This initial feedback is submitted on behalf of participants in the Umbrella Project ("UP")´s Exemption #6c technical Working Group ("WG") (hereafter referred to as "UP Exemption #6c WG Participants").

Clarification Questionnaire Exemption No. 6(c)

Exemption for „Copper alloy containing up to 4 % lead by weight“

Abbreviations and Definitions

C36000	Leaded copper alloy, CuZn39Pb3 with a lead content between 2.5 - 3.5%
EEE	Electrical and Electronic Equipment
UP	Umbrella Project
RoHS	Directive 2011/65/EU on the Restriction of Hazardous Substances in Electrical and Electronic Equipment

Background

The Oeko-Institut has been appointed by the European Commission, within a framework contract[1], for the evaluation of applications for exemption from Directive 2011/65/EU (RoHS), to be listed in Annexes III and IV of the Directive.

Your organisations Bourns Inc. and Rosenberger Hochfrequenztechnik and PHOENIX CONTACT on behalf of the “RoHS Umbrella Industry Project” (hereafter referred to as “Umbrella Project”) have submitted requests for the renewal of the above-mentioned exemption, which has been subject to an initial evaluation. A summary of the main argumentation for justifying the request is provided below as a first basis to be used in the stakeholder consultation planned as part of this assessment.

Please review the summary of the argumentation provided to ensure that your line of argumentation has been understood correctly and provide answers to the questions that follow that are to address aspects requiring additional information and/or clarification.

1. Summary of argumentation of applicant on the justification of the exemption

1.1. Background

Bourns Inc. and Rosenberger Hochfrequenztechnik and PHOENIX CONTACT on behalf of the “RoHS Umbrella Industry Project” request the renewal of exemption 6(c) for:

“Copper alloy containing up to 4 % lead by weight”

Lead in copper alloys improves the machinability by acting as an internal lubricant and chip breaker and by preventing cracks. Lead also improves the technical performance of parts e.g. increases corrosion resistance and influences stress relaxation behaviour or mechanical deformation.

According to the Umbrella Project, the exemption covers the following copper alloys:

[1] The contract is implemented through Framework Contract No. ENV.B.3/FRA/2019/0017, led by Ramboll Deutschland GmbH.

- Leaded brass: copper-zinc-lead alloys are by far the most used leaded copper alloys.

Other leaded copper alloys are used in smaller amounts than brass:

- Leaded bronze: copper-tin-lead alloys;
- Leaded nickel silver: copper-nickel-zinc-lead alloys;
- Leaded copper beryllium: copper-beryllium-lead alloys.

Bourns Inc. is a manufacturer of small passive electronic components for which the following components of leaded copper alloys are needed: bushings, shafts, terminals, terminal strip and rivets. Bourns Inc. explains that leaded copper alloys can be precisely processed in fast screw machines.

The Umbrella Project applies for the renewal of the above-mentioned exemption for electrical and electronic equipment (EEE) of category 1 to 10 with the maximum validity periods. Bourns Inc. applies for EEE of category 1-11 "*depending on EEE manufacturer using electronic components as part of their assembly*" as well with the maximum validity period.

1.1.1. Volume of lead to be placed on the EU market through the exemption

Both applicants are not able to give an estimation on the amount of lead placed on the EU market through leaded copper alloys:

- The Umbrella Project states that nearly no "new" lead from primary sources will enter the EU market as the alloys (especially brass) are made from recycled material.
- Bourns explains that their electronic components are sold by distribution so that they do not know the number of components including the leaded copper alloy C36000 (CuZn39Pb3[2]) brass entering the EU.

  However, Bourns Inc. specifies the use of lead by providing a list of the different models of the electrical components that Bourns manufactures, with unit weight in grams and the share of lead of the total unit weight based on the C36000 composition. Thus, the finished units contain between 0,0003 and 0,33 gr lead.

1.2. Technical description

The Umbrella Project generally claims that copper alloys are neither cheap nor light materials and assumes that they will only be used when needed. The Umbrella Project argues that the machinability of the leaded copper alloys is important to produce a specific component/part and makes a substitution impracticable as components/parts made of leaded copper alloys have essential properties e.g. conductivity, relaxation, corrosion, lubricity, for which substitutes have not shown comparable performance.

According to the Umbrella Project, electrical or thermal conductors are the majority of applications of leaded copper alloys in EEE, e.g. all kinds of connections for the transfer of data, signal or power. Furthermore, leaded copper alloys are widely used for specifically designed mechanical parts with small scale features like e.g. cable glands, housing parts, filigree formed accessory parts, etc.

