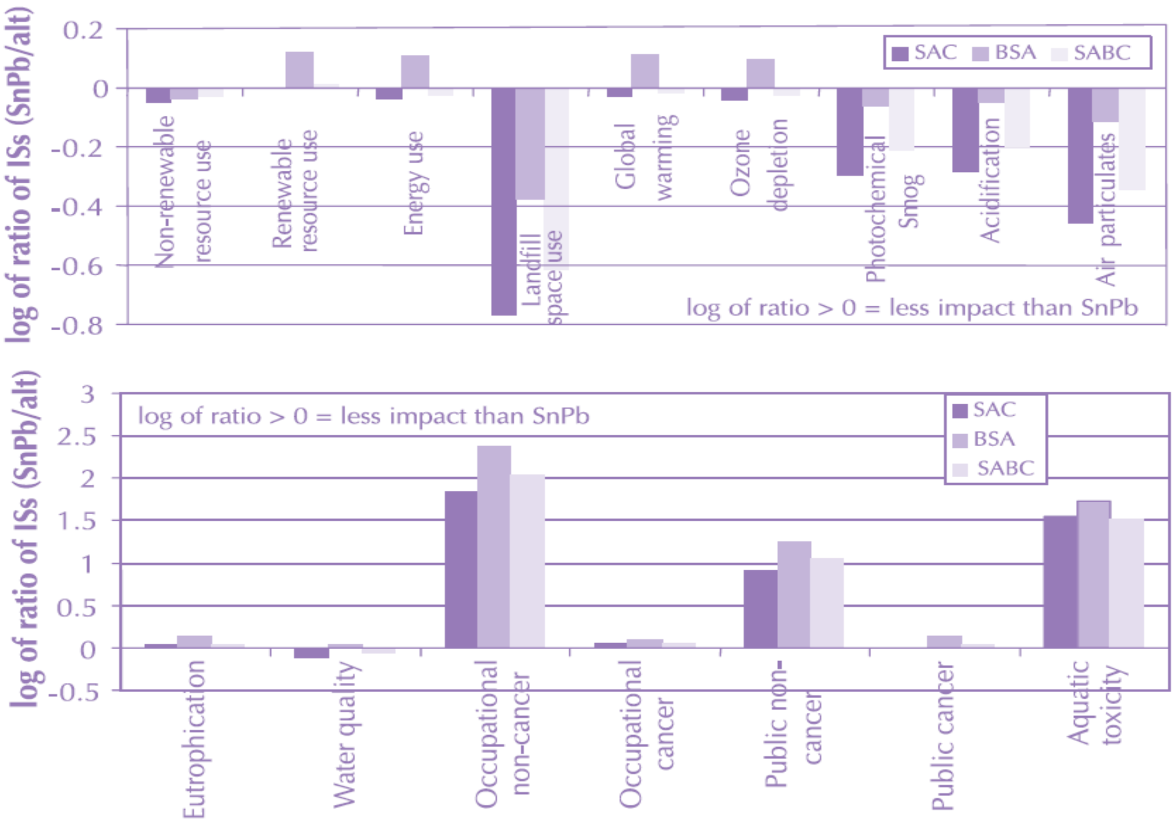
The solders assessed against the tin-lead baseline alloy are:

SAC	tin-silver-copper reflow and wave solder (solder bars and solder pastes)
BSA	bismuth-tin-silver reflow solder (solder paste)
SABC	tin-silver-bismuth-copper wave and reflow solder (solder bars and solder pastes)

The study's scope does not include the finishes on the PWBs and on the electrical and electronic components.

Figure 5-1 shows the results of the evaluation of solder pastes for reflow soldering. All values above zero show that the lead-free solders are advantageous against the tin-lead baseline alloy in the respective impact category considered. Vice versa, values smaller than zero show that the tin-lead baseline alloy has a lower impact in the respective category.

[7] Geibig, Socolof, University of Tennessee, August 2005, file name "lfs-lca-final.pdf"



Note: Do not compare across impact categories.

Figure 5-1: Summary of environmental and health impacts of solder pastes (Geibig, see references on page 23)

Figure 5-2 depicts the evaluation results of solder bars used for wave soldering.

