Assistance to the Commission on Technological Socio-Economic and Cost-Benefit Assessment Related to Exemptions from the Substance Restrictions in Electrical and Electronic Equipment:

Study to assess renewal requests for 29 RoHS 2 Annex III exemptions [no. I(a to e -lighting purpose), no. I(f - special purpose), no. 2(a), no. 2(b)(3), no. 2(b)(4), no. 3, no. 4(a), no. 4(b), no. 4(c), no. 4(e), no. 4(f), no. 5(b), no. 6(a), no. 6(b), no. 6(c), no. 7(a), no. 7(c) - I, no. 7(c) - II, no. 7(c) - IV, no. 8(b), no. 9, no. 15, no. 18b, no. 21, no. 24, no. 29, no. 32, no. 34, no. 37]

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Report for The European Commission

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18.0 Exemption 6a: "Lead as an alloying element in steel for machining purposes and in galvanised steel containing up to 0,35 % lead by weight"

Declaration

In the sections that precede the “Critical Review” the phrasings and wordings of stakeholders’ explanations and arguments have been adopted from the documents provided by the stakeholders as far as required and reasonable in the context of the evaluation at hand. Formulations have been altered in cases where it was necessary to maintain the readability and comprehensibility of the text. These sections are based exclusively on information provided by applicants and stakeholders, unless otherwise stated.

Acronyms and Definitions

11SMn30	Lead-free cutting steel containing high sulphur and also manganese
11SMn37	Same as 11SMn30 but with a higher Mn content
1215	Lead-free low carbon free cutting steel
12L14	Leaded low carbon free cutting steel
ECHA	European Chemicals Agency
EGGA	The European General Galvanizers Association
EEE	Electrical and Electronic Equipment
ELV	End-of-Life Vehicle
EUROFER	The European Steel Association
KEMI	Kemikalieinspektionen, the Swedish Chemicals Agency
MnS	Manganese(II)sulphide
NSSMC	Nippon Steel and Sumitomo Metal Corporation
Pb	Lead
tpa	Tonnes per annum
TMC	The Test & Measurement Coalition
WEEE	Waste of Electrical and Electronic Equipment

18.1 Background

Exemption 6a covers different uses of lead in steel: the use of lead added as an alloying element in steel for machining purposes and the presence of lead in galvanized steel.

According to the European Steel Association (EUROFER) and the European General Galvanizers Association (EGGA),[487] lead is added to steel as a machinability enhancer for industrial production. Lead as an alloying element in steel for machining purposes has a lubrication effect that eases deep drilling and high speed operations. This kind of steel is also called free cutting or free machining steel. For the production of free cutting steels, lead provides a good hot workability.[488]

Galvanisation is the process of applying a protective zinc coating to steel in order to prevent corrosion. The most common form of galvanisation is hot dip galvanisation, where iron or steel articles are galvanised by dipping in a molten bath of zinc or zinc-alloy; a small amount of lead tends to be present in the zinc bath, and hence this the source of lead in the galvanised steel (as discussed further in Section 18.2). Hot dip galvanisation can be done in continuous or batch operation: In hot dip galvanization as a continuous process, the steel is continuously drawn through a bath with a liquid zinc alloy. Individual metal articles are hot dip galvanized by a process called batch galvanizing. Both the continuous and batch processes of hot-dip galvanizing result in a metallurgical bond between zinc and steel. The bonding region is an intermetallic compound, termed the “alloy layer”.[489] EGGA[490] states that the presence of lead in the continuous galvanizing process is sufficiently low to meet the default requirement of 0.1% Pb. Therefore EUROFER and EGGA[491] propose to restrict the exemption to batch hot dip galvanised steel instead of all types of galvanised steel.

EUROFER and EGGA[492] with the support of a number of organizations have submitted a request for the renewal of the above mentioned exemption with the following wording formulation (the additional wording is underlined):

> *“Lead as an alloying element in steel for machining purposes and in <u>batch hot dip</u> galvanized steel items containing up to 0.35% lead by weight.”*

[487] EUROFER and EGGA (2015a), European Steel Association (EUROFER) and European General Galvanizers Association (EGGA) (2015a), Original Application for Exemption Renewal Request, submitted 16.01.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_6_a_/Eurofer/6a_RoHS_Application_Form_6a_16012015-.pdf

[488] According to EUROFER and EGGA (2015a and b), steel is being hot-rolled to the required size for a customer from a piece with a larger (as-cast) cross sectional area.

[489] Gensch et al. (2009), Carl-Otto Gensch, Oeko-Institut e. V., et al. 20 February (2009), Adaptation to scientific and technical progress under Directive 2002/95/EC: Final Report. With the assistance of Stéphanie Zangl, Rita Groß, Anna Weber, Oeko-Institut e. V. and Otmar Deubzer, Fraunhofer IZM. http://ec.europa.eu/environment/waste/weee/pdf/final_reportl_rohs1_en.pdf

[490] EGGA (2016), European General Galvanizers Association (EGGA) (2016), Answers to 3rd Clarification Questions, submitted 01.03.2016.

[491] Op. cit. EUROFER and EGGA (2015a)

[492] Op. cit. EUROFER and EGGA (2015a)

Besides the associations EUROFER and EGGA, two companies have submitted a renewal request, both referring to the use of lead as an alloying element in steel for machining purposes:

- **Dunkermotoren**[493] a manufacturer of electric drives, uses lead based steel alloys in gear parts because of the improved machinability that is achieved by lead. Dunkermotoren requests an exemption period of at least 5 years to allow requalification. Dunkermotoren estimates that if a substitute were available 2 to 5 years would be needed for this purpose.
- **Sensata Technologies Holland B.V.**[494] a manufacturer of sensor and control products purchases latching components within the tripping and actuation mechanism from the supply chain.[495] Sensata[496] generally refers to the function of lead in all alloys covered under Ex. 6 (steel, aluminium and copper) such as improved "*micro-machining, electrical conductivity, galvanic corrosion resistance, mechanical relaxation, tribological behaviour etc*.".

As for the history of the exemption, it has to be noted that when the RoHS 1 Directive was published in 2002, Exemption 6 covered lead as an alloying element in steels, aluminium and copper.[497] After the last revision in 2009[498], the exemption was split into three exemptions 6a, 6b and 6c in order to cover each alloy with a separate wording.

In the end-of-life vehicles (ELV) Directive 2000/53/EC, the corresponding exemption has been narrowed to refer only to batch hot dip galvanizing processes as a result of the last revision in 2008 and 2009.[499] The current wording of ELV Annex II Exemption 1(a) is "*Steel for machining purposes and batch hot dip galvanised steel components containing up to 0,35 % lead by weight*".