[2] The material designation of this alloys is: CuZn39Pb3 with the number CW614N; the alloys contains 2.5-3.5% lead.

The UP does not provide further specifications for the components made of leaded brass besides examples where substitution has shown special problems, e.g. crimp connections, knurls, gas nozzles and retaining heads.

Bourns Inc. manufactures electronic components such as precision potentiometers, encoders, panel controls, rotary sensors, and trimming potentiometers for which they need leaded copper-zinc alloys (or the “free cutting brass C36000” - CuZn39Pb3) for the following parts:

- Encoders: (shafts, terminals, terminal strip);
- Panel Controls: (brass shafts, strips, rivets);
- Precision Potentiometers: (wiper terminal, terminal, shafts, bushings);
- Rotary Sensors: (bushings);
- Slide Potentiometers (rivets);
- Trimming Potentiometers (shafts);

Bourns Inc. explains that the brass can be precisely processed in fast automatic screw machines.

1.3. Applicant’s justification for the requested exemption

The Umbrella Project have performed a standards survey and have identified four lead-free brass alloys basically available that have different mechanical properties compared to leaded copper alloys:

- CuZn21Si3P, is defined with a lead content ≤ 0.1% w/w; this silicon brass is also called Ecobrass; it has a lower electrical and thermal conductivity than leaded copper alloy.
- Three Copper-Zinc alloys are commercially available with a lead content ≤ 0.1% w/w: CuZn40, CuZn42 and CuZn38As which have a higher zinc content. It is important to note that these alloys do not contain a chip breaker such as lead or silicon.

The Umbrella Project argues that no new lead-free copper alloy became available in the last five years since the last evaluation of the exemption in 2015/2016.

Bourns Inc. argues that no substitutes have been identified that showed the same machinability in automatic screw machines; the machinability is not further specified e.g. by speed or tool life.

1.3.1. **Availability of alternatives** *(Substitution or Elimination, roadmap to substitution, reliability of substitutes)*

The Umbrella Project specifies the less favourable properties of the lead-free alloys as follows:

- The high zinc content in the alloys CuZn37, CuZn40 and CuZn42 cause several changes to the mechanical behaviour e.g.:
  - A higher hardness together with long chip formation causes a higher wear or a break of tools: Special tools with chip breaker partly helped to overcome the problems, however, for the occurrence of chatter marks, burrs or edges no solutions were found.
  - A lower cold forming ability makes the material unsuitable for crimping as cracks from the conductor until the edge of the connection and at the outside surface were reported from several manufacturers.

- The silicon brass (Ecobrass) CuZn21Si3P has a lower electrical and thermal conductivity and is therefore not used for electrical or thermal conductors. In mechanical parts/components, the machinability of CuZn21Si3P is indicated at 70 – 75% of the leaded copper alloy CuZn39Pb3/C36000. For drilling of small bores, no practicable solution has yet been found and applying the five-step drilling strategy proposed by the Ecobrass manufacturer a maximum number of 25,000 bores of one drill whereas the Umbrella Project specifies the requirement to be at 1.000.000 bores before the drill has to be changed; thus Ecobrass was not found to be practicable. However, there were no further actions taken by the applicant since the last evaluations of this exemption in 2015/2016 on further possible adaptations in the machining processes.

For Bourns, the use of Ecobrass is not possible for the following reason: The distributor of Ecobrass only provides bars with the smallest diameter of 0.250; however, Bourns require a diameter size of 0.075; using 0.250 bars would result in 91% waste if machined down to 0.075.

Other substitutes mentioned by the applicants but not further explored are the following:

- The alloy CuZn38As is applied in some drinking water applications as Arsenic hinders de-zincification; this requirement is not relevant in EEE; besides, the high toxicity of arsenic this alloy is not used in EEE.
- Lead-free alloys with high copper content, e.g. C18625 with 99.4% w/w copper are much softer than brass which results in a lower strength and shows long chip formation.
- Stainless steel has a lower machinability of 40-50% compared to leaded brass.
- Bourns Inc. mentions different material such as aluminium, zinc die cast and nickel silver but state that all three alternatives have a higher raw material cost and a slower machining rate which reduces the overall capacity the company can manufacture and shortens tool life.