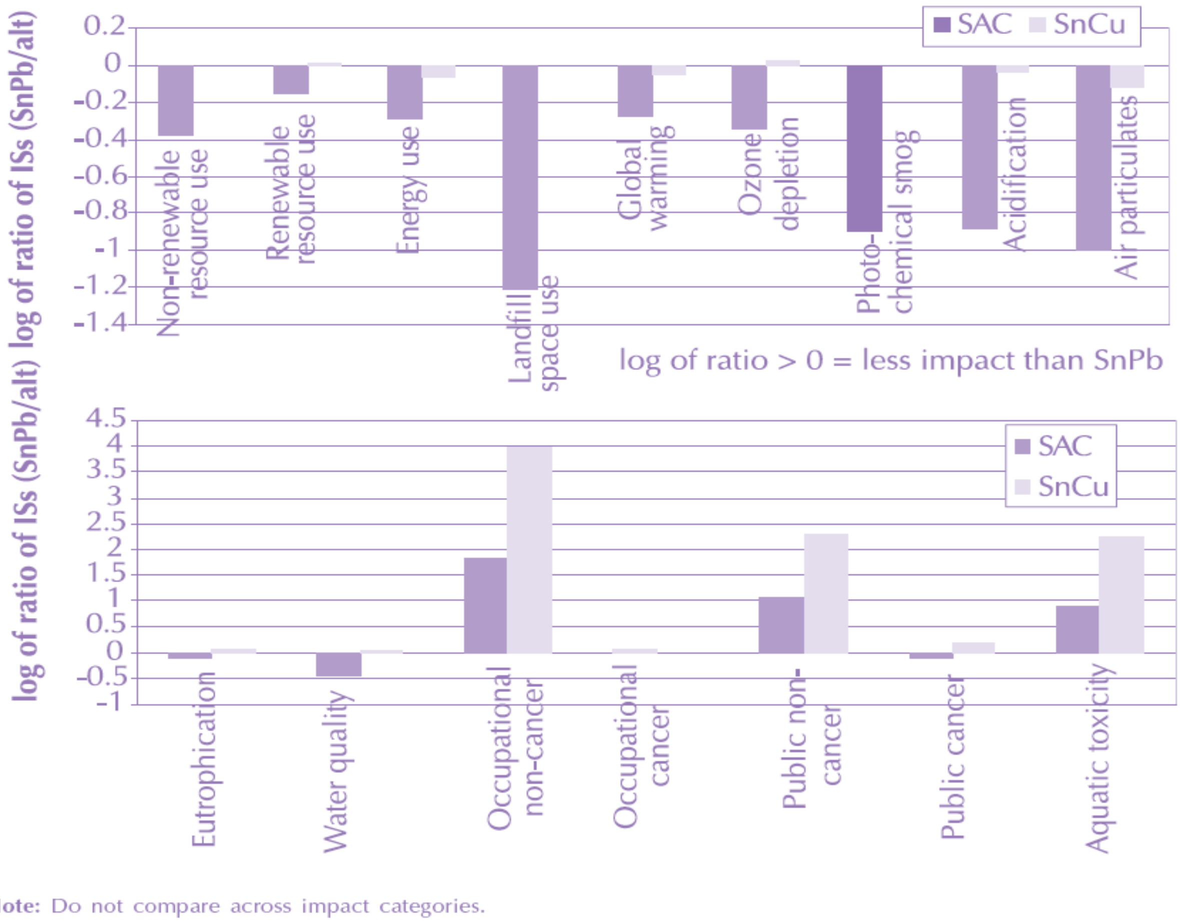


Figure 5-2: Summary of environmental and health impacts of solder bars (GEIBIG, see references on page 23)

All lead-free alloys assessed show advantages and disadvantages for the lead-free alloys depending on the impact category. The authors of the study explicitly warn “Note: Do not compare across impact categories” (see bottom left of both figures). The results illustrated in the figures thus show that lead-free soldering in some environmental and health-related categories have more severe impacts than the tin-lead alloy, in others they are advantageous. The lead-free alloys in general score better in the health-related impact categories related to cancerous and non-cancerous diseases and in aquatic toxicity, while in most other categories the tin-lead alloys are more advantageous. The bismuth-tin-silver reflow solder additionally shows less environmental impacts in some of the other impact categories, which are not directly health-related.

The applicant argues that the EPA study clearly proves that lead-free solders are environmentally inferior to the lead-containing ones. It is not clear whether “environmental” in the applicant’s sense means the overall term comprising all the results: the more environmental impact categories (acidification, landfill space, non-renewable resources etc.) and the more health-related (cancerous and non-cancerous occupational and public diseases). The applicant might as well limit his argument on the environment-related impact categories. In the latter case, the applicant neglects parts of the results, where the lead-free solders score better than the lead-containing ones. If he is referring to both the environmental and health-related impacts, the applicant must have done what the authors of the study warn to do: He must have compared across the impact categories and must have weighted the different impact categories in order to arrive at his final conclusion about the inferiority of the assessed lead-free solders. In any case, the applicant drew conclusions which the study results clearly not supported by the study results.

The authors of the study themselves do not conclude this from their results following their warning not to compare across impact categories. They highlight the strong and weak points of each of the alloys and give recommendations to the different stakeholders on how to properly implement lead-free soldering in order to reduce adverse impacts (see page 27 in GEIBIG LCA Summary document).

