D&M
Premium Sound Solutions

PSS Belgium NV
Industrieterrein Hoogveld, Zone A4
Hoogveld 50
B - 9200 Dendermonde

Tel. 052 / 261 434
Fax. 052 / 261 674
e-mail: mark.schaerlaekens@dmpss.com

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

Your ref.	Our ref.	Date
	MSC	

BELGIUM

REQUEST FOR EXEMPTION RELATED TO DIRECTIVE 2000/53/EC ON THE END-OF LIVE VEHICLES

Dear Ms Hatzi-Hull,

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 for tweeters in vehicles.

Kind regards,

Mark Schaerlaekens
Senior Chemical Engineer

Bernard Geldof
Chief Executive Officer
PSS Belgium NV

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REQUEST FOR EXEMPTION RELATED TO DIRECTIVE 2000/53/EC ON ON THE END-OF LIVE VEHICLES

Requested to

European Commission
DG Environment- Directorate General

by

PSS Belgium NV

Materials and components exempt from Article 4(2)(a):

"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.

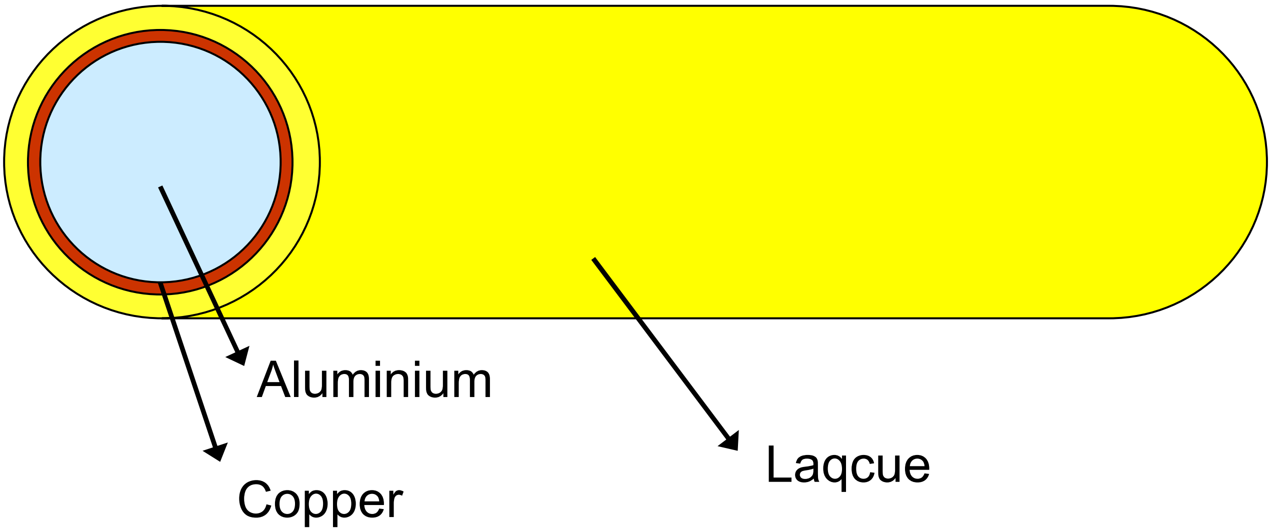

Figure 1: Schematic presentation of an enamelled CCAW.

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).

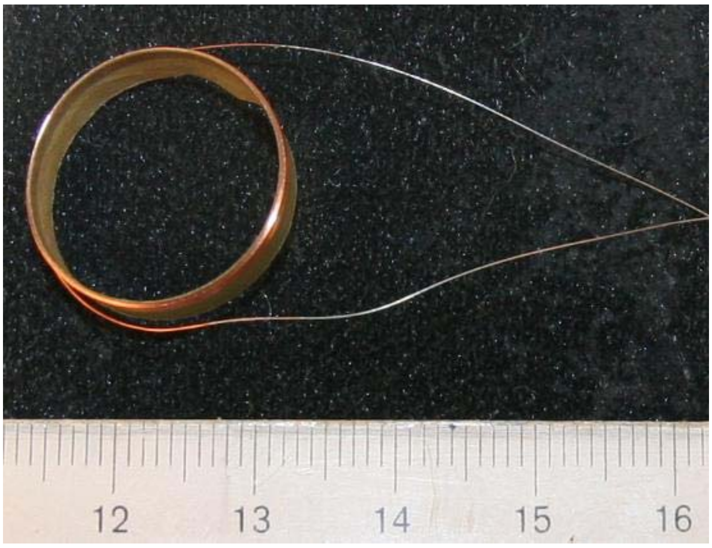

Figure 2: A voice-coil with a pre-tinned enamelled CCAW

4. Justification for the exemption

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.

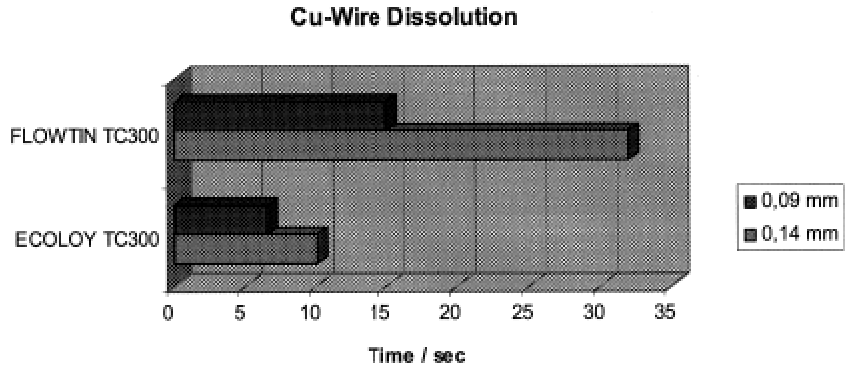

Figure 3: Time for the complete dissolution of copper wire: (figure taken from the Stannol website)

- 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.
- As described in the Öko-institute report *“Adaptation to Scientific and Technical progress under Directive 2002/95/EC, Final Report 22 october 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. 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. 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.

-Lead free 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.
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 ELV 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.
Thus the total amount of lead in a vehicle that would be covered by this application falls below 240 mg.

The applicants sells a total amount of speakers in the order of magnitude of 10 million annually worldwide that would fall under this exemption, of which the larger part is designated towards the automotive industry.