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[493] Dunkermotoren GmbH (2014), Dunkermotoren GmbH (2014), Original Application for Exemption Renewal Request, submitted 15.12.2014, English version available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_6_a_/DUnkermotoren/Ex_6a_Dunkermotoren_150806_Ausnahmeantrag_Stahl_englisch.pdf

[494] Sensata Technologies (2015a), Sensata Technologies Holland B.V. (2015a), Original Application for Exemption Renewal Request, submitted 15.01.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_6_a_/Sensata_Technologies/6a_6b_6c_RoHS-Exemptions_Application-Format_Ex_6a_b_c_Pb_in_St_Al_Cu.pdf

[495] Sensata Technologies (2015b), Sensata Technologies Holland B.V. (2015b), Answers to Clarification Questions, submitted 20.08.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_6_c_/Sensata/Ex_6a6b6c_Sensata_Questions_response_20150820.pdf

[496] Op. cit. Sensata Technologies (2015a)

[497] The wording of exemption 6 was as follows: "Lead as an alloying element in steel containing up to 0,35% lead by weight, aluminium containing up to 0,4% lead by weight and as a copper alloy containing up to 4% lead by weight"

[498] Op. cit. Gensch et al. (2009)

[499] Zangl et al. (2010), Stéphanie Zangl et al., Oeko-Institut; Otmar Deubzer, Fraunhofer IZM (2010), Adaptation to scientific and technical progress of Annex II to Directive 2000/53/EC (ELV) and of the Annex to Directive 2002/95/EC (RoHS), final report; 28 July 2010; http://elv.exemptions.oeko.info/fileadmin/user_upload/Final_Report/Corr_Final_report_ELV_RoHS_28_07_2010.pdf

18.1.1 Amount of Lead Used under the Exemption

Steel for machining purposes

In their renewal request, EUROFER and EGGA[500] estimate the amount of substance entering the EU market annually through applications for which the exemption is requested as follows:

> *"Machining steels – in 2013 the import of steel products for machining purposes amounted to approximately 73,000 tons. Assuming that the lead content in steel for machining purposes is between 0,2 and 0,35%, this means that the lead annually entering in the EU market through the import of free cutting steels can vary between 146 to 255 tons. However, note that these figures do not correspond solely to steel intended for EEE (which was not possible to estimate) and that also contains the volumes of steel intended for automotive."*

During a 2nd round of clarification questions, EUROFER was asked to specify the production volume of leaded steel in the EU and to estimate the share of the total amount of leaded steel in the EU used for EEE by indicating at least a range of the amount of leaded steel in the EU used for EEE.[501] However, EUROFER[502] did not provide any further information.

The following estimations have been made during the last revision of the exemption:[503]

> *"The main production countries of leaded steels are UK, Germany, France and Spain. The total production volume of leaded steel in the EU is estimated to be 1,3 Mt per year. It is, however, not possible to accurately say how much of this material is used for applications covered by RoHS due to the length of supply chains and sales to stock-holders and intermediate processors selling steels to different applications. Within EEE, leaded steels are mainly used in larger equipment with smaller volumes. Therefore, yearly quantities are expected to be some tons at maximum."*

As for the other applicants of renewal requests, Dunkermotoren does not provide information on the amount of lead in the production of the engine and transmission parts (gear parts), whereas Sensata[504] estimates the amount of lead in the predefined components supplied to Europe to be less than 1kg.

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[500] Op. cit. EUROFER and EGGA (2015a)
[501] In analogy to the REACH registration, the following tonnage ranges were proposed: < 100 tonnes per annum (tpa); 100 - 1.000 tpa; 1.000 - 10.000 tpa; 10.000 - 100.000 tpa; 100.000 - 1.000.000 tpa.
[502] EUROFER (2016), European Steel Association (EUROFER) (2016), Answers to 2nd Clarification Questions, submitted 15.01.2016.
[503] Op. cit. Gensch et al. (2009)
[504] Op. cit. Sensata Technologies (2015a)

Galvanized steel

EUROFER and EGGA[505] estimate the amount of lead intentionally added "*for applications in the scope of WEEE/ROHS*" to be less than 1 tonne per year. They further state not to be able to estimate the amount of unintentional lead in the recycled zinc (see Section 18.3.2. for further details).

18.2 Description of Requested Exemption

Steel for machining purposes

According to EUROFER and EGGA,[506] lead is added as an alloying element in steel in order to enhance machinability "*if a variety of machining operations is required or if deep drilling of material is required*". EUROFER and EGGA further explain that lead acts as a lubricant and thereby provides "*a reduced cutting force when machining steel, appropriate chip formation (length and force), facilitation of a smooth surface finish, facilitation of a good dimensional achievement under commercial production conditions or reduced "tool wear" during the machining operation*" are of relevance.

EUROFER and EGGA are not able to provide an exhaustive list of EEE applications or of application sub-groups for which such steel is applied. EUROFER and EGGA[507] explain that the problem is a result of the long and complex supply chain "*with many different actors, including stockists and intermediate processors. The producer of the free cutting steel itself rarely has detailed, if any, contact with the final EEE producer (or even the producer of the components that become part of EEE).*"

[505] Op. cit. EUROFER and EGGA (2015a)
[506] Op. cit. EUROFER and EGGA (2015a)
[507] EUROFER and EGGA (2015b), European Steel Association (EUROFER) and European General Galvanizers Association (EGGA) (2015b), Answers to Clarification Questions, revised version, submitted 15.09.2015, available under:
http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_6_a_/Eurofer/Ex_6a_Eurofer_1st_round_of_Clarification-Questions_final-20150803_DRAFT_REPLY_-_EGGA_EUROFER_MCchanges15-9-15_revised.pdf
A number of organizations supported this compilation of information: European General Galvanizers Association (EGGA); European Steel Association (EUROFER); European Partnership for Energy and the Environment (EPEE); Digital Europe; Information Technology Industry Council (ITI); European Garden Machinery Industry Federation (EGMF); European Passive Components Industry Association (EPCIA); European Semiconductor Industry Association (ESIA); Japan Business Council in Europe (JBCE); Japan Business Machine and Information System Industries Association (JBMIA); Japan Electronics and Information Technology Industries Association (JEITA); Japan Electrical Manufacturers´ Association (JEMA); Knowles UK Ltd.; LIGHTINGEUROPE; WirtschaftsVereinigung Metalle (WVM); German Electrical and Electronic Manufacturers´ Association (ZVEI); European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry (COCIR); American Chamber of Commerce to the EU (AmCham EU); European Committee of Domestic equipment Manufacturers (CECED).

Instead, EUROFER and EGGA[508] provide the following list of typical components: fuel injector systems, hydraulic clips, keys, motor shafts, fasteners, printer shafts, and a wide range of office equipment parts – for example lap top screen screws.

Galvanized steel

Lead is present in the zinc coating of batch hot dip galvanised steels, but does not provide a function in the coated product.[509]

According to the EUROFER and EGGA[510], lead in galvanised steel is mostly unintentionally present as an impurity related to the use of recycled zinc. EGGA[511] explains that the unintentional lead content arises from the remelting of zinc metal from the crude galvanizers ashes (arising from oxidation of the zinc bath surface) and secondly from the recovery and recycling of scrap metallic zinc from roofing/gutters (often of 50 – 120 year vintage) made from former standard zinc grades with lead impurities[512] that additionally contain lead-based solders that were used to join roofing sheets and gutters.