5.1.3.2 University of Stuttgart Department of Lifecycle Engineering

The publication of N. Warburg, which the applicant submitted as supporting document[8] is a presentation showing evaluation results of different lead-free solder pastes.

Table 5-1: Solders assessed by Warburg, Unversity of Stuttgart*

Lead Solder Pastes	Lead-free Solder Pastes
SnPb37	SnAg3.5Bi3
SnPb36Ag2	SnAg3.8Cu0.7
	SnAg3.3Bi4.8
	SnAg2.5Cu0.5Bi1
	SnBi58
	SnAg3.5
	SnCu0.7
	SnZn8Bi3

* Values behind the chemical Symbols indicate the mass-% share of the respective metals in the alloy, the rest missing to 100 % being tin.

In contrary to the EPA study, in this publication the lead-free reflow solders containing silver and their processing have more adverse impacts than tin-lead solder pastes in all impact categories considered. Both studies use the same life cycle assessment (LCA) software and still produce different results highlighting the importance of the scope and the framework for the final results.

The lead-free solder pastes without silver, tin-copper and tin-zinc-bismuth solder pastes, are similar to the tin-lead reference paste without silver. The silver-containing tin-lead solder has high scores as well. All environmental impacts are increasing with the silver content. As an example, Figure 5-3 shows the human toxicity potential.

[8] File name “Stuttgartpaper.pdf”

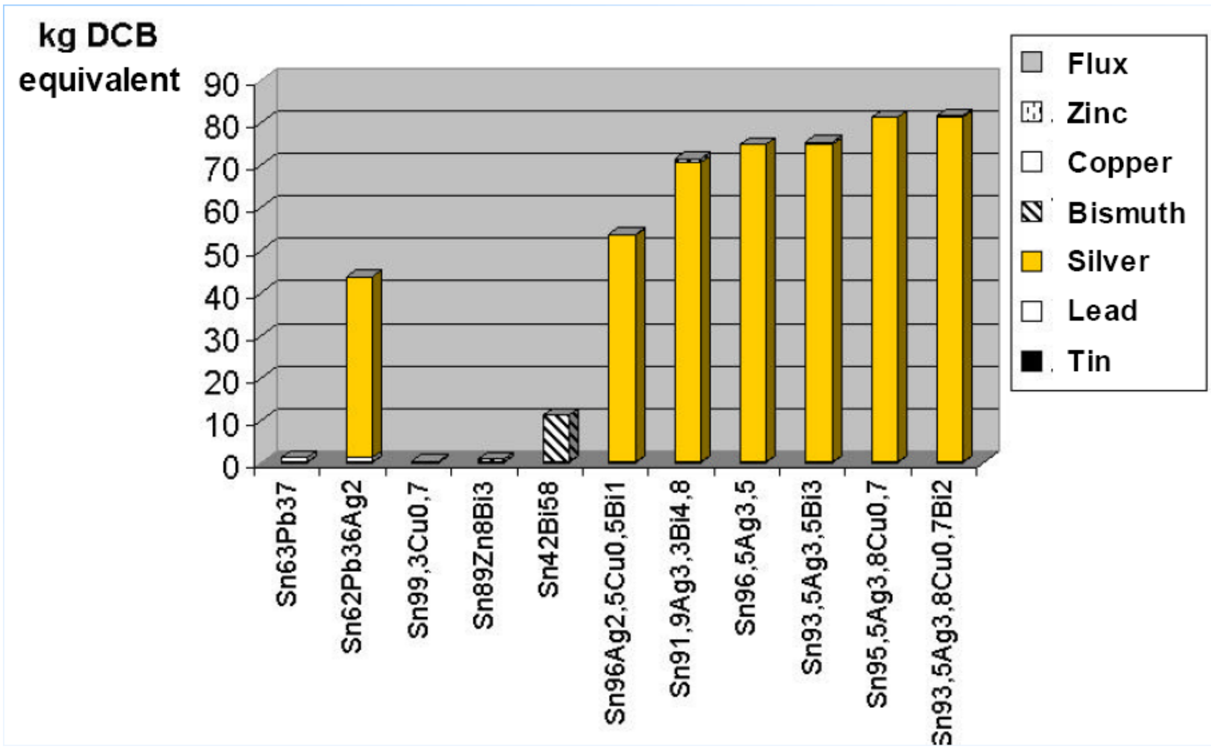


Figure 5-3: Human toxicity potential of equal masses of different solder pastes

[Warburg, as submitted by applicant]; DCB: Dichlorobenzene]

The results are referred to 1 kg of alloy as the functional unit. The study compares mass equivalent substitutes for the tin-lead and lead-free solder pastes.

