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

Exemption request No. 5

"Lead in solders for the connection of very thin (<100 µm) enamelled copper wires and for the connection of enamelled copper clad aluminium wires (CCAWs) with a copper layer smaller than 20 µm."

Cover letter and checklist as submitted by D&M Premium Sound Solutions

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DG Environment- Directorate G
Unit G.4 Sustainable Production and Consumption
Attn. Ms Madalina Caprusu
Avenue de Beaulieu 5 (BU-5), B-1049 Brussels
Belgium

Your ref.	Our ref.	Date
	MSC	

BELGIUM

REQUEST FOR EXEMPTION WITH RESPECT TO DIRECTIVE 2002/95/EC ON THE RESTRICTION OF THE USE OF CERTAIN HAZARDOUS SUBSTANCES IN ELECTRICAL AND ELECTRONIC EQUIPMENT (ROHS)

Dear Ms Madalina Caprusu,

Attached you will find a request for an exemption for the use of lead in solders for the connection of very thin (<100 µm) enamelled copper wires and enamelled copper clad aluminium wires with a copper layer smaller than 20 µm.

Kind regards,

Mark Schaerlaekens
Senior Chemical Engineer

Bernard Geldof
Chief Executive Officer
PSS Belgium NV

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
ENVIRONMENT
Directorate G - Sustainable Development and Integration
ENV.G.4 - Sustainable Production & Consumption

DIRECTIVE 2002/95/EC[1] ON THE RESTRICTION OF THE USE OF CERTAIN HAZARDOUS SUBSTANCES IN ELECTRICAL AND ELECTRONIC EQUIPMENT (ROHS).

CHECK LIST FOR REQUESTS FOR ADDITIONAL EXEMPTIONS

Industry has sent to the Commission's services a number of requests for exemptions from the requirements of the RoHS Directive that are additional to those currently covered by the study and the stakeholder consultation. In most cases these are not substantiated by scientific and technical evidence. The proposed check-list will enable the Technical Adaptation Committee (TAC) to carry out a first screening of the requests received. Proposals that successfully pass the screening process will then be considered for a possible exemption.

Article 4(1) of Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment1 provides 'that from 1 July 2006, new electrical and electronic equipment put on the market does not contain lead, mercury, cadmium, hexavalent chromium, PBB or PBDE.' The Annex to the Directive lists a limited number of applications of lead, mercury, cadmium and hexavalent chromium, which are exempted from the requirements of Article 4(1).

Adaptation to scientific and technical progress is provided for under Article 5 of the Directive. Pursuant to Article 5(1): "Any amendments which are necessary in order to adapt the Annex to scientific and technical progress for the following purposes shall be adopted in accordance with the procedure referred to in Article 7(2):"

Article 5(1)(b) allows the exempting of materials and components of electrical and electronic equipment from Article 4(1) if their elimination or substitution via design changes or materials and components which do not require any of the materials or substances referred to therein is technically or scientifically impracticable, or where the negative environmental, health and/or consumer safety impacts caused by substitution are likely to outweigh the environmental, health and/or consumer safety benefits thereof. <u>These terms of reference mean that the TAC cannot consider exemptions for any other reason, for example a justification based on increased costs.</u>

In order to allow the TAC to consider submissions for additional exemptions, the information in Table I should be provided as a minimum requirement. The request for submissions must fulfil the criteria of Article 5(1)(b). The information provided should be supported, as far as possible, with relevant technical and scientific evidence.

[1] OJ L 37, 13.2.2003, p. 19

Commission européenne, B-1049 Bruxelles / Europese Commissie, B-1049 Brussel - Belgium. Telephone: (32-2) 299 11 11. Office: BU-5 5-167. Telephone: direct line (32-2) 2960493. Fax: (32-2) 2963980.