EUROFER and EGGA[513] state that lead is intentionally added in the galvanizing bath to adjust the viscosity and reach optimal drainage of excess zinc "*in a small number of plants*". According of EUROFER and EGGA,[514] the intentional addition of lead to the galvanizing bath is rapidly declining due to technical innovation.

According to EUROFER and EGGA[515], batch galvanized steel is used in components like fasteners, brackets, fixings "*for a range of EEE items such as lighting units that require high levels of durability in outdoor or aggressive environments*" as well as in e.g. transformer housings and heat exchangers.

18.3 Applicant's Justification for Exemption

Steel for machining purposes

EUROFER and EGGA[516] argue that lead provides an excellent machinability in a variety of machining processes such as e.g. turning, drilling, tapping, parting, grooving which is favourable especially in cases where the manufacturing of an EEE component requires a combination of different machining operations.

EUROFER and EGGA further argue not to be able to provide an exhaustive list of functionalities respective of performance aspects of lead because *"'machinability' cannot be restricted to a property of the machined material. It is not a single material*

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[508] Op. cit. EUROFER and EGGA (2015b)
[509] Op. cit. Gensch et al. (2009)
[510] Op. cit. EUROFER and EGGA (2015a)
[511] Op. cit. EGGA (2016)
[512] So-called 'Good Ordinary Brand' / 'Prime Western' zinc.
[513] Op. cit. EUROFER and EGGA (2015a)
[514] Op. cit. EUROFER and EGGA (2015a)
[515] Op. cit. EUROFER and EGGA (2015b)
[516] Op. cit. EUROFER and EGGA (2016a)

property like tensile strength, ductility or electrical conductivity, which we can measure and have one value to characterize the material." Instead machinability depends also on the "*material of the tool, the geometry of the tool, the machining operation itself (turning, drilling…), the machine type (autolathes, machines for specific applications, single spindle, multispindle…), the machining parameters, the cooling conditions. All these parameters have an influence on tool life, chip form, process forces and surface quality. This means it is a sum of chemical, mechanical and tribological properties which cannot be examined with a simple statistical correlation. The combination of various machining operations with a set of different tools in one machine is an additional difficulty. In this case one single operation can be the limiting factor for the whole machining process of a special part."*

The other applicants Dunkermotoren and Sensata provide the following justifications:

- Dunkermotoren[517] argues with increased costs because the use of alternative material would increase the production time and shorten tool life.
- Sensata[518] who uses latching components within the tripping and actuation mechanism made from leaded steel argues that "*the Sensata supply chain for lead-containing steel alloys comprises companies whose expertise is in stamping and screw-machining. Neither Sensata nor the Sensata supply chain has the expertise or resources to develop alternatives to lead-containing steel alloys. For this reason the focus of the efforts made by Sensata has been on existing materials, none of which has proven to be a suitable replacement.*"

Galvanized steel

EGGA[519] explains that lead influences certain aspects of the process such as fluidity, drainage and ease of removal of dross for recycling. EUROFER and EGGA[520] cannot give an estimation on the share of hot dip galvanization that still needs the intentional addition of lead. EGGA[521] explains that "*there are no other limitations on the use of lead in the galvanizing process and the proportion of components coated that are within the scope of the WEEE directive is very small in volume terms. Decisions on the intentional use of lead or the use of recycled zinc would not be solely influenced by the processing of EEE-related components.*" EGGA further states that EEE normally represents a very small proportion of a plant's throughput.

[517] Op. cit. Dunkermotoren (2015)
[518] Op. cit. Sensata Technologies (2015b)
[519] Op. cit. EGGA (2016)
[520] Op. cit. EUROFER and EGGA (2015b)
[521] Op. cit. EGGA (2016)

18.3.1 Possible Alternatives for Substituting RoHS Substances

Steel for machining purposes

In their application, EUROFER and EGGA[522] confirm that the steel mills are continuously researching, searching for new alternatives in order to find efficient substitutes to avoid the use of lead in steel. However they state that "*no alternatives have been identified that can effectively replace lead as a machinability enhancer in steel in all respects. Lead-free alternatives may show acceptable results in single machinability tests, but the overall performance of the lead-free steels is worse than that of leaded steel. The lack of hot workability of the lead-free alternatives is also an important obstacle towards the substitution*".[523]

EUROFER and EGGA[524] mention the following possible alternatives that each shows certain disadvantages according to EUROFER and EGGA:

- Lead-free alternatives from Nippon Steel and Sumitomo Metal Corporation are used for the manufacture of printer rails. EUROFER and EGGA[525] explain that printer rails are surface quality critical and are manufactured using very low feed rates. Initial problems related to built-up edge formation[526] on the cutting tool have been solved by new developments of the steel that contains finer inclusions of Manganese(II)sulfide (MnS).[527] EUROFER and EGGA[528] are not aware of a wider use then printer rails.
- A lead-free development of the steel grade C45 by Toyota is mentioned; however, EUROFER and EGGA[529] explain that a research project in 2005[530] tested deep hole drilling applications and complex machine features where this lead-free development failed; EUROFER and EGGA conclude that it would therefore not be applicable for EEE.

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[522] Op. cit. EUROFER and EGGA (2015a)
[523] Op. cit. EUROFER and EGGA (2015a)
[524] Op. cit. EUROFER and EGGA (2015b)
[525] Op. cit. EUROFER and EGGA (2015b)
[526] The so called "built-up edge" is a formation of metal deposits sticking to the tool close to the cutting edge. It can be observed usually at low cutting speeds, which causes chips to be torn away rather than cleanly cut, resulting in rough part surface, and it may damage the tool. Low cutting speed favour the formation of built-up edge as well as other cutting parameters such as e.g. large depth of cut. See e.g. https://www.researchgate.net/post/How_does_the_built-up_edge_lead_to_surface_damage.
[527] Hashimura M. et al (2007), Hashimura M., Miyanishi, K., Mizuno, A. (2007), Development of Low-Carbon Lead-Free Free-Cutting Steel Friendly to Environment, Nippon Steel Technical Report, No. 96, 2007. http://www.nssmc.com/en/tech/report/nsc/pdf/n9608.pdf
[528] Op. cit. EUROFER and EGGA (2015b)
[529] Op. cit. EUROFER and EGGA (2015b)
[530] P.E. Reynolds et al. (2005), Technically and commercially viable alternatives to lead as machinability enhancers in steel used for automotive component manufacture, Report EUR 21912, Office for Official Publications of the European Communities, Luxembourg, 2005.

- There is also lead-free steel with a higher quantity of sulphur in free cutting steels, so called resulfurized steel grades. According to EUROFER and EGGA,[531] they showed "*disappointing*" results compared to leaded steel in deep drilling operations or high speed machining, due to decreased machining speed, increased tooling wear and an increased fragility and reduction in hot workability which results in yield losses. EUROFER and EGGA[532] do not provide further details on this statement.
- As for the alternatives with bismuth, increased sulphur (with and without tellurium), tin (with low and high copper), phosphorus and calcium, EUROFER and EGGA[533] refer to results that already have been presented in the frame of the ELV Directive review of exemptions in 2008 and that are included in the corresponding report of Oeko-Institut.[534]
  In brief, "*Although the machining properties of bismuth-treated steels approach those of lead-treated steels for certain machining operations, in the majority of machining operations lead remains the most effective machinability additive through its wide range of machining characteristics. It was further concluded in the report that calcium can substitute lead in C45 steels for use at higher cutting speeds. However, calcium treated steels require higher cutting forces, have poorer chip form and have their best performance limited to a narrower range of machining speeds in comparison with the leaded product. The more limited benefits of calcium treated grades may not be able to match the benefits of leaded grades in many instances since it is very likely that a large variety of machining operations are required for many engineering components.*
  Steels containing tin generally did not show good performance in the machinability tests and thus, was not considered as a suitable replacement for lead in steel."