The substitution of tin-lead solders, however, is done volume equivalently, not mass equivalently. The density of most lead-free solder alloys is around 15 % lower compared to the conventional tin-lead solders. Only around 850 g of SnAgCu solder, for instance, will be sufficient to replace 1,000 g of SnPb on printed wiring boards. The mass equivalent approach does not reflect the actual replacement of tin-lead by lead-free solders and yields a methodical disadvantage of around 15 % for the lead-free solder pastes.

The publication is limited to reflow soldering. Wave soldering is not taken into account. The amounts of tin-lead solder pastes to be replaced by lead-free ones is around 7,000 t, the amount of wave solders around 63,000 t worldwide [Deubzer]. Therefore, around 90 % of the solder alloys are clearly out of the scope limiting the representativeness of the study results.

Narrowing the scope even more, the study is not a cradle-to-grave life cycle analysis, but a cradle-to-gate-analysis, considering the life stages from mining and smelting of the metal to the finished product. It is not clear, whether post-industrial recycling of reflow solder wastes is included or not, and if, whether there are differences for the tin-lead and lead-free solder wastes.

The EoL phase is completely neglected. The publication does not take into account any recycling, landfilling or incineration of WEEE (waste electrical and electronic equipment) containing the solders on the PWBs. Like in the EPA study, the finishes on the printed wiring boards and on the components are not considered either.

The missing EoL scenario is an essential shortcoming of this study, as the potential impacts of lead in the EoL phase were a crucial reason to ban it from the use in solders and finishes (see page 16 for the explanatory note in the RoHS Directive). The missing EoL phase may decisively influence the final result.

The negative results for the silver containing lead-free solder pastes in most impact categories arise from silver in the solder pastes. Recycling may positively influence these adverse silver impacts. Especially noble metals can benefit considerably from recycling, as their recyclability is very high (close to 100 % in copper smelters) and much higher than e. g. for lead (around 65 %) [Deubzer]. For this reason, the impact of lead on the final results is growing compared to that of noble metals at higher WEEE collection and recycling rates. The share of lead in the metals released into the environment increases compared to silver and other noble metals. Lead-free soldering alloys with noble metals benefit most from recycling, which the Warburg study does not take into account. The risk of hazardous impacts from lead in the EoL phase, however, was the reason for the ban of lead. The study thus leaves out the crucial risk that in the rating of the Commission resulted in the ban of lead.

In a second publication, “Lead free from different stakeholders point of view” (“Warburg_Apex.pdf”), Warburg considers the same solder pastes, but this time correctly bases his study on the volume-equivalent solder replacement. The study again is limited to reflow soldering, but reflects on possible impacts of WEEE disposal.

This publication comes up with similar tendencies of the results. This time, however, the potential impacts of landfill on the human toxicity potential are considered as well. Figure 5-4 shows that with increasing leaching rates from landfills, the human toxicity potential of the lead-containing solders increases and may even exceed that of the lead-free solder alloys with silver. The lead-free solder pastes without silver have the lowest human toxicity potential. The potential impact of lead on landfills drives up the human toxicity of lead-containing solder pastes.

Like in the previous publication, the possibly positive effects of recycling in particular for the silver containing solder alloys are not taken into account.

