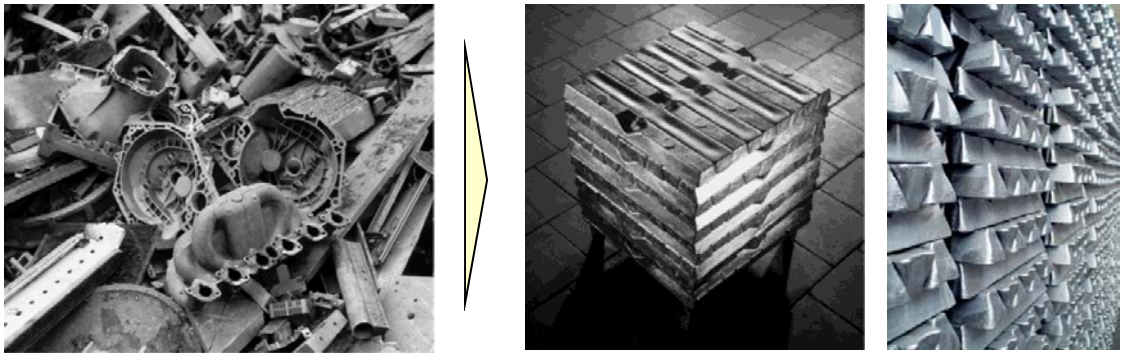
Stakeholder Consultation Questionnaire: Exemption No. 2(c)
"Aluminium with a Lead content up to 0.4 % by weight"

Industry contribution of ACEA, JAMA, KAMA, CLEPA and EAA

Please find below the answers to the stakeholder contribution concerning exemption 2c. Input is based on results of a working group consisting of OEMs, suppliers and the European Aluminium Association EAA.

Question 1
Please explain whether the use of Lead in the application addressed under Exemption 2(c) of the ELV Directive is still unavoidable, so that Art. 4(2)(b)(ii) of the ELV Directive would justify the continuation of the exemption.

Answer to Question 1
In most of the Aluminium used in cars, Lead is not needed to ensure material properties. The reason Aluminium is containing Lead is that when Aluminium is recycled Lead is sometimes present in the old scrap. So secondary Aluminium or recycled Aluminium contains Lead as background element /1/, /2/. The Lead content in the secondary Aluminium (*see picture 2*) depends on the available scrap (*see picture 1*) when the material is produced. To enable the use of different scrap sources derived from the recycling of industrial products with different age the secondary Aluminium alloys are specified to contain Lead. These material standards are EU-wide and globally applied. Aluminium scrap is a global traded product based on demands and prices and not focused to one single market.



(Picture 2/3): Aluminium scrap refined to secondary Aluminium alloy. The pictures show a bundle of ingots.

Source Picture 1-3: /3/

Until the year 2000 there was no legal limit to Lead content in Aluminium. By 1.7.2003 Aluminium with a Lead content of up to 4% was allowed in cars and until 1.7. 2008 Aluminium with a Lead content of 1.5% was allowed in cars and has later been reduced to 0.4 % Pb. The cars of the first phase mentioned above are now being recycled since the average age of a recycled ELV is ~ 10-15 years. The recycling of these cars is of course extremely important from an environmental point of view. Recycling of Aluminium requires only 5 % compared to the energy demand for producing primary Aluminium /*3, p.13*/.
With a reduction of the allowed Lead content in Aluminium, recycling would be less incentivized and instead more primary Aluminium would be required to dilute the Aluminium to achieve the lower Lead content.

As described later in the questionnaire there is currently no feasible method to remove the Lead from Aluminium scrap during the recycling process.

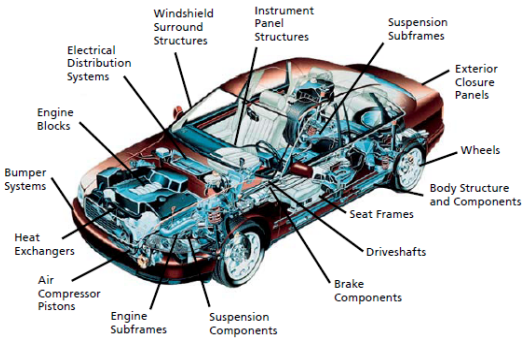
In order to enable the use of recycled Aluminium for car production, the exemption is needed. A future reduction of Lead content in recycled Aluminium is to be expected due to the recycling of products already produced under Lead restrictions. A significant impact/reduction of Lead in Aluminium scrap through whole Europe will depend on the end use, but in the case of automotive scrap is to be expected in approximately one decade.