EUROFER and EGGA[535] also state that the lead-free alternatives that contain bismuth or tellurium show a decreased hot workability in the temperature range normally used for hot rolling of steel. According to EUROFER and EGGA,[536] bismuth containing steel needs to be rolled at very high temperatures and often rolled material shows surface cracks like those shown in the following figures. EUROFER and EGGA[537] explain that tellurium causes similar cracks.

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531 Op. cit. EUROFER and EGGA (2015a)
532 Op. cit. EUROFER and EGGA (2015a)
533 Op. cit. EUROFER and EGGA (2015a)
534 Op. cit. Zangl et al. (2010)
535 Op. cit. EUROFER and EGGA (2016a)
536 Op. cit. EUROFER and EGGA (2016a)
537 Op. cit. EUROFER and EGGA (2016a)

Figure 18-1: Cracks in bismuth containing steel wire rods after rolling

Source: EUROFER (2016a)

As for bismuth containing steel, the following new efforts are reported:[538] "*Since 2010, this steel producer has carried out seven interconnected full scale trials related to the use of bismuth as an alternative to lead. During the last trial in 2012, a new 10MnSBi grade of steel (1215Bi) was manufactured under normal production conditions and supplied to customers. [...] The results from this and previous trials have indicated that bismuth steels are much more prone to surface break-up than normal leaded steels and the associated yield losses are not sustainable for routine production. [...]*

Overall the results of these trials confirm the conclusions from the collaborative ECSC project where bismuth was shown to be a potential alternative to lead for the purposes of enhancing machinability but that low hot ductility and limited availability (of Bi) could prevent the material being a feasible commercial product."

Generally, EUROFER and EGGA[539] raise concerns over the availability of bismuth and a higher price because bismuth production is most often a by-product of lead or tungsten production.

Galvanized steel

The research that EUROFER and EGGA mention for galvanizing processes do not deal with substitution of lead as it is mostly inadvertently present due to recycling of zinc scrap and galvanizers' ashes because the use of lead within the process have largely (but not completely) been replaced by other techniques, according to EUROFER and EGGA.[540] EGGA[541] explains that the general research approach targets to reach thinner coatings regardless of steel type ("*more zinc-efficient coatings*") and coatings of more consistent

[538] Op. cit. EUROFER and EGGA (2015b)
[539] Op. cit. EUROFER and EGGA (2015b)
[540] Op. cit. EUROFER and EGGA (2015a)
[541] Op. cit. EGGA (2016)

appearance and surface finish. EGGA argues that this goes hand in hand with a general "*desire to reduce the presence of hazardous substances, including lead. Intentional use of lead is now limited to a narrow, but important, set of processes and products.*" The problem that these processes cannot be separately dealt with is explored in Section 18.5.6.

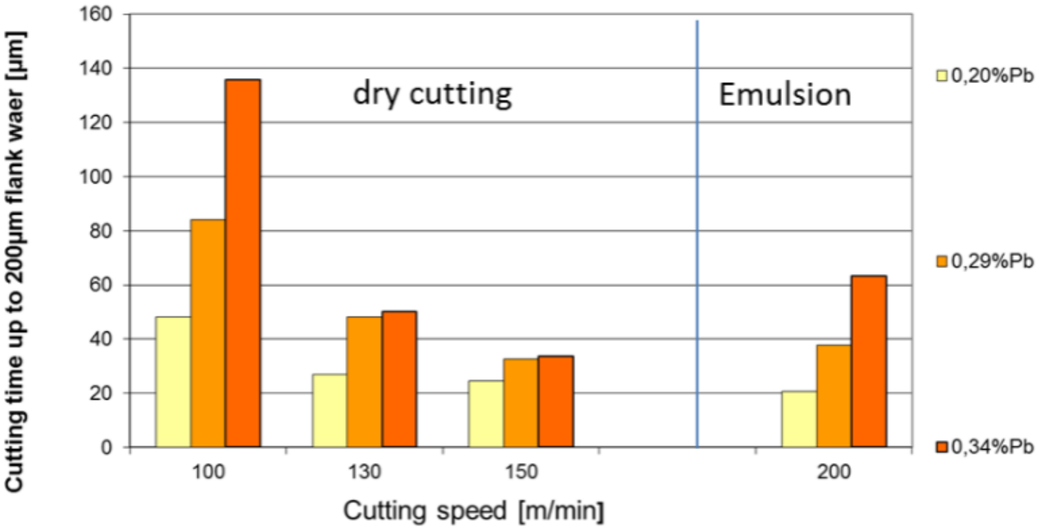
18.3.2 Possibilities for Reducing RoHS Substances

Steel for machining purposes

EUROFER and EGGA[542] report a recent collaborative project between Saarstahl and Tata Steel on the question whether the 0.35% threshold of lead in steel can be reduced. According to EUROFER and EGGA,[543] Tata Steel and Saarstahl produced several casts of low carbon free cutting steels with Pb contents from 0.11% up to 0.35%.

The machinability of the steel with different lead content was tested by producing a component on a single spindle automatic lathe using high speed steel tools under neat oil coolant and determining the maximum production rate than can be achieved. The tests showed "*progressive deterioration in machinability*" due to decreased tool life (see Figure 18-2) and higher cutting forces (see Figure 18-3), which result in either increased usage of cutting tools or longer machining times.

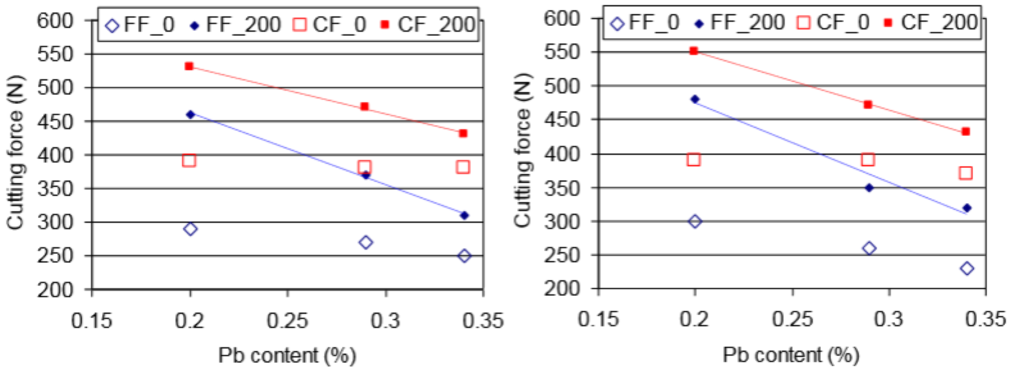
Figure 18-2: Tool wear by free cutting steels with different Pb content



Source: EUROFER and EGGA (2015b)

[542] Op. cit. EUROFER and EGGA (2015b)
[543] Op. cit. EUROFER and EGGA (2015b)

Figure 18-3: Cutting forces (CF) and feed forces (FF) of free cutting steels with different Pb content in dry cutting conditions (left: 100 m/min, right: 130 m/min)



Source: EUROFER and EGGA (2015b)

Galvanized steel

EUROFER and EGGA[544] expect the lead content within recycled zinc arising from scrap roofing/gutters to decrease in the long term "*(> ~50 years due to the very long product life)*", as a result of "*new solders*" being used. Also, customer-driven requirements for lower lead levels in markets outside EEE/ELV and the higher price of lead than zinc (affecting intentional use) might also result in lower lead levels in time.