The Umbrella Project dedicates one chapter of the application to “Examples for Successful Substitution” where feedback from a survey among the 50+ partnering associations of the Umbrella Project is cited. The electrical and electronic manufacturers' associations reported no examples of successful substitutions. One citation states that this topic should be better addressed directly to the members of metal industry associations and component manufacturers within the Umbrella project.

From mechanical engineering associations, statements indicate that one company was able to mostly substitute leaded copper alloys, another partly and still another company applies low leaded copper alloys for some applications.

1.3.2. **Environmental and health arguments** *(also LCA aspects)*

The Umbrella Project claims that for leaded copper alloys a closed loop exists and that semi-finished goods of leaded brass are nearly entirely produced from recycled material. The Umbrella Project claims that a sudden restriction of leaded brass would cause an adverse effect as the required material could not be made by direct recycling anymore.

Bourns Inc. refers to information that cover e.g. an Environmental Product Declaration of copper alloys, comments on the socio-economic analysis on classification and labelling of lead in copper

alloys and (refers to a life cycle assessment (LCA) on metals covering the life cycle stages mining, purification and refining that all however do not directly relate to the exemption request.

1.3.3. Socioeconomic impacts

Both applicants mention direct costs related to substitution but without further substantiating their statements:

- The Umbrella Project claims that investments in new machines would be difficult for small and medium sized enterprises; changes in the production process might require additional manual work that further increases direct costs ("especially problematic for companies in regions with high salaries").

  Besides, the Umbrella Project also raises the aspect of the direct recycling of chips that derives as pre-consumer waste from the machining processes. According to the Umbrella Project mixing of silicon brass and leaded brass chips would impede a direct recycling; they argue that a parallel use of both alloys are not practicable.
- Bourns Inc. mentions as direct costs a higher raw material price, higher prices if machining is slower and/or tool life shortened.

2. Clarification Questions

Answers of the UP Exemption #6c WG Participants:

We thank the Oeko-Institut for this summary and clarification questions. We confirm that main parts of the renewal request have been described correctly in this summary. In addition we would like to add two small further clarifications:

- **In chapter 1.3 the Oeko-Institut states: "The Umbrella Project argues that no new lead-free copper alloy became available in the last five years since the last evaluation of the exemption in 2015/2016."**

  We would like to clarify that other lead-free copper alloys are under development and have been tested by partnering companies/associations. But these alloys mostly only exist on lab scale and/or partnering associations/companies did not report them as promising or research is ongoing.

- **In chapter 1.3.1 the Oeko-Institut states: "However, there were no further actions taken by the applicant since the last evaluations of this exemption in 2015/2016 on further possible adaptations in the machining processes."**

  The cited report of RWTH Aachen from 2016 showed several results that were used by companies for in-house research and development but no working solution was reported by one of the partnering companies/associations of the UP.

To the Umbrella Project:

1. You state on the amount of substance entering the EU market annually through application for which the exemption is requested that "*we expect nearly no "new" lead from primary sources will enter the EU market as the alloys (especially brass) are made from recycled material.*"

Please provide an estimation on the amount of lead based on the use leaded copper alloys in EEE.[3]

The numbers reported in the 2015/2016 evaluation are still correct. Due to slightly smaller production volumes also the amounts slightly decreased while the main finding that "nearly no "new" lead from primary sources will enter the EU market as the alloys (especially brass) are made from recycled material" remains valid.

2. The Umbrella Project cites the following statements received from mechanical engineering associations:

- *"We already process low leaded copper alloys (Pb max. 0.2% w/w) for specific customers. The change to low leaded alloys requires longer process times and a shorter tool life. For castings in the field of vision (chromed parts) the surface quality is often only achievable with higher rejection rate (costs!). All together we would not call this a successful substitution."*
- *"[…] Our products are not yet completely changed to lead-free brass but we already produce some components in such a way and others are to follow. For this we use lead-free brass from our own foundry and we also process components from lead-free brass from suppliers. According to our experience the material is 15-20% more expensive than common brass with approx. 1.6% lead and it shows some challenges in machining. In addition we work with a higher wall thickness and thus the material demand is enhanced which has negative influence on the production costs. The tools and processes have to be adjusted to the new material to obtain the required surface quality. These adjustments are workable but they are time and cost intensive for the specific products in regards to preliminary investigations. Also the process time is increased."*
- *"We already introduced lead-free materials in many of our product groups and we mainly substituted the leaded materials. With appropriate preparation and today´s experience this can be done without problems if the higher prices are not considered. We are in the lucky position that our sector accepts acceptable additional costs for the predicate "lead-free."*

Please provide more information on these substitution examples e.g.

a. Please specify the lead-free or low leaded alloys that are used in these cases.