For a small number of car components a certain low amount of Lead in Aluminium is needed to ensure appropriate material properties for machining and safety-related corrosion resistance purposes. Substitutes for Lead are not available; no material is known to have the same properties; e.g. research activities / studies show that the required properties cannot be achieved by using Tin/Bismuth as substitute (having properties most similar to Lead in Aluminium alloys).

There is no indication that solutions - for these both issues - can be found on short/medium term.
Consequently the exemption should be continued with a review in 8 years.

Question 2
Please describe in which applications Aluminium alloys are used in vehicles at present and indicate the functionality of Lead in these applications (e.g. specific function and properties, performance criteria, etc.). Please make a distinction between applications in which the use of Lead is unavoidable (e.g. due to safety reasons) and other applications.

Answer to Question 2
In previous stakeholder consultations we mentioned some groups of applications like steering systems, chassis systems, brake systems, clutch systems, engine systems, transmission systems, fuel injection systems which need a Lead content up to 0.4 %. The picture 4 (to the right) exemplifies applications in a vehicle.



Picture 4: application examples

Wrought alloys
Some application are e.g. dependent on the low friction properties (coefficient of friction) of Lead containing alloys like valve actuation, valve operation, internal bushing of accelerator sensors; expansion valves, pressure sliding plates; axis pin for pivot lever, pumps, high pressure regulating valves, plungers, pistons, brake power assist unit, oil return stop valves. These parts are mainly small and made out of wrought alloys (sourced from primary Aluminium as well as from – already Lead containing - secondary Aluminium). Here the Lead is essential to reach the performance requirements for machining purposes (lowering energy consumption to machine parts, sufficient surface finish, part precision and tool life), low friction properties and for corrosion resistance.

Picture 5: Aluminium pressure die casting
Aluminium crankcase Material: AlSi9Cu3(Fe)
(Source BMW)

Cast Alloys

Casting components are usually big parts (like Engine-Block, Cylinder-head, Gearbox housing, Engine Sub frames), usually made out of secondary raw material from the scrap streams and consequently unintentionally containing the majority of the Lead. Recycled Aluminium from these applications can be reused for the production of the same components.

Because of the different design principles and use-cases among the car-manufacturers, we regret not to be able to provide an exhaustive list on applications.

Question 3

Please indicate how much Lead would be used under this application per annum and substantiate the amount of Lead with a calculation for vehicles put on the European market, and worldwide. If data is not available, please provide estimations. In your calculations, please provide detail as to the amounts of Lead present in Aluminium alloys used per vehicle (where possible please refer to the quantity of material per component and per vehicle in weight and in percentage by weight). Please provide an overview for the last ten years and an estimation how this is to evolve in the coming years

Answer to Question 3

Depending primarily on the use of recycled Aluminium in a vehicle we estimate a Lead content in the range of 40 to 200 g in Aluminium materials per car (upper figure: with automatic drive, big engine etc.) with an average of about 80 g/car. The majority of this Lead (~ 95%) is contained unintentionally by cast alloys for which secondary Aluminium is used.

Based on 13.3 Mio vehicles (M1/N1) put on the European Market in 2013, we estimate a total Lead amount per annum of about 1064 Tons.

Average Lead content in Al for typical European Car	
2010	120 g/car
2014	80 g/car
2022	50 g/car*

* Estimation: in 2022 it can be expected that the unintentional Lead content in Aluminium materials will be reduced by an average of approximately 0.1% wt.

Worldwide figures are not available because of limited information from some markets. As stated yet the major sources are reused recycled materials. To our knowledge no intentional use of lead is applied in recycling materials.

Question 4
In case the substitution of Lead is not viable, please explain the efforts your organisation has undertaken to find and implement the use of Lead-free alternatives in the manufacture of vehicles.

Answer to Question 4

In secondary casting alloys the Lead content needs to be tolerated to enable and ensure the continued use of recycled materials and to close the loop for recycled Aluminium. There is no specific demand for a Lead content.

As mentioned before only for some machining alloys Lead in a concentration of 0.4 % is necessary for technical reasons. All materials with higher Pb concentrations have been phased out yet.

The most common alloy AA 2011 has a standardized Pb range between 0.2 and 0.6%. Car industry conducted the following 2 main activities

1. Some applications of 2011 alloy have even been changed as far as possible to a Lead free alternatives e.g. AlEco62Sn or AA 6023

for the remaining applications

2. Specified Pb content up to 0.6% is not utilized, the metallurgical process can be controlled and the Lead content can be limited to 0.4%. The required properties can be met with 0.4 % Lead and this material can be produced from secondary Aluminium. (For detailed information see answer to question #7)

Conclusion:

For a very limited number of parts lead content is still required to ensure:

- necessary material properties (machining / durability / low friction)

- high safety standard (part precision and corrosion resistance)

The industry has changed to Lead free alloys as far as possible.