EGGA[545] states *"There may be a downward trend in lead content from sources from galvanizers' ashes associated with a general trend to avoid the intentional use of lead additions to the galvanizing bath. Recyclers estimate that will be >50 years before the lead content of recycled zinc from scrap metallic zinc from roofing/gutters shows any significant decline."*

18.3.3 Environmental Arguments

Steel for machining purposes

EUROFER and EGGA[546] specify processes where the scrap coming from machining of free cutting steel is recycled and the lead recovered by off gas treatment to 90%. EUROFER and EGGA do not provide information on the steel recycling circuit.

Besides this, EUROFER and EGGA raise the following environmental arguments, however without providing further evidence in both cases:

- EUROFER and EGGA[547] mention as "*wider environmental implications of material choice*" that "*the lower energy consumption of machining leaded*

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[544] Op. cit. EUROFER and EGGA (2015b)
[545] Op. cit. EGGA (2016)
[546] Op. cit. EUROFER and EGGA (2015a)
[547] Op. cit. EUROFER and EGGA (2015a)

steels means that there is a potential benefit of reduced electricity consumption and CO_2 emissions in fabrication": According to EUROFER and EGGA,[548] "*the addition of lead into low carbon free cutting steels enhances machinability and can increase the production rate of a component by up to 40% depending upon part and machining process design, and a potential reduction in energy usage of approximately 27% when machining parts using the leaded steel are compared to the non-leaded steel.*"

- As for bismuth containing steel, EUROFER[549] claims that "*the high rolling temperatures and a second or even third rolling process will cause additional energy consumption.*"

Galvanized steel

For galvanized steel, EUROFER and EGGA[550] bring forward the argument in favour of using scrap zinc for galvanizing purposes:

> *"A life-cycle comparison of the embodied energy of (i) remelt secondary zinc and (ii) primary zinc has been published in 'Sachbilanz Zink', Prof. J. Krüger, Institut für Metallhüttenkunde und Elektrometallurgie der RWTH Aachen (ISBN 3-89653-939-6, 2001). This publication reports that: "The energy required for the extraction of zinc from scrap to obtain alloys capable of further use demands a primary energy input of only approximately 2.5 GJ/t. During the extraction of zinc from ores, the primary energy requirement for mining and ore dressing is around 5-9 GJ/t metal content in the concentrate. Concentrate processing to obtain a pure metal however calls for a primary energy input of 46-48 GJ/t zinc. Based on this information, the use of remelt secondary zinc reduces the embodied energy of the zinc used in batch galvanizing by over 20 times.""*

18.3.4 Socio-economic Impact of Substitution

No information has been submitted on socio-economic effects of substitution by EUROFER and EGGA. As for general economic impacts, EUROFER and EGGA mention the following, but without providing further evidence to substantiate or quantify their claims: EUROFER and EGGA argue that an increasing demand for bismuth might result in a strong rise in the bismuth price and consequently an increase in production costs.[551]

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[548] Op. cit. EUROFER and EGGA (2015a)
[549] Op. cit. EUROFER (2016a)
[550] Op. cit. EUROFER and EGGA (2015a)
[551] Op. cit. EUROFER and EGGA (2015b)

18.3.5 Road Map to Substitution

Steel for machining purposes

EUROFER and EGGA[552] do not provide a road map for substitution because substitutes in machining steel would need to first show the same level of hot workability as lead-containing free cutting steel, which has not occurred so far with the identified alternative materials.

Besides, EUROFER[553] explains that the huge diversity of applications in (often small) different machining companies and the diversity of parameters in the system "machining" makes it very difficult to provide a timeframe for the substitution.

Galvanized steel

EUROFER and EGGA[554] do not provide a road map because the inadvertent presence of Pb in the recycling chain does not demand substitution and the intentional addition of lead cannot be separated for the purpose of the production of EEE, which is explained to account for only a small portion of production (see Section 18.5.6).

18.4 Stakeholder Contributions

Six contributions to Exemption 6a have been submitted during the stakeholder consultation. The contributions are presented in order of submission and shortly summarized:

- The **Robert Bosch GmbH**[555] generally supports the applicants without providing further information.
- **JBCE[556]** – Japan Business Council in Europe in a.i.b.l. states that they understand that EEE of Category 8 and 9 are out of scope of this review. The JBCE understands that "*the exemption 6(a) in annex III can be applied to category 8&9 products for seven years from identified date when entry into force for each products, at the earliest July 2021.*"
- CETEHOR, the technical department of the Comite Franceclat (French Watch, Clock, Jewellery, Silverware & Tableware Centre)[557] generally states the better

[552] Op. cit. EUROFER and EGGA (2015a)
[553] Op. cit. EUROFER (2016)
[554] Op. cit. EUROFER and EGGA (2015a)
[555] Robert Bosch GmbH (2015), Contribution by Robert Bosch GmbH, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_6_a_/Bosch-Stakeholder-contribution-Exemption-request-6a.pdf
[556] JBCE (2015), Contribution by JBCE – Japan Business Council in Europe in a.i.b.l, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_6_a_/Comment_on_public_cousulation_of_Exemption_request_2015-2_6_a__.pdf
[557] CETEHOR (2015), Contribution by Comite Franceclat (French Watch, Clock, Jewellery, Silverware & Tableware Centre), CETEHOR, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_6_a_/Ex_6_a_Comite_Franceclat_Cetehor_20151012.pdf

machinability of leaded steel with a lead content of 0.2%; a greater weal tool with unleaded steel would hinder a profitable manufacturing "*in a severe context of competition with low-cost labour countries*" and the longer machining cycles would increase energy consumption. CETEHOR claims to use a leaded steel with a lead content of 0.2%; therefore "*the regulatory limit could be reduced to 0.3% to allow alloy suppliers to guarantee conformity to the regulatory value.*"
CETEHOR[558] estimates a quantity of lead of 1 kg per year based on the average amount of 1 g of machining steel per watch movement, a maximum lead content of this steel of 0.2% and the annual French production of quartz watches of 0.5 million.