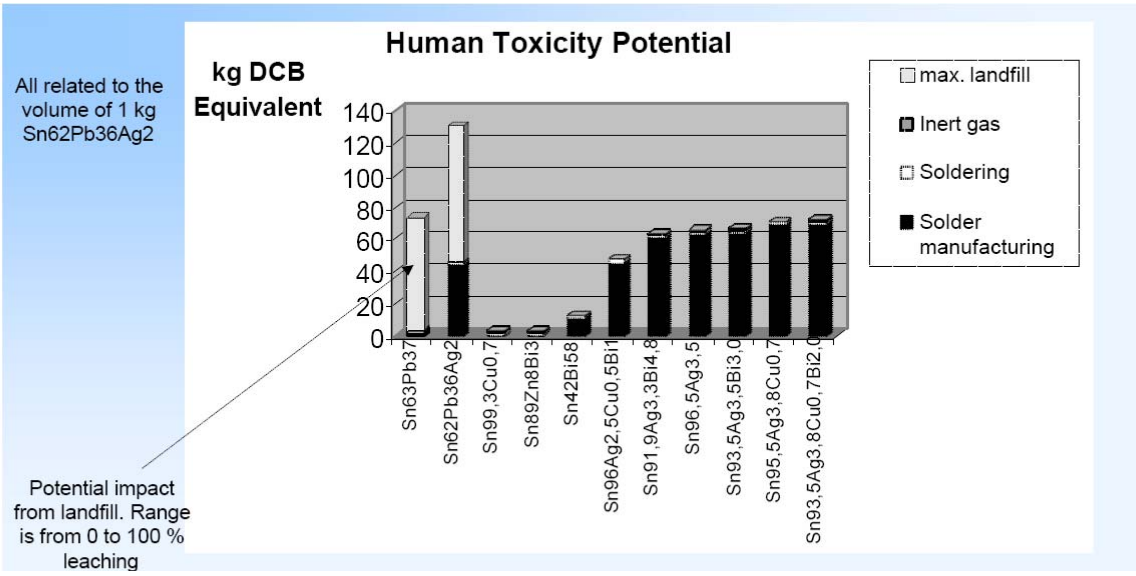


Figure 5-4: Human toxicity potential of lead-free solder paste volumes equivalent to 1 kg of tin-lead solder paste

(source: WARBURG, see references on page 23)

Figure 5-4 is not a proof for or against an environmental advantage of lead-free solders, as the degree of leaching in the long term is not considered. The figure, however, shows that the EoL phase may have a crucial influence on the author's results. The author himself concludes that for lead-free soldering there is a „ […] EOL uncertain situation at landfills, but [lead-free solders] may offer a high improvement chance. […] Lead-free is environmentally acceptable and offers chances to improve […] toxicity, handling in EoL, closed loop recycling economy".

The author himself thus leaves open the final conclusion in his second study given the insecurities and the limitations of the assessment.

5.1.3.3 Summary of the Warburg publication results

The Warburg studies indicate negative results for the lead-free solders and the tin-lead solders containing silver. The impacts from lead- and silver-free solders in most environmental categories considered are similar to tin-lead solders.

In total, the Warburg study is too limited to allow an overall assessment of the environmental impacts of lead-free soldering. The publications are only based on a presentation, the background data and conditions are not revealed sufficiently. It is not life cycle based, but only a cradle to gate analysis neglecting the EoL impacts of WEEE with tin-lead and lead-free solders. The risk of negative impacts on health and environment in the EoL phase of WEEE, however, was a main reason for the ban of lead.

As soon as the author took potential impacts from the EoL phase into account, the tendency of the overall negative lead-free soldering results became less. The author himself leaves open the possibilities that lead-free reflow solders offer improvement potentials compared to tin-lead reflow solder use. Warburg in the end thus does not conclude that the use of lead-free reflow solders is overall environmentally worse than tin-lead soldering.

Additionally, wave soldering and thus around 90 % of all solders used to form solder joints between components and printed wiring boards is out of scope of the study [Deubzer]. The Warburg publications thus are not appropriate to support the applicant's core argument that lead-free solders environmentally are inferior to the tin-lead solders.

5.1.3.4 Overall summary of submitted environmental studies

The EPA study submitted by the applicant does not prove his statement that the substitution of lead in solders and finishes is environmentally more adverse or produces more negative health impacts than tin-lead solders. The Warburg study is too limited in its scope to support the applicant's statement.

There is thus no evidence that lead-free solders are inferior to tin-lead solders in their environmental and health-related properties.

A general exemption of lead application in solders and finishes thus would not be in line with Article 5 (1) (b) of the RoHS Directive.

5.1.3.5 General remarks on the interpretation of lead-free soldering environmental studies

All LCA and similar environmental evaluations of lead-free vs. tin-lead soldering follow the pattern that they assess environmental, health and possibly further impacts in different impact categories as shown e. g. in the EPA study (see Figure 5-1 on page 8 and Figure 5-2 on page 9). These impact categories are not comparable with the means of natural sciences and the results cannot simply be mathematically added or subtracted. The authors of the EPA study therefore explicitly warn "Do not compare across impact categories" [GEIBIG].

Both the EPA and the Warburg publications prove that the ban of lead in solders and finishes and lead-free soldering produces environmental and health impacts, and the EPA study shows that these impacts may be more or less serious than from tin-lead solders.

The decision on whether the ban of lead in solders is justified on environmental, health and safety grounds is justified must be the result of a societal and political evaluation and prioritization of the different impact categories. The question whether the reduction of non-cancer and cancer diseases and aquatic toxicity by lead-free solders (Figure 5-1 and Figure 5-2) justifies the increased global warming potential, photochemical smog, landfill space use and other adverse impacts of lead-free solders depends on how much risk of what kind society is ready to accept.

Science can provide the facts, assess and quantify the different risks as far as possible and provide the results as an input to this societal and political decision process. In this context, the LCA and other studies on lead-free soldering contain valuable information, as far as their limitations and boundary conditions are clear enough to ensure sufficient transparency on the scope, validity and limitations of the results.

Some LCA methodologies include a weighting process of different impact categories based e. g. on panel discussions or on cultural theories [Pré Consultants, see references on page 23] and come up with a single indicator giving overall evaluation results for lead-free and tin-lead soldering respectively. This approach may be appropriate for instance for product evaluations for industries. It can, however, not replace the political and societal priority setting and risk ranking in the context with legislative processes.