TABLE I – CHECK LIST

PROPOSALS FOR FURTHER EXEMPTIONS FROM THE REQUIREMENTS OF ARTICLE 4(1) OF DIRECTIVE 2002/95/EC FOR SPECIFIC APPLICATIONS OF LEAD, MERCURY, CADMIUM, HEXAVALENT CHROMIUM.

Submitted by: PSS Belgium NV………………………………………………………

Criteria	Information: Please provide supporting technical and scientific evidence
1. Please indicate the specific application for which the exemption is requested and indicate a precise and clear wording for the new exemption.	**A comprehensive document with the complete exemption request is attached.** Solders used for the connection of thin enamelled copper wires, or enamelled copper clad aluminium wires with a thin cladding. These wires are used in light coils, when fast movement is required. The use of thin and light wires ensures less power consumption during the life-cycle of the product. **“Lead in solders for the connection of very thin (<100 µm) enamelled copper wires and for the connection of enamelled copper clad aluminium wires with a copper layer smaller than 20 µm”**
Please describe the material/ component of the electrical and electronic equipment that contains the hazardous substance.	During the pre-tinning of the enamelled CCAW, a thin layer of lead (60%) containing solder (less than 0.1g), is placed upon a very thin wire.
Please indicate the functionality of the substance in the material of the equipment.	The solder has to remove the lacquer (enamel) by thermal composition at high temperature (+/- 450°C) and to give an electrically conductive, mechanically strong connection.
Provide a detailed description of the application which explains why the restricted substance is currently required or used.	To make a good electrical contact between the enamelled CCAW and the electrical power source a solder with 60% lead is the most viable option. • The solder has to remove the enamel by thermal decomposition at a temperature above 450°C. • The solder has to give an electrically conductive, mechanically strong and reliable connection. • Copper dissolves too fast in RoHS compliant solders to make a reliable connection to CCAWs; • Other substitutes cannot withstand the high temperatures (450°C) needed for stripping; these solders are oxidising to fast at these temperatures. • The changeover to a HMP solder with >85% lead was not tested as an alternative, as this would logically lead to an increase with 42% of the total lead concentration used for this application. First of all this would be a counterproductive measure according to the philosophy behind the RoHS regulation, secondly, the mechanical strength of this connection could prove to be insufficient.
Please indicate the quantity of the	

Criteria	Information: Please provide supporting technical and scientific evidence
hazardous substance present in the whole equipment (Kg).	Maximum 100 mg of solder containing 60% lead within a device starting from a mass of 50 g.
2. Please explain why the elimination or substitution of the hazardous substance via design changes of materials and components is currently technically or scientifically impracticable.	See paragraph 4 of the exemption request for more details o Copper dissolves too fast in RoHS compliant solders to make a reliable connection to CCAW o Other substitutes cannot withstand the high temperatures (450°C) needed for stripping; these solders are oxidising to fast at these temperatures. o The stripping of the insulation layer cannot be done mechanically because the small wire cannot withstand forces higher than 0.35N. o The changeover to a HMP solder with >85% lead would logically lead to an increase with 42% of the total lead concentration used for this application. Also, the mechanical strength of this connection could prove to be insufficient. o A solution would be an Al/Cu/Ni/Cu wire, as introduced by Totoku under the name KCCAW. At his time KCCAWs are not available on the market with diameter smaller than 150 µm. Upon drawing the wires to obtain very small diameters, small defects in one of the very thin layers can easily cause failure to the desired functionality of this layer. Due to the complicated production process, at the moment KCCAWs are only technical practicable for larger diameters.
3. Please indicate if the negative environmental, health and/or consumer safety impacts caused by substitution are likely to outweigh the environmental, health and/or consumer safety benefits. If existing, please refer to relevant studies on negative impacts caused by substitution.	See paragraph 4 of the exemption request for more details o The soldering problem could be partially overcome by replacing the CCAWs with copper wires. For applications that need a very thin (< 100 µm) copper wire, this is still not a technically reliable option. The reason to make the changeover from copper wires to CCAWs was primarily to improve the environmental impact. In the envisaged application of tweeters, replacement of the CCAWs with copper can easily double the weight of the moving part of the speaker. This leads to a decrease of output of the speaker. To compensate this loss in acoustical power, the electrical power needs to be multiplied by a factor 4. o To compensate the extra weight of the copper wire, 12% of extra material and thus extra weight needs to be added to the magnet system.
4. Please indicate if feasible substitutes currently exist in an industrial and/or commercial (please provide reference for the substitutes).	Currently, no feasible substitute does exist

