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

Clarification Questionnaire Exemption No. 6(b)-II

Exemption for „Lead as an alloying element in aluminium for machining purposes with a lead content up to 0,4 % by weight“

Abbreviations and Definitions

Al	Aluminium
EEE	Electrical and Electronic Equipment
Pb	Lead
RoHS	Directive 2011/65/EU on the Restriction of Hazardous Substances in Electrical and Electronic Equipment
UP	Umbrella Project

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 COCIR, HARTING Stiftung & Co and Pepperl + Fuchs AG on behalf of the “RoHS Umbrella Industry Project” (hereafter referred to as “Umbrella Project”) has submitted a request 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 address aspects requiring additional information and/or clarification.

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

1.1. Background

The Umbrella Project, represented by COCIR, HARTING Stiftung & Co and Pepperl + Fuchs AG, applies for the renewal of exemption 6(b)-II of Annex III of the RoHS Directive with its current wording:

> „*Lead as an alloying element in aluminium for machining purposes with a lead content up to 0,4 % by weight*“

The Umbrella Project summarizes that lead in aluminium alloys improves machinability by acting as a lubricant. Through the presence of lead, better chip fracturing and surface finish as well as higher

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

cutting speeds and a longer tool life are achieved. The Umbrella Project requests the applicability of the exemption for the categories 1 to 10.

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

The applicant does not specify the volume of lead to be placed on the EU market through the exemption, but rather of lead placed on the market as a constituent of Al alloys, where it is not added through the use of secondary Al. The Umbrella Project estimates an annual amount of lead of about 90 tonnes, however stating that this is lead in Aluminium which is not recycled. [2] The estimates are based on general considerations on the European Al production and the share thereof for industrial sectors. The Umbrella Project states generally that only a very low amount of leaded aluminium is still required for some niche applications.

1.2. Technical description

The Umbrella Project states that leaded aluminium is still required for some so called “niche” applications but on the other hand that an exhaustive list of applications cannot be provided due to the diverse nature of the end products which utilise components with leaded aluminium.

The applicants explain the required use with technical characteristics that relate in part to manufacturing and in part to the manufactured components:

- Micro-machining;
- Electrical conductivity;
- Galvanic corrosion prevention;
- Corrosion resistance against e.g. chemicals;
- Mechanical relaxation;
- Tribological behaviour;
  - Superior machinability due to factors such as chip fracturing and surface finish;
  - Enhanced cutting tool lifetime;
  - Better wear resistance of components made of leaded aluminium as it reduces friction and wear of surfaces that slide against others (such as connectors);
- Ability to form lightweight, intricate shape parts.

The Umbrella Project does not provide performance indicators for these characteristics / functionalities.

As examples for parts and components, the following are listed by the Umbrella Project:

- Frameworks and equipment housings that need to be machined to precise shapes and dimensions in complex electromechanical gears e.g. tools and parts which need to be used in fluorinated or

[2] “*In Europe about 7,7 million tonnes of Aluminum were produced in 2018. Assuming that about 4,5 million tonnes are in industrial sectors, out of this (based on statistical assumptions) about 450000 tonnes (10%) is not recycled. However, not all of these applications would contain lead up to 0,4%, assuming that 5% of the unrecycled material includes lead up to 0,4% results in 22500 tonnes of aluminium containing lead. Consequentially, this would result in 90 tonnes of lead which is not recycled. In the overall scheme this will have minimal impact as it results in 0,3% of the EU total aluminium production*.”

chlorinated gas ambient like chemical vapor treatment for semiconductor processes or chemical surface treatment;

- Precision machined frame of body-parts of handheld tools;
- Metal knobs (of switches), connector bodies, terminals, crimp connectors, cable glands, pipe fittings, nuts, hooks, eyelets, etc.;
- Platens and hard masks for CVD evaporation in fluoric ambient with local high temperature gradients and no allowed distortion; and
- Electrical components that have variable functions that are adjusted using screws having very precise dimensions made from leaded aluminium alloys, e.g. variable inductors;
- Precision machined flow meters for marine applications;
- Explosion proof enclosures.

1.3. Applicant's justification for the requested exemption

The Umbrella Project claims that no suitable alternative exists for all applications and argues that "*until all applications are able to trial lead free alloys then the reliability is not ensured.*"

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

The Umbrella Project mentions cadmium, tin, bismuth and beryllium as possible substitutes.