Question 5
Please provide information as to Lead free alternatives, which are available for certain applications (e.g. tin or bismuth containing alloys). Where reference is made to research or results thereof, please specify what year such studies/results are from.

a. If substitutes are not yet applied in the vehicle industry, please explain why Lead-free alternatives cannot yet be applied.

b. Please specify the effects of Lead-free substitutions on material characteristics and performance (e.g. appearance, (long-term) reliability, manufacturing yield, safety, life-cycle aspects)?

c. Please indicate which research has been performed during the last years to find substitutes and/or to develop alternatives? Please provide specific documents/evidence supporting the search for substitutes (e.g. roadmap).

Answer to Question 5

To ensure a proper machinability of Aluminium, a total amount of approximately 1% of additives is needed. There are 2 reasons why Lead is needed as one of the additives:

1. Resistances against corrosion – in special pitting corrosion in acid systems e.g. brake systems. This corrosion resistance can only be achieved by Lead – alternative alloys are not available.

   To prevent serious safety risks, it is unavoidable to use Lead as an alloy element for safety relevant parts/components like on chassis and brake- system applications.

2. The Lead content is necessary to reach the performance and accuracy requirements for machining purposes (sufficient surface finish, part precision and tool life, lowering energy requirement to machine parts), low friction properties.

Substitution of Lead by tin or bismuth in alloys will

1. Increase cutting forces / energy consumption and shorten tool-life
2. Cannot provide the needed surface-finish & low friction properties
3. Increase environmental impact of Aluminium production
   - Bismuth is a by-product of Lead production
   - to produce 1 Ton of Bismuth production of 30-200 tons of Lead are necessary (2)
4. Lower the eutectic point
5. Exclude use of significant amounts of end-of-life scrap as material source.

(2) 'Recommendation on the non-use of bismuth for Lead substitution', 2007, European Copper Institute

While more focus and studies are given to the impacts of Lead, the effects of bismuth on the environment and human health are not well studied and there is little information and data collected from the past, as the use of bismuth have been minor. Comprehensive toxicity and risk assessment may become available under REACH in due time.

Question 6

If substitution is not yet possible, please provide information if there are technical developments that allow a further reduction of the quantities of Lead present in Aluminium alloys? Can the limit of 0.4% be further minimized? If not, please explain why this is currently technically or scientifically impossible / impracticable.

Answer to Question 6

Since the Lead restrictions were permanently lowered by the ongoing Annex II revisions, we have now reached a level (0.4%) which cannot be reduced any further. A continued reduction of the Lead level would jeopardize the recycling of Aluminium from vehicles in the EU and would pose a safety risk for some critical components. Already with the 0.4% limit, industry experienced minimal negative effects in manufacturing process, surface/friction properties and corrosion resistance.

Question 7
Please provide information as to the Lead content, which is unintentionally present in Aluminium alloys used in the automobile industry through the use of scrap metal.

Answer to Question 7
As shown in CEN standards most of the secondary alloys have a Lead content of about 0.2% but the CEN standards allow a Lead content up to 0.6% in these alloys.

Aluminium casting alloys are produced from a wide range of mixed scrap. This scrap can sometimes, unintentionally, contain relatively high Lead contents. The explanation for this lies in the long life time of cars or other industrial products. E.g. the average age of vehicles is 10-15 years and in the cars produced at the beginning of this century Aluminium with an unlimited Lead content has been allowed. When these cars, as well as other industrial products are recycled the Lead containing Aluminium will unintentionally and unavoidably be transferred to new casting alloys. Due to a dilution effect (not all Aluminium scrap contains Lead) casting alloys might contain 0.2%-0.4% Lead, depending on the source material.

Since last stakeholder consultation, a slight reduction of the average Lead amount introduced by recycling could have been recognized. This can be explained by larger shares of the cars/industrial goods that will be recycled has been produced under Lead restrictions. This effect is already well-marked in northern Europe but because of the higher age of cars recycled in Southern / Eastern Europe the trend is less visible there.

Today the demand for Aluminium scrap and recycled Aluminium is very high on global level. If the material is excluded from being used for car components on the European market other sectors and markets will use the cast materials and virgin material must be utilised instead for casting applications, resulting in even higher environmental burdens.

To reduce the exemption of Lead in Aluminium below 0.4% would force some recyclers to dilute their recycled alloys with more primary material to stay below the exempted levels.