Mainly Ecobrass was named as substitute by members of the partnering association. Some members did not identify which alloy type (Ecobrass or CuZn37/CuZn40/CuZn42) is used due to confidentiality issues. Replies specific for drinking water applications have not been considered in this answer as they are often not relevant for RoHS exemption 6c (either no electrical/electronic equipment or excluded from RoHS scope as large scale fixed installation).

b. Please specify the components/parts where substitution could be reached also naming the sectors where this experience has been gained.

Mechanical parts have been reported: bearings, housings, couplings and spindles. All are from the mechanical engineering sector. One partnering company named cast or forged and machined counterweights used in air conditioning and refrigeration compressors when space allows the use of lead-free material.

[3] E.g. in the last evaluation in 2015/2016, Phoenix Contact and Harting stated that "ca. 2500 tpa lead based on a use amount of leaded alloys in EEE of 100,000 tpa with 2.5% lead threshold is assumed."

c. Please specify what kind of adaption in the production process and to machines, tools were necessary.

Adaptions in the production process like feed rate and speed have been reported by the members of the partnering association without more specific information.

d. Please provide estimates of the range of additional costs, additional time and additional resources needed where substitutes have been applied.

The overall cost increase when substituting leaded brass CuZn39Pb3 by CuZn21Si3P has been calculated by Schultheiss et. al. as 77%[4] which is far beyond everything acceptable for series production. The answers received from the partnering association support this finding but they do not allow an exact quantification as information required for quantification e.g. production amounts or market share of the company are of course confidential and not known to the working group answering this questionnaire.

Additional information about the substitution of leaded copper alloys by Ecobrass can be derived from a recent publication given by Mitsubishi Materials Corporation (MMC), the owner of the patent of Ecobrass, in the course of the assessment of ELV exemption 3.[5] We understand that Mitsubishi Materials Corporation calculates from its overall sales that 4% of leaded brass have been substituted by Ecobrass (pages 1 and 3). The annual total sales volume of Ecobrass increased in the years 2007 until 2016 (Fig. 1 on page 3). Between 2016 and 2017 only a very small increase in sales happened and the total sales for 2017 and 2018 are constant while they decreased in Europe.

In conclusion the findings of the survey about succesfull substitution in the UP working group and the findings of Mitsubishi Materials Corporation are in line:
Partnering associations and companies have been asked from 26th of August until 30th of September 2019 repeatedly to provide information about successful substitution of leaded copper alloys, stressing the importance of showing industry´s willingness to substitute. One partnering association received answers from some members (the statements reported in our renewal request). In the course of answering this questionnaire this association again checked with its members and in addition one partnering company supported with information. Other partnering associations and companies did not report successful substitutions.
All information received supports the finding that for a very small portion of mechanical applications substitution of leaded brass with Ecobrass was possible. Quantification is not possible due to confidentiality: the partnering association received statements from <10 member companies and their market share as well as the marked share of the products for which a successful substitution was possible can not be disclosed to the working group answering this questionnaire.
As we understand the 4% of leaded brass replaced by Ecobrass as reported by MMC is calculated from the overall sales of Ecobrass. As the electrical and electronic industry has just a very small share in the sales of Ecobrass we have to be careful when we transfer this 4% to this industry. But we think that it is correct to estimate that up to 4% of leaded brass

[4] F. Schultheiss, C. Windmark, S. Sjöstrand, M. Rasmusson, J.-E. Ståhl, *Int. J. Adv. Manuf. Technol.*, **2018**, *99*, 2101-2110.

[5] https://elv.biois.eu/MITSUBISHI.pdf

used in the elctrical and electronic industry can be substituted now and in the future by Ecobrass. Even this is just a small number it should be taken into account that it is achieved under technically extremly challenging requirements.
On the other hand we do not expect a further increase in this substitution. The constant and in Europe even decreased sales of Ecobrass support this outlook that we derived from the technical findings as explained in our renewal application. Even the small share of the electrical and electronic industry in the overall sales of Ecobrass does not allow to directly receive a conclusion from these sales, the information given by MMC does not support another interpretation. Even more the fact that the automotive applications reported for Ecobrass by MMC in 2020 are the same as reported by Mitsubishi Shindoh in 2014[6] and the lack of examples from the electrical and electronic industry support our finding.