Criteria	Information: Please provide supporting technical and scientific evidence

If substitutes exist on the market, please indicate why they are not used. Please indicate in which applications they are used.
 	
Please indicate what efforts are being made by your company to develop alternative techniques.
 	
Please indicate if the alternative techniques will be available by 1 July 2006 or at a later stage. If not by that date, please indicate when you expect an alternative to be available?
	Not applicable
	
	Different alternatives were tried;
	o Different RoHS compliant solders were tested, none of them provided reliable, good mechanical bonding.
	o Chemical stripping was tried which resulted in incomplete removal of the lacquer
	o Preliminary testing with KCCAWs was done, but due to technological issues at supplier side, this route has been omitted as no KCCAWs with desired diameter is currently available.
	o Micro-welding with aluminium proved to be impossible.
	o Stripping with heat, other than from solder, was also tried without success.
	  o Hot air
	  o Molted salts
	
	No alternative techniques are available. There are two possible alternative routes that can become available in the future.
	-RoHS compliant reliable solders that are not dissolving copper as fast as the presently available RoHS compliant solders.
	-KCCAWs (see paragraph 4) or alike with sufficient low diameters will be technological feasible.
	
	We expect that a least on of these solutions will be available starting from 2012-2014. For this reason, the timeframe of the requested exemption is proposed to be 2014, with an intermediate evaluation after 4 years, to update the exemption towards the new state-of-the-art.

5. Please provide any other relevant information that would support your application for an additional exemption.	**A comprehensive document with the complete exemption request is attached.**

Additional guidelines

To support your application, it may be useful to provide, in addition, an assessment of your application from an independent expert. These should be accompanied by information that will allow the Commission and TAC to be satisfied that the consultant is independent and is qualified to assess the application.

Explain the reasons why potential alternative materials, designs or processes are unsuitable with quantitative data wherever possible. If possible, provide photographs or diagrams to illustrate claims. Sources of information should be referenced where possible.

D&M
Premium Sound Solutions

REQUEST FOR EXEMPTION WITH RESPECT TO DIRECTIVE 2002/95/EC ON THE RESTRICTION OF THE USE OF CERTAIN HAZARDOUS SUBSTANCES IN ELECTRICAL AND ELECTRONIC EQUIPMENT (ROHS).

Requested to

European Commission
DG Environment- Directorate General

by

PSS Belgium NV

"*Lead in solders for the connection of very thin (<100 µm) enamelled copper wires and for the connection of enamelled copper clad aluminium wires with a copper layer smaller than 20 µm"*

1. Specific application and wording

A request for exemption related to the ELV-directive and to the RoHS directive is filed at the same time with the same wording. Allthough there are is a minor difference in the exemption request originating from the diffences in consumer and automotive market, the thechnological reasoning supporting the application is the same for both applications:

Lead in solders for the connection of very thin (<100 µm) enamelled copper wires and in copper clad aluminium enamelled wires with a copper layer smaller than 20 µm

2. Background

An enamelled copper clad aluminium wire (CCAW) is schematically depicted in Figure 1.