- **KEMI** Kemikalieinspektionen, the Swedish Chemicals Agency[559], recommends to "*split into a number of more specific exemptions, related to applications where it has been verified that feasible alternatives are not currently available*" and argues that the "*broad and unspecific wording does not conform with the requirements in the updated RoHS Directive 2011/65/EU any longer*". KEMI lists the specific applications provided by the applicants: Electric drives, engines and transmission parts (gear parts), latching components within the tripping and actuation mechanism, fuel injection systems, hydraulic clips, keys, motor shafts, printer shafts, lap top screen screws and the following articles manufactured in batch galvanised processes fasteners and support brackets/fixings in lighting units that require high levels of durability in outdoor or aggressive environment, transformer housings and heat exchangers.
- **PennEngineering,**[560] a designer and manufacturer of specialty fasteners,[561] objects the renewal request because they have substituted lead-free cutting steel with "*traditional grades of low carbon, rephosphorized, resulfurized, free machining steels*" by applying "*changes to tool materials and other subtle proprietary changes to minimize the loss of efficiency*".
PennEngineering requests a transition period of more than 18 months because of the "*significant inventory of steel fasteners with up to 0.35 % lead content in the distribution channels*" and because "*customers will stop accepting non-compliant product many months before it becomes non-compliant*".
PennEngineering states that they currently use 907 t (*"2,000,000 lb"*) of leaded steel per annum globally; the amount of the contained lead is calculated at 2.3

[558] Op. cit. CETEHOR (2015)
[559] KEMI (2015), Contribution by KEMI Kemikalieinspektionen, Swedish Chemicals Agency, submitted 19.10.2015 , available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_6_a_/Ex_6a_KEMI_Answer_to_SC_RoHS_20151016_Lead_in_Steel.pdf
[560] PennEngineering (2015), Contribution by PennEngineering, submitted 19.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_6_a_/Ex_6a_PennEngineering_Consultation_Questionnaire_PE_AS_20151016.pdf
[561] For fasteners used in EEE, see at http://www.pemnet.com/fastening_products/pdf/kdata.pdf

tpa ("*5,000 lb*"). PennEngineering estimated that approximately 25% of their sales of leaded products go towards EEE in the EU.

- The **Test & Measurement Coalition**[562] (TMC) submitted a general contribution on Category 9 Industrial monitoring and control instruments similar in its nature to that of JBCE.

18.5 Critical Review

18.5.1 REACH Compliance – Relation to the REACH Regulation

Appendix A.1.0 of this report lists Entry 30 in Annex XVII of the REACH Regulation, stipulating that lead and its compounds shall not be placed on the market, or used, as substances, constituents of other substances, or in mixtures for supply to the general public. A prerequisite to granting the requested exemption would therefore be to establish whether the intended use of lead in this exemption request might weaken the environmental and health protection afforded by the REACH regulation.

In the consultants' understanding, the restriction for substances under Entry 30 of Annex XVII does not apply to the use of lead in this application as lead is used as an alloying element. In the consultants' point of view it is not a supply of lead as a substance, mixture or constituent of other mixtures to the general public. Pb is part of an article and as such, Entry 30 of Annex XVII of the REACH Regulation would not apply.

Appendix A.1.0 of this report lists Entry 63 in Annex XVII of the REACH Regulation, stipulating that lead and its compounds shall not be placed on the market or used in articles supplied to the general public, if the concentration of lead (expressed as metal) in those articles or accessible parts thereof is equal to or greater than 0,05 % by weight, and those articles or accessible parts thereof may, during normal or reasonably foreseeable conditions of use, be placed in the mouth by children.[563] Entry 63 however further specifies this restriction not to be applicable for articles within the scope of the RoHS Directive 2011/65/EU.

No other entries, relevant for the use of lead in the requested exemption could be identified in Annex XIV and Annex XVII (status January 2016).

Based on the current status of Annexes XIV and XVII of the REACH Regulation, the requested exemption would not weaken the environmental and health protection afforded by the REACH Regulation. An exemption could therefore be granted if other criteria of Art. 5(1)(a) apply.

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[562] Test & Measurement Coalition (2015), Contribution by Test & Measurement Coalition, submitted 19 October 2015, available under http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/General_Contribution_Test___Measurement_Coalition_package_9_exemptions_20151016.pdf

[563] Other restrictions of entry 63 cover e.g. jewellery and are thus not applicable here.

18.5.2 Scientific and Technical Practicability of Substitution

Steel for machining purposes

The basic problem for assessing the scientific and technical practicability of substitution of leaded steel is the fact that the applicant EUROFER as an association of steel producers does not have information on the detailed machining procedures. Therefore, EUROFER was not able to provide an exhaustive list of applications nor to specify in which EEE applications available alternative material might be practicable and reliable.

Nippon Steel and Sumitomo Metal Corporation were contacted to gain more information on their lead-free steel development. Nippon Steel and Sumitomo Metal Corporation[564] state that they are supplying the material in the Asian market, however unfortunately not in Europe at this moment. They indicated that their lead-free steel is used for "*printer shafts, pins and small parts for automobile and industrial machines*", which are produced by many different companies, and confirm that these components are also applicable in EEE. It has to be noted that printer shafts are among the typical components that require leaded steel according to EUROFER and EGGA.[565] The following figure shows machine intensive application examples provided by NSSMC.[566]

Figure 18-4: Application examples of the lead-free steel developed by NSSMC

Source: Nippon Steel and Sumitomo Metal Corporation (NSSMC) (2016)

The lead-free steel by NSSMC[567] is resulfurised free cutting steel; the hardness is stated to be almost equivalent to that of other low-carbon free cutting steels; it has a higher

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[564] NSSMC (2015), Nippon Steel and Sumitomo Metal Corporation (2015), Information submitted by email, 07 December 2015.
[565] Op. cit. EUROFER and EGGA (2015b)
[566] NSSMC (2016), Nippon Steel and Sumitomo Metal Corporation (2016), Information submitted by email, 08 January 2016.
[567] Op. cit. Hashimura M. et al (2007)

sulphur content and contains MnS which is distributed in very fine particles through controlled manufacturing conditions. NSSMC[568] indicated the following chemical composition of their lead-free cutting steel (Figure 18-5).

Figure 18-5: Chemical composition of the lead-free free cutting steel developed by NSSMC

		Chemical composition(mass%)					MnS control
		C	Mn	P	S	Pb	
SAE Leaded free cutting steel	12L14	≦0.15	0.85 -1.15	0.04 -0.09	0.26 -0.35	0.15 -0.35	–
JIS Leaded free cutting steel	SUM24L	≦0.15	0.85 -1.15	0.04 -0.09	0.26 -0.35	0.10 -0.35	–
NSSMC Lead free free cutting steel	Sumigreen CS	≦0.15	0.90 ~1.70	0.04 ~0.09	0.40 ~0.70	-	Spindle shaped
	EZ	≦0.15	0.90 ~1.30	0.07 ~0.12	0.35 ~0.60	-	Fine dispersed

Source: Nippon Steel and Sumitomo Metal Corporation (NSSMC) (2016)

Nippon Steel and Sumitomo Metal Corporation[569] estimate that the application of their lead-free steel does not require large process changes but some modifications of the cutting conditions. NSSMC[570] estimates that the adaptations could comprise changes in the material and/or design of cutting tool, cutting speed, feeding speed, depth of cut, oil etc. NSSMC further estimates that the application of their lead-free steel does not require large investment costs but is not able to determine the costs. NSSMC[571] states that the cost of their lead-free steel approaches the same as leaded free cutting steel.