3. The Umbrella Project concludes on the five-steps drilling strategy for Ecobrass as proposed by Mitsubishi-Shindoh that *"we do not think that a 5 steps drilling is a practicable strategy as already explained in the RWTH Aachen report about drilling. As explained in this report, the requirement is a one step drilling with 1.000.000 bores before the drill has to be changed. The Aachen report gives several good results and hints for improving the drilling of CuZn21Si3P. This report only reports a maximum number of 25.000 bores for one drill. After this the experiment was stopped. Although only low wear of the bore was observed after the experiment, as the numbers of required bores (1.000.000) and experimentally achieved bores (25.000) differs so much, it is not possible to conclude from it. All together the findings of Mitsubishi Shindoh and RWTH Aachen are promising but they do not yet show a possibility of drilling CuZn21Si3P as required."*

   Please provide an estimation on the increase of direct costs if the different drilling strategy is applied so that your argument for the non-practicality can be followed.

   Please detail your estimations by indicating e.g. increase in time needed for production, costs for tools, coolant lubricant, etc.

The 5 steps drilling approach was elaborated on a CNC (Computerized Numeric Control) machine. But in most industrial machining shops rotary transfer machines are used. For these machines the 5 step drilling technology is not applicable. The reason for this is that they are mechanical machines with a limited number of machining stations. Each station is mechanically controlled and always makes the same movement with a tool. One machining station can therefore not perform five different drilling depths, only the one step drilling technology is feasible. To exchange all machines of the whole electrical industry in short time is not realistic due to extremely high costs and simply unavailability of such a high number of machines. Therefore the findings on the CNC machine are good hints for future developments but for the moment they are more of academic nature. An estimation of the increased costs is therefore not yet relevant as the 5 steps drilling approach is technically not practicable at the moment.

4. You state on the lead-free brass CuZn38As that "the use of highly toxic arsenic without its need would not make sense in electrical and electronic equipment." However, you mentioned that this alloy is applied in several drinking water applications.

[6] https://elv.exemptions.oeko.info/fileadmin/user_upload/Consultation_2014_1/Ex_3/2014-12-10_Mitsubishi_elv-exception-main-en.pdf

Arsenic is added to brass to prevent dezincification when brass is immersed in potable waters and in seawater (pipes, heat exchangers, etc.). Dezincification is when the zinc in the brass dissolves to leave porous copper which is physically weak and easily fractures. Dezincification can be prevented by added arsenic and this arsenic remains in the brass and should not dissolve in the water. Almost all of the arsenic is present within the bulk of the alloy and only atoms at the surface will be in contact with water. Therefore, arsenic does not dissolve in the water as the arsenic in the brass prevents corrosion. Typically, dezincification resistant brass contains <0.1% arsenic, so its use is not a concern for contaminating potable waters although arsenic free dezincification brass is now also available.
But for electrical and electronic equipment dezincification is usually not a relevant problem as a contact with relevant amounts of water as in drinking water applications will not happen. Thus, the use of arsenic in alloys used in electrical and electronic equipment would not make sense as still arsenic is a toxic element and it does not enhance the machinability of the alloys.
It should be noted that also lead is not released from copper alloys during intended use of electrical and electronic equipment. As a closed loop exists, we also expect no relevant release of lead during the treatment of waste electric and electronic equipment and the recycling of the copper alloys. A release of lead due to improper waste treatment is usually the consequence of illegal actions, e.g. illegal export of waste electrical and electronic equipment.

To Bourns Inc.

5. You state that "*Bourns continues to work with our current and potential suppliers, explore possible solutions, experiment with possible alternatives. We are currently evaluating other potential alternatives that offer rod diameters that would not result in a more significant amount of waste material than usable parts. Identification of these potential alternatives are proprietary at this time. It is a slow process with research, experimentation, testing, scale-up, qualification & reliability testing. If there is a failure along the way, the process starts over.*"

   Please submit more detail information on a confidential base on the substitute material (e.g. is it a copper alloy or a different material) and whether adaptations in the machining process of the rivets, shafts etc. are necessary.

   Please explain whether there are also adaptations in the manufacturing of the finished units necessary.

   Please provide a roadmap for substitution that illustrates the stages and timeline that are needed to reach substitution.

In case parts of your contribution are confidential, please provide your contribution in two versions (public /confidential). Please also note, however, that requested exemptions cannot be granted based on confidential information!

Finally, please do not forget to provide your contact details (Name, Organisation, e-mail and phone number) so that Oeko-Institut can contact you in case there are questions concerning your contribution.