- **Cadmium** is not further detailed because it is itself RoHS restricted.
- **Tin** is mainly argued as providing less favourable mechanical properties to the material (causing cracking in machined parts when exposed to stress and high temperature; causing surface darkening on annealing and increasing the susceptibility to corrosion).
- **Bismuth** is mainly argued as having limited availability due to its being defined as a critical raw material. The Umbrella Project further argues that Bismuth has a more negative overall health and environmental impact (see section 1.3.2).

  On the machinability level, the Umbrella Project states that the manufacturability of bismuth alloys for some alloy types is similar to lead containing alloys: "*However to fully understand the quality of a machined surface after machining it is essential to know for each alloy type the microstructure which has not been fully investigated for all alloys and uses*."
- **Beryllium** is also not further detailed because the Umbrella Project concludes that it has similar toxicity to lead and also limited availability.

The Umbrella Project provides a list of lead-free aluminium alloys (wrought alloys as they are designated with a four-digit number). These alloys rely on bismuth and / or tin. There is no further assessment of technical performance presented. Rather general statements are given such as e.g.

- "*In some alloys tin is used as a substitute to lead often in combination with bismuth. However, in turning and machining tests long and continuous stripes were observed which cause very poor machinability*."

- "*The lack of availability of bismuth and lead-free aluminium alloys would support the assessment that the technical performance of tin alloys is not as closely matched to the traditional lead containing aluminium alloys*."
- "*Some alloys have been substituted by lead free compositions like e.g. AW-6026 to AW-6026LF as lead free alternative with high bismuth content. However, this is not possible for all applications currently*."

Another substitution option is indicated as aluminium foam compositions (without the inclusion of lead), however without giving further information. UP explains that aluminium foam compositions are currently only available as sheets and that testing is needed for complex structures.

As for the reliability of substitutes, the Umbrella Project claims that some products need to be requalified such as e.g. medical devices where the Medical Devices Regulation requires a re-approval by a Notified Body. The roadmap for substitution is also specified for medical devices, indicating a total time of 5 years with the following stages: testing of alternative alloy; testing of components made with the new alloy; redesign of the component/device (reasonable that minor changes are required); system performance and reliability testing and global approvals.

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

The UP claims that there are environmental and health impacts of bismuth and refers to an LCA that compares the life cycle stages mining, purification, and refining of different metals.

Furthermore, the UP claims that the use of bismuth containing alloys can negatively affect recycling of aluminium and might increase the waste to be landfilled, however without providing further information.

1.3.3. Socioeconomic impacts

The UP expects an increase in direct production costs because lead-free alloys may require more energy for machining, cause greater tool wear and create more scrap. Further the UP claims that Bismuth is around 7 to 17 times more expensive than lead and states that "*if the demand for bismuth increases and the demand for lead decreases, the price of bismuth may become even higher*." The UP also claims that for medical devices this could impact on EU patients' health, but without giving further information.

2. Clarification Questions

General Comment

The renewal request for exemption 6bII, submitted by the Umbrella Project is mainly based on the 3rd criteria listed in RoHS article 5.1.a):

the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof.

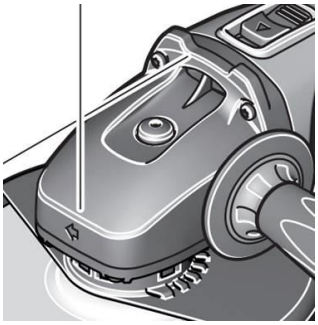
In the renewal dossier we highlight the higher environmental impact of bismuth compared to lead. According to our analysis, leaded and lead-free aluminium alloys shows that all leaded 2000 and 6000 series aluminium alloys with 0.2 – 0.4% lead also contain some bismuth that is specified within certain ranges. Most of the "lead-free" 2000 and 6000 series aluminium alloys that can be machined contain tin which have reliability concerns as described in the exemption renewal request. Machinability of tin-free aluminium is achieved by addition of lead and bismuth. If the total concentration of these metals (Pb + Bi) were reduced, the machinability would deteriorate and so if lead is omitted, the bismuth concentration must be increased (closer to the upper limit of the specification) to achieve suitable machinability performance. Although leaded alloys contain some bismuth, to achieve the same performance with bismuth only, a higher bismuth concentration is needed with the associated environmental impact described in our exemption request. Lead and tin free machinable alloys tend to have higher bismuth specification ranges, up to 1.5% than alloys than most leaded alloys.