The contribution by PennEngineering shows that plant-specific adaptations in the machining procedures makes it possible to use lead-free steel grades that are available on the market: PennEngineering[572] is a designer and manufacturer of specialty fasteners.[573] It has to be noted that fasteners are one of the typical components that according to the application of EUROFER and EGGA[574] needs the use of leaded steel.

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[568] Op. cit. NSSMC (2016)
[569] Op. cit. NSSMC (2016)
[570] Op. cit. NSSMC (2016)
[571] Op. cit. NSSMC (2016)
[572] Op. cit. PennEngineering (2015a)
[573] http://www.pemnet.com/comp_lit_files/, see bulletin K for fasteners used in EEE.
[574] Op. cit. EUROFER and EGGA (2015b)

PennEngineering[575] states that they have started to test lead-free free cutting steel "*over three years ago*" (as of October 2015). For environmental and strategic reasons,[576] PennEngineering focused on "*traditional grades of low carbon, rephosphorised, resulfurised, free machining steels*", such as 1215, 11SMn30, and 11SMn37, that are commercially available in the small bar sizes PennEngineering uses.[577] PennEngineering states that for most of our product, these grades can be run at the same surface footage and feed rates as 12L14 leaded steel with some reduction in efficiency: "*In the majority of cases the decreased efficiency is from more frequent tool changes driven by faster deterioration of the surface finish. We are making changes to tool materials and other subtle proprietary changes to minimize the loss of efficiency.*" PennEngineering[578] explains that the machining is done on five and six spindle automatic screw machines that perform a variety of machining operations.[579]

PennEngineering states that they managed the increased cost of the machining operation down to the area of 10%. However, PennEngineering did not reveal details of the technical changes in order to protect the "*significant investment in preparing for the eventual removal of RoHS Exemption 6a*".

Besides the above mentioned examples of lead-free free cutting steel covering resulfurized (NSSMC) and rephosphorized and resulfurized (PennEngineering) steel grades, there are basically also lead-free alternatives available that contain bismuth or tellurium.[580] EUROFER and EGGA[581] state that "*bismuth alloyed low carbon free cutting steels have been supplied for certain applications*." However, EUROFER and EGGA do not further specify these applications with "*very specific machining conditions*" but rather claim that this alternative is not practicable due to the above mentioned difficulties in hot workability. It might be that the difficulties in how workability cause negative environmental impacts by increased energy costs in the steel production; however in the absence of detailed comparisons, the consultants cannot conclude on this statement.

[575] Op. cit. PennEngineering (2015a)
[576] "We are well aware that other elements such as bismuth, selenium, tellurium, tin and calcium have been used to replace lead. Off these, bismuth, selenium and tellurium are the most commercially viable. Because environmental legislation is constantly changing, and because there are some environmental concerns with selenium and tellurium, we stayed away from steels with these two elements out of concern about future restrictions. We are still open to bismuth steels, but there are concerns about price and availability of bismuth."
[577] According to PennEngineering (2015b), "round bar in the 5/32 inch to 5/8 inch range and hex bar in the 3/16 inch to 5/16 inch range".
[578] Op. cit. PennEngineering (2015b)
[579] Most commonly performed machining operations are rough forming, finish forming, turning, shaving, knurling, facing, cut off, drilling, form tapping, back working (primarily countersinking). Other machining operations also performed include reaming, slotting, broaching and external threading (primarily rolling with some cutting).
[580] Op. cit. EUROFER and EGGA (2015a)
[581] Op. cit. EUROFER and EGGA (2015b) and (2016b)

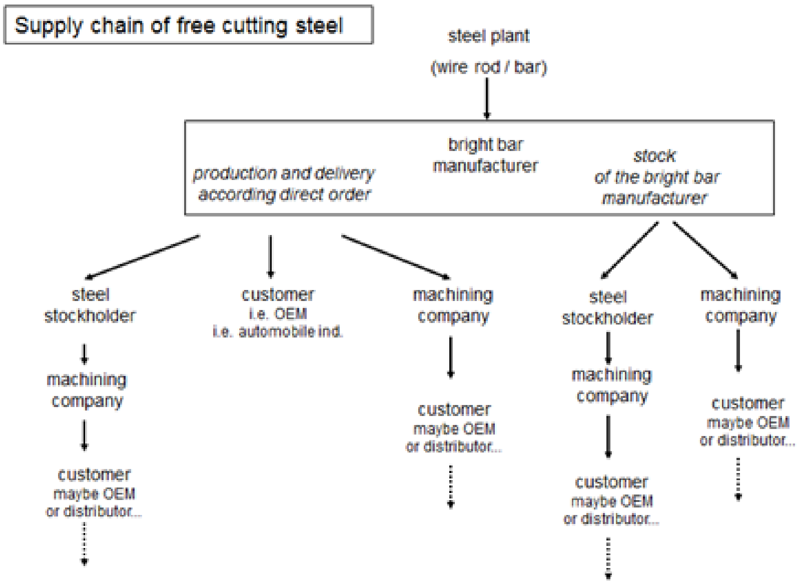
It is apparent from the paragraphs above that there are alternatives on the market that are scientifically and technically practicable for at least some applications: This is the case for resulfurised and rephosphorised and resulfurised steel grades; for bismuth or tellurium containing steel, the information is not conclusive.

These single cases are not reflected by EUROFER and EGGA as it seems that they rather search for an all-round alternative: "*No alternatives have been identified that can effectively replace lead as a machinability enhancer in steel in all respects. Lead-free alternatives may show acceptable results in single machinability tests, but the overall performance of the lead-free steels is worse than that of leaded steel."* Though the consultants understand this statement from a perspective of the steel producer, the example of PennEngineering shows that substitution efforts are successful when undertaken in the specific manufacturing case with different alternatives available.

The consultants understand that there might be components that require a combination of different machining operations and therefore that the machinability over a broad range of cutting parameters has to be guaranteed, which might only be provided by leaded steel. However these cases have to be specified in the future. If steel manufacturers or OEMs lack sufficient information to specify these aspects, they should embark on dialogue and joint investigation with the component manufacturers who are expected to be aware of modifications needed to allow workability with lead-free alloys. This need of a different approach is supported by the statement of EUROFER and EGGA[582] already mentioned above that the supply chain is complex and that the steel producer has limited, if any, contact to the final OEM producer. EUROFER[583] states that "*the steel producer has a direct contact usually only to the bright drawer. In some special cases there are contacts also with the final producer (e.g. Bosch) for the discussion of special properties. But this is not the case for the commodity products.*" The supply chain of free cutting is illustrated in the following figure.

[582] Op. cit. EUROFER and EGGA (2015b)
[583] Op. cit. EUROFER (2016b)

Figure 18-6: Supply chain of free cutting steel



Source: EUROFER (2016b)

To conclude, the consultants understand from the information provided by EUROFER and EGGA that the steel producers are not able to provide the detailed information on the specific applications of leaded steel in the EEE sector that would be needed to assess the technical and scientific practicability of available substitutes. NSSMC confirm this estimation by stating that "*NSSMC do not know the detailed machining procedure*".