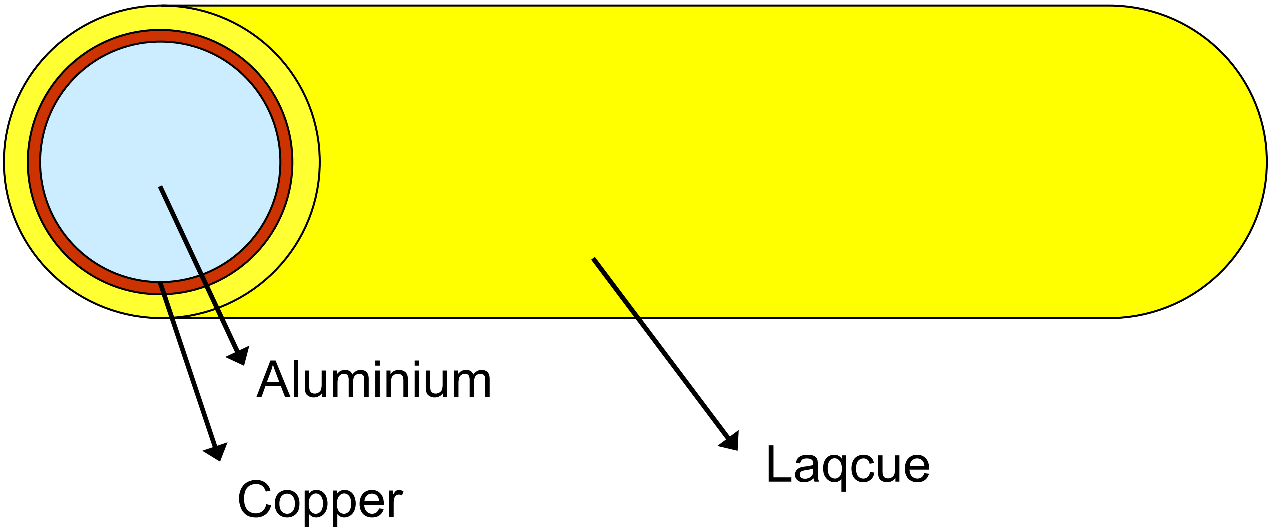

Figure 1: Schematic presentation of an enamelled CCAW.

Enamelled CCAWs are used to make light coils. These light coils are used in cases were fast movements are required.

- Aluminium is used as a core material because of its combination of good electrical conductivity and light weight.
- The copper cladding is necessary to ensure a good and reliable contact between the wire and the soldering contact. Without this thin copper layer, because of the electrical potential between tin and aluminium in combination with humidity (Volta element), the aluminium is hydrolysed. This makes the aluminium wire brittle and vulnerable to micro cracks, resulting in the breaking of wires and failure of the product. In practice, the copper layer is 3-10 µm thick.
- The lacquer is the electrical insulation layer around the coil. As a large amount of heat is generated in the electrical conductive wire during operation, the lacquer has to withstand to relatively high temperatures.

To make a good electrical contact between the enamelled CCAW and the electrical power source a solder with 60% lead is the most viable option.

- The solder has to remove the enamel by thermal decomposition at a temperature above 450°C.
- The solder has to give an electrically conductive, mechanically strong and reliable connection.

3. Process description and minimizing lead containing solder

In our application, the enamelled CCAW is soldered in a two step process. Due to this two-step process, the use of lead containing solder is minimized.

- In a first step, the thin enamelled CCAW is pre-tinned. In this step, a lead containing solder is proposed (60(Pb) / 38(Sn) / 2(Cu)). During this processing step, the lacquer is removed by thermal degradation, and a thin (<10 µm) layer of solder is deposited on the the CCAW. The estimated weight of solder (60% Pb) necessary to pre-tin a single voice coil is calculated to be below 0.1 g (20 to 100 mg). An example of the resulting intermediate article is presented in Figure 2.
- In a second step, the pre-tinned enamelled wire is soldered to the loudspeaker frame with lead free solder. During this second solder step, part of the lead present on the pre-tinned wire dissolves in the secondly used solder, resulting in a solder connection point with variable concentration of lead (from below 1000 ppm to 2% depending on measuring area).