Following the precautionary principle, the ban of lead in EEE (electrical and electronic equipment) was a political and societal decision, which prioritized the avoidance of potential toxic impacts from the use of lead to other possibly adverse impacts. "The available evidence indicates that measures on the collection, treatment, recycling and disposal of waste electrical and electronic equipment (WEEE) as set out in Directive 2002/96/EC of 27 January 2003 of the European Parliament and of the Council on waste electrical and electronic equipment […] are necessary to reduce the waste management problems linked to the heavy metals concerned and the flame retardants concerned. In spite of those measures, however, significant parts of WEEE will continue to be found in the current disposal routes. Even if WEEE were collected separately and submitted to recycling processes, its content of mercury, cadmium, lead, chromium VI, PBB and PBDE would be likely to pose risks to health or the environment.“ [9]

[9] DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equip, RoHS Directive.

5.1.3.6 Documents Provided for Additional Support: The RoHS USA Supporting Letter

The applicant has prepared a supporting letter (http://rohsusa.com/page27.html), which around 180 stakeholders have signed and submitted in support of this exemption request:

"I believe that the lead in solders removal as legislated under the RoHS EU directive is environmentally damaging, and that the exemption applied for by the company "RoHSUSA Inc." for an Exemption under Directive 2002/95/EC, Article 5(1) (b), for lead in solders for all classes of solders in electronics on the grounds of increased environmental impact of alternative materials, is both valid and environmentally necessary.

Unless this exemption is granted the environment will suffer as a result. The environmental impact of not allowing this exemption are fully outlined in the support documentation supplied with the RoHSUSA request notably the US EPA report and the university of Stuttgart report both of which address the life cycle environmental impact of the replacements for leaded and unleaded solders. [...] …as outlined in the data submitted by RoHSUSA the substitutes constitute between a 5 and 6 times increased environmental burden over lead containing solder."

On request, the applicant did not explain in detail how he had calculated the overall five to six fold inferiority of lead-free solders. He referred to the Warburg presentation pointing out that this can speak for itself and does not require explanation, as Warburg had done a very thorough job in his opinion on the lifecycle assessments. As illustrated above it must be stated that the study is not a life cycle assessment, but just a cradle to gate assessment excluding the EoL phase and thus a crucial part of the life cycle. The study further only deals with reflow solders neglecting around 90 % of solders, the wave solders (see previous sections). The Warburg study thus certainly is not appropriate to support the applicant's statement, as it is too limited in its scope.

The applicant and the supporters assume that the removal of lead from solders and finishes is environmental damaging and that the environment will suffer, if the exemption for lead in finishes is not granted. It must be considered as a fact that lead-free solders have environmentally adverse impacts, but also environmental and above all health-related advantages compared to the lead-containing solders. This is what the EPA study clearly shows, which the applicant himself had submitted. The studies, however, do not prove the overall environmental and health-related inferiority of lead-free solders, as was discussed in the previous sections. Correctly, this is a matter of personal priorities, not of scientific evidence. The supporting letters are not based on scientific evidence and thus do not support a positive recommendation to grant the requested exemption for lead in solders and finishes.

5.1.3.7 Stakeholder documents on environmental issues

The Health and Environment Alliance (HEAL) has submitted a stakeholder document[10] opposing the applicant's exemption request.

"In a recent study of the European Commission two recommendations were made, both highly relevant to this application." (see EUROPEAN COMMISSION in the references on page 23).

"More attention needs to be paid to the waste treatment options applied to products containing lead. The residual flows from waste incineration are of special concern. These are voluminous flows like fly ash and slugs, and several EU member states prefer to re-use these materials in road building and other building products. This might result in a greater use of lead in the building sector. It appears that under unfavourable conditions, young children may exceed their tolerable daily intake. Therefore, for children there is a need for further information and testing."

"Lead therefore is still the single most important chemical toxin for children and is probably the best known example of a neurotoxin to which children are particularly vulnerable. Their special vulnerability to lead is related to their exposure (hand–mouth activity, pica, ingestion of paint chips), their absorption (the fraction of absorption in children is 40% compared with 10% in adults) and their susceptibility at a critical period of brain development. "

"The above study is only the view from within the EU where the control of exposure to lead is of an advanced nature however, as reported recently by the BBC "at the moment a lot of this waste ends up, often illegally, in dumping sites around the globe, especially in the developing world." The potential for lead exposure of children in the developing world caused by this hazardous waste must also be of concern to European citizens."

The HEAL document rises more arguments, which the LCA studies might not or only partially have taken into account. The document shows that the lead issue has many environmental and health related aspects which the applicant's statement that lead-free solders are environmentally inferior does not reflect sufficiently.