This means that revoking exemption 6bII would imply an increased environmental impact, as detailed in the renewal dossier.

1. The Umbrella Project states that "*this renewal request is based on the fact that only a very low amount of leaded aluminium is still required for some niche applications*."

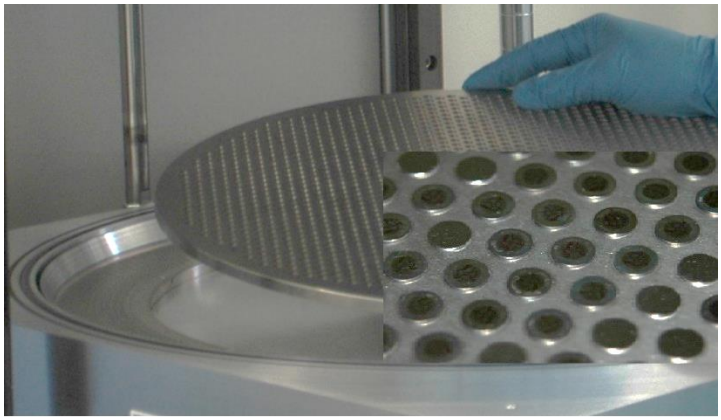
   - Please specify the exact applications where leaded aluminium alloys are still needed.
     As we expect these alloys to be used in several niche applications, the following three have been reported to the working group answering this questionnaire

   - *One example is cast and machined aluminium gear boxes from handheld tools. They are made of EN AC-46000-D-F. This material is allowed to have up to 0,35% Lead. As long as the standard allows the lead content up to 0,35% in the international supply chain the lead content can rise up to it's limits although in most cases the lead content to the alloy in most cases is <0,1%.*



To our knowledge adjustments in the standard defining the composition of of EN AC-46000-D-F are not planned at the moment".

- *Another example is a production tool for MEMS sensor applications. The base elements for sensors need to be glass deposited on their surfaces. This process is done in a dry plasma chemical process the glass is formed out of SiH4. The process is tightly controlled and runs at accelerated temperature. The base elements need to be assembled into charge holders which are placed into the reaction chamber and heated up. These charge holders need to be very accurate without any warpage to achieve very homogenous temperature transmission. The charge holders of 500 mm diameter are made of EN AW 2007 cut of from a rod. Up to now no lead free alternative with comparable mechanical propertied and available rod diameter is commercially available. Sheet material can't be used because of it's intrinsic stress which leads to inacceptable warpage.*



- *A medical equipment manufacturer machines aluminium for stand-offs and spacers that are used to connect parts, such as heat sinks, of the equipment to "ground" (earth voltages). Machined aluminium alloys must be used to create the required precise shapes and the alloy must be sufficiently flexible and ductile to allow rivets to be used to create electrical connections. Aluminium must be used to connect to other aluminium parts to avoid galvanic corrosion issues that would occur if combinations of different metals were used. Also, high electrical conductivity is required which is not achieved with steel alloys or plastics. Aluminium alloys that are not intended for machining such as 6061 are too brittle and risk cracking when bent for rivet bonding.*

- Please specify the material properties, provided by the leaded aluminium alloy, which are needed in these specific applications.

  The main effect of lead is improved machinability and less induced stress during machining processes. Lead acts as a lubricant to enable smooth surfaces without flow marks on the machined surface, better chip fracturing to keep swarf short, and less mechanical stress remaining in the machined parts". There are more details in Q4 (B) and (C), but it is not possible to define specific properties as they will be different for each application and in any event, are usually not quantified. Experience will have shown that the leaded alloys give suitable performance, but the specific quantitative requirements for each use are never measured.

  The Aluminium Association lists at least 11 alloys that contain >0.1% and <0.4% of lead. Each of these alloys has different properties and so have different end uses. Heat treatment and aging also affect the alloys properties.

2. The Umbrella Project lists mechanical relaxation as one technical characteristic which is provided by lead in the alloy.