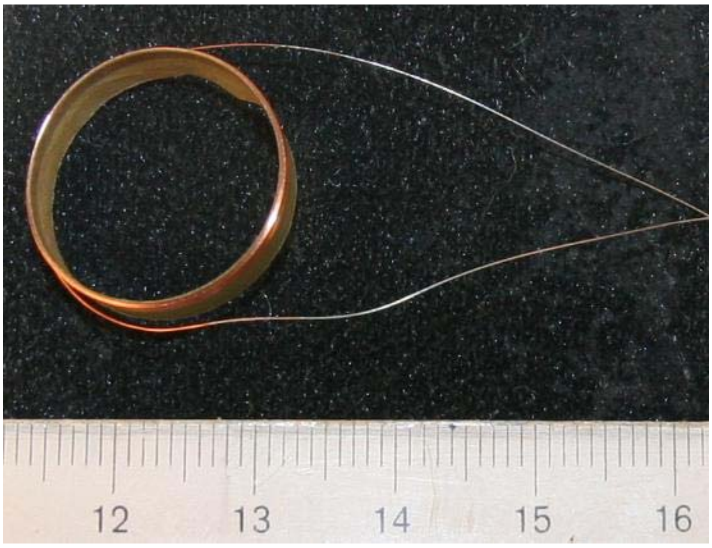

Figure 2: A voice-coil with a pre-tinned enamelled CCAW

4. Justification for the exemption according to Article 5 (1) (b) of the RoHS Directive:

Replacement of the solder

- Copper dissolves too fast in RoHS compliant solders to make a reliable connection to CCAWs; Figure 3, illustrates how fast a copper wire dissolves in the current state-of-the-art lead free solder, specially developed to reduce the dissolution of substrate metal. During the contact time in the pre-tinning process, an important fraction of the copper wire/cladding is dissolved, leading to a less reliable connection. Note that the results are obtained at 350°C, and that the dissolution will be significantly higher at 450°C.

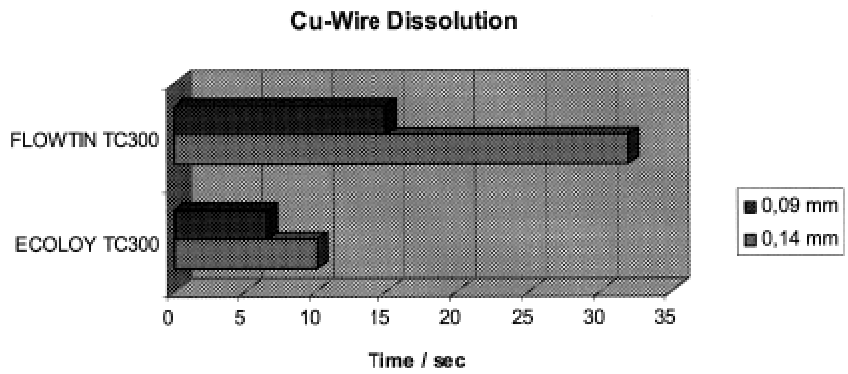

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Figure 3: Time for the complete dissolution of copper wire: (figure taken from the Stannol website)

- Other substitutes cannot withstand the high temperatures (450°C) needed for stripping; these solders are oxidising too fast at these temperatures. The stripping of the insulation layer cannot be done mechanically because the small wire cannot withstand forces higher than 0.35N. Chemically stripping was tested as an alternative but proved to be impossible due to incomplete removal of the lacquer.
- Also the chemical stripping would have a serious negative environmental impact.
- To remove the lacquer in a single separate step, with heat was also tried:
  - Hot air stripping proved to be impossible due to the small possible operating temperature window. Either there is nor reaction at al, and the lacquer is not removed, or the total wire is destroyed.
  - Removal of the lacquer with heated molted salts proved also to be incomplete and very critical. In addition, incomplete removal of the residual salt created an extra problem.
- The changeover to a HMP solder with >85% lead was not tested as an alternative, as this would logically lead to an increase with 100% of the total lead concentration used for this application. First of all this would be a counterproductive measure according to the philosophy behind the RoHS regulation, secondly, the mechanical strength of this connection could prove to be insufficient.
- As described in the Öko-institute report 2007, § 5.1.4, “there is no clear evidence that it is feasible to solder thin wires of 100 micrometer diameter and less with RoHS compliant solders.