The WG for International Restrictions on the Chemical Substances among other aspects, states that lead is more toxic than the lead-free soldering metals citing the international joint research project IMS-EFSOT (Japan, Europe, and Korea, in 2000-2005). The stakeholder did not submit the respective supporting evidence cited in the stakeholder document. The stakeholder opposes the assumption that WEEE collection and recycling might solve

[10] File name „RoHS Ex 15 (1).doc"

this lead toxicity problem. “It is simplistic to say that recycling solves the problem. […] In 2001, Japan started recycling air conditioners, refrigerators, washing machines, televisions, and other major appliances. […] the actual collection rate is about 50%, due to illegal dumping and hidden distribution channels. 100% collection is extremely difficult, even under the WEEE directive in Europe. Needless to say again, the environmental problems are global issues and more acute in some countries, which are still inadequate in terms of the recycling of waste electric and electronic equipment. Collection and recycling schemes for lead batteries are well established, while complete recycling of tiny lead solder spots distributed over boards is practically impossible. In other words, stating that “lead solder is appropriately collected for recycling” remains an idealistic theory and it is not actually feasible to realize 100% recycling of lead solder. “[11]

5.1.3.8 Documents Provided for Additional Support: Lead-free Solder – A Push in the Wrong Direction? [12]

This document shows the results of different leaching tests with different lead-free solders and a tin-lead solder. The paper shows that leaching from lead-free solders is possible to a level that the concentrations of metals used in lead-free solders exceed limit concentrations in the EPA “Toxicity Characteristic Leaching Procedure” (TCLP) or the EPA drinking water guideline. Especially antimony exceeds the limits considerably, partially also silver. The paper does, however, not comment on the leaching results of the SnPb baseline alloy. Tin-lead leaching results are only mentioned in one table:

[11] WG for International Restrictions on the Chemical Substances of 4 electrical and electronics industry associations in Japan (JEITA, CIAJ, JBMIA, JEMA; file name “Attachment_1 Explanatory document (JEITA) REVISED.doc”

[12] File name „expo99pdf__IT_1.pdf”

Table 2 - Complete Results of the TCLP Leach - *3/8 inch size solder solids used except where noted*

Alloy	Sn, mg/L	Ag, mg/L	Cu, mg/L	Sb mg/L	Pb, mg/L
1	<0.05	9.32	43.75	NA	NA
2	<0.05	11.56	NA	NA	NA
3	<0.05	8.46	NA	NA	NA
4	<0.05	NA	44.52	NA	NA
5	<0.05	NA	NA	55.50	NA
Sn/Pb paste	11.39	NA	NA	NA	1800
Sn/Pb wire	0.082	NA	NA	NA	1002
average Pb free	<0.05	9.78	44.14	55.50	standard dev.
1.60	0.54	3s upper	14.58	45.77	average SnPb
5.74	1401	standard dev.	8.00	564	3s upper
29.72	3094				

Source: E. B. Smith, L. K. Swanger: Lead-free Solder – A Push in the Wrong Direction?

The table shows that the concentrations of lead from solder wires in the leachate are more than 100 times that of silver from the standard tin-silver-copper alloy compared to the tin-lead wire, and even almost 200 times that of silver compared to the leachate from the tin-lead solder paste. The paper does not comment on the lead results nor give any clear indication on whether and to what degree these values would exceed legal limits. The paper describes the results of more leaching tests, but without a tin-lead baseline comparison. It is not clear, either, why the study takes tin-lead paste and wires as testing materials and not the 3/8 inch size solder solids used for the lead-free solders.

The document thus shows that lead-free solders are "[…] not the panacea to solve the potentially toxic effects from tin-lead solder alloys." Lead-free solder alloys as well may have an environmental and health impact via drinking water. The paper does not comment on any results for lead-containing solders. The baseline of comparison thus is not available and the paper does not prove that lead-free solders are environmentally inferior to tin-lead solders – which article 5 (1) (b) of the RoHS Directive requires for an exemption. It is not sufficient to show that the substitutes have or may have environmental impacts as well. An exemption can only be based on clear evidence that the substitutes have more serious overall environmental and health impacts than the substituted materials. The paper thus does not support the applicant's request to exempt lead in solders and finishes for environmental reasons.

5.1.3.9 Additional documents on reliability issues

Whiskers

The paper "jes00c337pdf__IT_1.pdf" submitted by the applicant shows the results of research into the mechanisms of how lead reduces whisker growth on tin-lead surfaces. The applicant submitted the paper to give additional evidence justifying the use of lead in solders and finishes due to reliability reasons.