Keeping the exemption of 0.4% Lead content in Aluminium provides an effective and efficient way of utilisation for recycled Aluminium scrap sourced within the entire European Union.

It is therefore too early to reduce the allowed Lead content in Aluminium if it is intended to maintain high recycling rates of Aluminium from ELVs in line with the European Commission communication on a Circular Economy at the same time.

The industry is however confident that the Lead contents will automatically been reduced when more and more cars are produced with Lead restrictions. Given the introduction of the 0.4% limit in 2010, the majority of these cars will be back for recycling around the year 2024.

We therefore suggest a new revision of the Lead exemption should be performed in ~ 8 years. By that time an effect of the introduction of the 0.4% limit should be verifiable.

Justification:
Historical limits for Lead in Aluminium in the ELV directive:

Until 2000 = 4% for wheels, engine components and window levers

Until July 2005 = 2%

Until July 2008 = 1.5%

since July 2008 = 0.4%

The age of recycled cars in EU today is between 10 and 15 years. This means that many cars that reach the ELV stage today were produced around the year 2000. Since a rather high Lead content were allowed in the cars at that time, this Lead will now be a part of the raw material supply since End-of-Life vehicles are efficiently recycled.

Question 8

It is understood that possible processes to remove Lead from Aluminium scrap are in development; concerning such methods, please provide information as to such processes, also referring to:

a. How promising such methods are a) from a technical point of view, b) from an economical point of view?

b. What obstacles currently hinder the upscaling of such processes from laboratory scale to large scale?

c. What future stages are needed in the development of promising technologies and how much time is needed before this could result in a reduction of Lead quantities present in scrap Aluminium?

Answer to Question 8

OEA conducted a study on 'Existing technologies for Lead removal from Aluminium melts'. The study was carried out by MIMI Tech UG and finalized in June 2012.

The study reviewed a number of methods to remove Lead from the Aluminium alloys. These methods are summarised here:

Phase separation: The phase separation of the Aluminium-Lead alloy is examined by solidification in the molten phase. With the help of nucleating agents, Lead droplets rise and freeze below the binodal temperature. The droplets can thus possibly be separate from the molten Aluminium.

This procedure is only an academic one due to the small scale of melt treatable and no reproducible results have been achieved in a pilot scale. This method might, if at all, be used for high-cost/ high-purity Aluminium and special applications. But in those cases, the use of primary Aluminium is probably more economical.

Electrochemical refining: Tests were carried out electrochemically in a three-layer cell. With direct addition of alkali salts and controlled addition of sodium, significant reductions for Lead have been achieved.

This method is existing since more than 20 years with little success beyond testing. The key obstacle is the significant amount of energy needed for the process, which makes the method both environmentally and economically undesirable.

Vacuum distillation: Laboratory and pilot tests show that vacuum treatment can also remove Lead from molten Aluminium at above 1000°C. However, only at 1300°C and with one hour distillation time, the removal of Lead can take place with sufficient speed.

Again apart from the high system cost and difficulties to scale up, the high energy consumption deems the method environmental undesirable.

All three methods are in the stage of laboratory/academic research and small scale testing, the obstacles to the development of these methods are not only economic in terms of system and equipment cost, but also an environmental issue, mostly due to the high amount of energy required. There are very limited options, if any, to overcome the latter. Furthermore, such Lead-reduced Aluminium is expected to be used in special applications. But whichever applications they are, high quality Aluminium from primary production is likely to be a ready and less expensive alternative. For the above discussed arguments, there are no clear steps forward. Beside this generic approach in practice the background levels of different tramp elements other than Lead which may occur in the different scrap grades will influence the efficiency of such methods.

Evidently, more ground research and tests are needed to enable further conclusions on these methods. On that, the industry is and will continuously be in cooperation with academics and research institutes.

Conclusion:

In order to ensure a closed loop recycling of Aluminium, the 0.4% threshold is still required.

Therefore we request to continue exemption 2c without limitations and propose a review in 8 years.

Sources:

/1/ J. Lohse, U. Pirnkte, K. Sander: Report heavy metals in vehicles I, Final report 27. March 2000; Oekopol – Institut für Ökologie und Politik GmbH Hamburg,

/2/ J. Lohse, K. Sander, M. Wirts: Final report heavy metals in vehicles II; July 2001; Oekopol – Institut für Ökologie und Politik GmbH Hamburg,

/3/ Aluminium Recycling in Europe OEA Brussels 2013 http://www.world-aluminium.org/media/filer_public/2013/01/15/fl0000217.pdf last acessed 23.10.2014