Design Changes

- The soldering problem could be partially overcome by replacing the CCAWs with copper wires. For applications that need a very thin (< 100 µm) copper wire, this is still not a technically reliable option. The reason to make the changeover from copper wires to CCAWs was primarily to improve the environmental impact. First of all, there is the difference in weight of the winding wire itself, which leads to weight increase of 240% of the coil wire. As the voice-coil is a fast moving part in the envisaged application, higher electrical power will be consumed. In the envisaged application of tweeters, replacement of the CCAWs with copper can easily double the weight of the moving part of the speaker. This leads according to the formula mentioned below to a decrease of output of the speaker with 6 dB. To compensate this loss in acoustical power, the electrical power needs to be multiplied by a factor 4.

  -20 log (Mmd with copper/ Mmd with CCAW) = 20 log (2) = -6 dB

  In practice, the loss in acoustical power will be partially compensated by using a stronger magnet system, which leads to a higher yield in the transfer of electrical power towards acoustical power. To fully compensate the extra weight of the copper wire, 12% of extra material and thus extra weight needs to be added to the magnet system.

- Another viable option would be looking for alternatives for CCAWs that have an intermediate density between CCAWs and copper. A solution would be an Al/Cu/Ni/Cu wire, as introduced by Totoku under the name KCCAW. At his time KCCAWs are not available on the market with diameter smaller than 150 µm. Due to the complicated production process, at the moment KCCAWs are only technical practicable for larger diameters.

5. Time perspective

No alternative techniques are available. There are two possible alternative routes that can become available in the future.

-RoHS compliant reliable solders that are not dissolving copper as fast as the current available RoHS compliant solders.

-KCCAWs (see paragraph 4) or alike with sufficient low diameters will be technological feasible.

We expect that a least on of these solutions will be available starting from 2012-2014. For this reason, the timeframe of the requested exemption is proposed to be 2014, with an intermediate evaluation after 4 years, to update the exemption towards the new state-of-the-art.

6. Additional information

Specific application for the exemption

The application for in which the exemption would be used by the applicant are high tone tweeters. For the phrasing of the exemption is chosen to focus on the technical and scientific aspect, that justify the exemption and not on the final market application. This is done to avoid a number of parallel exemption initiatives that are all related to the same technological challenges. In the past, at least two related exemption requests were filed to the European Commission were the technical argumentation to justify an exemption were largely overlapping with this new exemption request.

- *"Lead in Solders for the connection of very thin enamelled wires with a terminal".*
- "*Lead in solders for the soldering of thin copper wires of 100 µm diameter and less in power transformers"*

In our opinion it would lead to a European Legislation 'personalised' towards the specific stakeholders that request for one exemption.
If nevertheless a more specific market application would be preferred, the following phrasing is proposed:

Lead in solders for the connection of the Cupper Clad Aluminium Wire of a tweeter voice coil to the tweeter frame

Quantity of substance covered by the RoHS directive

The total amount of lead present in one device is calculated to fall between the 12 and 60 mg for a 50 g tweeter.

The applicant has no exact information on the total quantity of products that would fall under this exemption, but as tweeters are omnipresent in European households, in principle this could apply to >30 millions of products.

The applicants sells a total amount of speakers in the order of magnitude of 10 million annually worldwide, and a large proportion is designated towards the automotive industry for which there is an overlap with the ELV Directive. Simultaniously with this exemption application, another exemption application is also filed related towards the ELV directive.