Although the mechanism of how lead reduces the whisker risk maybe at least partially new knowledge, the fact that lead reduces whisker growth is well known. The supporting document does not prove that only lead can eliminate or reduce the whisker risk to a level, which is acceptable or manageable.

A second paper [13]describes failures of pacemakers due to whisker growth on tin surfaces. The paper seems to be from the late eighties. At least the literature cited in the references is from the seventies. The paper thus does not reflect the current state of knowledge concerning whisker growth and whisker mitigation techniques. The paper thus does not give evidence justifying a re-evaluation of the whisker risk as the consultants's already conducted it.

A third document [14] is a single presentation slide listing partial or complete losses of satellites due to whisker growth. It is not clear whether the respective surfaces did contain lead additionally or not. The document shows that whiskers pose a certain risk for failures in satellites operating in space. Space conditions, however, are not comparable to the operation conditions of equipment within the scope of the RoHS Directive. Satellites are out of the scope of the RoHS Directive.

The stakeholder document thus does not say anything about the risks of such products within the scope of the RoHS Directive that they might fail due to whisker growth on tin-lead or lead-free finishes.

Whisker growth on lead-free finishes was already dealt with in other exemption requests (see http://forum.europa.eu.int/Public/irc/env/rohs/library?l=/requests_exemptions/resistant_applications&vm=detailed&sb=Title, second stakeholder consultation, set 1, exemption requests HP, FCI, etc.). The applicant's supporting evidence document does not provide new

[13] File name "FDA -1986 Tin Whisker induced failures in Pacemakers.pdf"

[14] File name "Satellite failures due to Tin Whiskers.pdf"

information justifying a re-evaluation of these previous exemption requests or even a general exemption for lead in solders and finishes due to reliability reasons.

General reliability and technical issues

Electrolux has submitted a stakeholder document opposing, among others, the exemption of lead in solders and finishes. [15] Electrolux argues that it has successfully changed its products to the use of lead-free solders and finishes. Electrolux has found that lead-free solders and finishes are technically appropriate and can replace lead solders and finishes.

The Working Group for International Restrictions on the Chemical Substances submitted a stakeholder comment 16 opposing the applicant's statement about the inferior reliability of lead-free solders. The stakeholders state that "Lead-free solder has been already used in Japan and elsewhere for large screen TVs, car navigation systems, cellular phones, and automobile control circuit boards, etc. This actual achievement of lead-free solder contradicts the assertion about low reliability."[16]

The stakeholder documents prove that a general exemption for lead in solders and finishes for technical reasons would not be justified as manufacturers have successfully shifted their products to RoHS compliance.

5.1.4 Final recommendation

Concluding on the above mentioned review and evaluation, it is recommended not to grant this exemption. The applicant did not provide evidence that, as a consequence of the substitution of lead in solders and finishes, the overall environmental and health impacts are more severe than without the substitution. The applicant did not provide evidence, either, that the reliability or other technical properties of lead-free solders and finishes generally require the use of lead in solders and finishes. The applicant's request and supporting information thus do not suffice the requirements of article 5 (1) (b) for an exemption.

[15] File name "Electrolux_RoHS Stakeholder Consultation November 2006_VS to DG Env.pdf"

[16] WG for International Restrictions on the Chemical Substances of 4 electrical and electronics industry associations in Japan (JEITA, CIAJ, JBMIA, JEMA; file name "Attachment_1 Explanatory document (JEITA) REVISED.doc"

5.1.5 References - Other than Submitted Stakeholder Documents

DEUBZER, Otmar: Explorative Study into the Sustainable Use and Substitution of Soldering Metals in Electronics - Ecological and Economical Consequences of the Ban of Lead in Electronics and Lessons to Be Learned for the Future; PhD thesis TU Delft, The Netherlands, January 2006, ISBN 978-90-5155-031-3

EUROPEAN Commission DG Enterprise report "Risk to health and environment of the use of lead in products in the EU", Contract no. ETD/00/503273, http://ec.europa.eu/enterprise/chemicals/docs/studies/tno-lead.pdf.

GEIBIG, Jack R.; Socolof, Maria Leet, University of Tennessee: Solders in Electronics – A Life Cycle Assessment Summary; US Environmental Protection Agency (EPA), EPA 744-S-05-001, August 2005; download from **http://www.epa.gov/dfe/pubs/solder/lca/lca-summ2.pdf**, last access June 10, 2006

WARBURG, Niels et al.: Lead free from different stakeholders point of view; IKP University of Stuttgart, Germany

PRE Consultants, The Netherlands: http://www.pre.nl/eco-indicator99/weighting.htm; last access December 22, 2006

6 Further proceeding

The next step will be to finalise sending out the first questions to applicants (for 9 of the 23 requests). Furthermore, recommendations for the requests for which they are already in progress will be finalised.

The next monthly report is scheduled for 24 February 2007.