   Please provide technical specifications for mechanical relaxation.

   The absence of lead free material alternatives is in many cases based on the experience and tests made by the experts who developed and produce the aluminium parts.

   Mechanical relaxation is measurement of the viscoelastic response of the material which offers an approach for analysing the microstructure and the fatigue behaviour of a material. For certain applications where the service life of the part is lengthy, and the precise geometric tolerances of the parts need to be maintained for the life of the part, this is essential.

3. Please provide information on the efforts made by the Umbrella Project since the last exemption evaluation in 2015 to evaluate lead free aluminium alloys.

   Based on the feedback of a few companies, about 2/3 of aluminium parts have been already transferred from leaded to unleaded aluminium. In these cases, bismuth is used instead, with the very questionable environmental advantages discussed in the dossier.

4. Please specify which performance indicators for the functionalities of lead in aluminium alloys have been tested with the available lead-free Al alloys listed in your application.

   The performance indications vary depending on the applications. In the above given examples, the indicators are the geometrical variations and distortions during the use phase. But of course, they are others like surface smoothness, geometrical precision, strength, ductility, corrosion resistance, etc.

5. You state that "*some alloys have been substituted by lead free compositions like e.g. AW-6026 to AW-6026LF as lead free alternative with high bismuth content. However, this is not possible for all applications currently.*"

   Please specify the specific applications where the substitution with AW-6026 to AW-6026LF as lead free alternative with high bismuth content is possible.

   Material AW-6026LF is offered by a few aluminium producers with special focus on turned parts. It is used for bolts, screws, etc. in a wide range of applications.

   Please indicate the automotive applications where information on reliability for industrial purpose is available.

   - As for the amount, the Umbrella Project indicates about 90 tonnes of lead from Aluminium which is not recycled ("*Assuming that about 4,5 million tonnes are in industrial sectors, out of this (based on statistical assumptions) about 450000 tonnes (10%) is not recycled. However, not all of these applications would contain lead up to 0,4%, assuming that 5% of the unrecycled material includes lead up to 0,4% results in 22500 tonnes of aluminium containing lead. Consequentially, this would result in 90 tonnes of lead which is not recycled. In the overall scheme this will have minimal impact as it results in 0,3% of the EU total aluminium production.*") Please specify the amount of lead entering the EU market annually through applications for which the exemption is requested.

It is not possible to provide a more detailed estimation of the quantities entering the EU market.

As a minimum:

- Please explain your assumptions behind the estimations that about 450000 tonnes (10%) is not recycled. To what material flows are you referring to?

This value is an estimation based on the fact that in the EU most of the production waste is recycled because of its commercial value. On the other hand, a lot of old tools and machines are in operation in the EU with end of life for production after more than 30 year. These machines are either disposed of and the material is available for recycling or they are exported to countries outside of EU for further on production. The out of EU exported machines are added to the amount of disposed aluminium because this amount of aluminium isn't available for recycling any more.

Because of the commercial value of aluminium waste, the real losses will probably be much less than the estimated of 10%.

- Please estimate what share of the 90 tonnes of lead referred to above are applied in the manufacture of EEE at best and at worst.

The 90tonnes cover all commercial applications including aluminium in buildings, ships, railway, automotive, etc. and EE industries. This is the only estimation available.

6. The roadmap indicated in the application specifies the stages needed for medical devices (EEE of category 8 and 9). Please also provide a roadmap for EEE of category 1-7 and 10.

The stages and timescales after a suitable alloy has been identified for evaluation will vary depending on the type of products. The timescale for some products will be similar to category 8 and 9 EEE, but most types of products will have shorter timescales as regulatory approval will not be needed. Also, reliability testing will be shorter for shorter lifetime and less safety critical products. Also, simple product designs will take less time to redesign. Probably category 8 products will take the longest after a suitable substitute is developed. A typical timescale after a suitable alloy is identified for a complex household appliance is likely to be:

Test	**Timeframe**
Testing of alternative alloy	6 months
Testing of component made with new alloy	6-12 months
Redesign of the component/device (reasonable that minor changes are required)	3 - 6 months (redesign + retesting)
System performance and reliability testing	3 - 6 months
CE certification	3 months

Total elapsed time	About 2 to 3 years but only if alloy passes all tests and is suitable

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