The supply chain provided by EUROFER in the figure above points out that the machining companies might be the right stakeholders for providing more precise information. It is understood from the example of PennEngineering that alternative materials might need adaptations in the machining procedures, which every EEE component manufacturer has to carry out for his specific machining operations; however, substitution at least for some applications is understood to be possible.

Galvanized steel

As the intentional addition of lead in the galvanizing process cannot be separated from the unintentional presence due to the use of zinc scrap and galvanizers' ashes, substitution of lead is not further discussed. For further information, please see section 18.5.6.

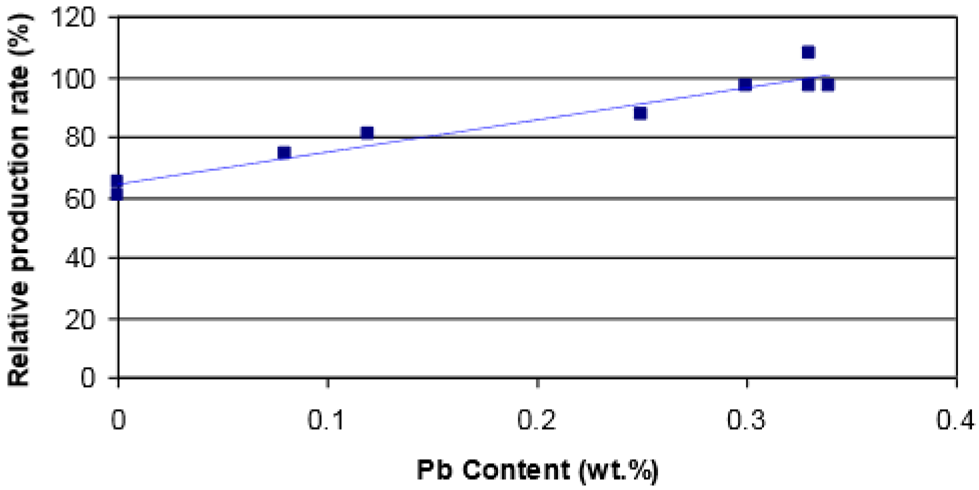
18.5.3 Possibilities for Reducing RoHS Substances

Steel for machining purposes

EUROFER and EGGA reported tests conducted by Tata Steel and Saarstahl according to which a reduction of lead in steel for machining purposes results in a decrease of production rate which subsequently caused an increased usage of cutting tools and/or longer machining times. The following figure shows this overall result according to EUROFER and EGGA. It is however unclear if attempts were made by Tata Steel and

Saarstahl to adjust the processing to accommodate the decreasing lead content materials tested. This makes it difficult to assess the overall conclusion of EUROFER and EGGA on the "*progressive deterioration in machinability*": Are longer machining times acceptable in some applications? Which possibilities can be explored to minimize the loss of efficiency as in the case of PennEngineering?

Figure 18-7: Effect of Pb reduction in steel alloy on production rate in a component production test



Source: EUROFER & EGGA (2015b)

The consultants can follow that steel with a lower lead content may suffer technical drawbacks for e.g. machining in automated series production. There might, however, be applications where a reduction of lead does not pose a significant problem as the contribution of CETEHOR shows, where generally leaded steel with a lead content of 0.2% is used. It might be that the required level of performance cannot be generally defined but depends on the machining processes. However, where substitution with lead-free alloys is not possible, the second approach in the future strategy of companies could be to apply lower leaded steel in their applications where a complete phase-out is not practical.

Galvanized steel

The consultants' understand the lead in the batch hot dip galvanization is expected to slightly decrease in the future due to different reasons such as reduction of intentional addition of lead, decrease of lead in the galvanizers' ashes together with decrease in the very long term (50 years and more) of lead in recycled zinc scrap.

18.5.4 Environmental Arguments

Steel for machining purposes

EUROFER and EGGA raise general environmental arguments on higher energy use of alternative material due to lower production rate in the components manufacturing[584] or higher temperature needed in the steel production.[585] Though those differences may be of relevance, available information does not allow a comprehensive comparison in this respect. Especially for comparison of the energy use in the component manufacturing, it is expected that this could be case specific and dependent on adaptations in the machining conditions, which helps to reduce the efficiency loss shown in the case of PennEngineering. However, it might be that the energy savings could support the exemption for specific applications if it is comprehensively documented.

Galvanized steel

It is understood that the introduction of lead is unintentional and merely a result of lead being present in the secondary zinc. From an environmental perspective, the consultants can follow that the recycling of zinc scrap and its reuse is a positive practice, as it enables a reuse of ressources and as stated by EUROFER and EGGA[586] this is understood to be more energy efficient than the use of primary zinc: "*the use of remelt secondary zinc reduces the embodied energy of the zinc used in batch galvanizing by over 20 times*"[587] (see section 18.3.3).

18.5.5 Stakeholder Contributions

Six contributions were submitted to the stakeholder consultation. The contributions of KEMI,[588] CETEHOR[589] and PennEngineering[590] are discussed in the sections above as well as below. Bosch[591] did not provide any evidence to its claims; therefore the contribution was not further considered.

The contributions submitted by TMC[592] and JBCE[593] raise a legal question as to the availability of the current exemption to category 8 and 9 equipment. TMC and JBCE claim the availability of Annex III exemptions to category 8 and 9 for seven years starting in 22.7.2017. EUROFER and EGGA[594]state in this regard:

[584] Op. cit. EUROFER and EGGA (2015a)
[585] Op. cit. EUROFER (2016a)
[586] Op. cit. EUROFER and EGGA (2015a)
[587] Op. cit. EUROFER and EGGA (2015a)
[588] Op. cit. KEMI (2015)
[589] Op. cit. CETEHOR (2015)
[590] Op. cit. PennEngineering (2015a)
[591] Op. cit. Bosch (2015)
[592] Op. cit. TMC (2015)
[593] Op. cit. JBCE (2015)
[594] Op. cit. EUROFER and EGGA (2015a)

"We apply for renewal of this exemption for categories 1 to 7, 10 and 11 of Annex I for an additional validity period of 5 years. For these categories, the validity of this exemption may be required beyond this timeframe. Although applications in this exemption renewal request may be relevant to categories 8 & 9, this renewal request does not address these categories. Further, categories 8 & 9 have separate maximum validity periods and time limits for application for renewals."

Since lead as an alloying element in steel for machining purposes and in galvanised steel is understood to be relevant to all categories, it can be concluded that expiration dates should be specified for all categories.

18.5.6 The Scope of the Exemption

The scope of the current exemption is viewed as very wide. As mentioned above, the contribution of the Swedish Chemicals Agency KEMI makes reference to Article 5(1)(a) that stipulates an inclusion of materials and components of EEE for specific applications in the lists in Annexes III and IV. The specifications of applications are so far missing for exemption 6a. KEMI therefore proposes to split into a number of more specific exemptions, related to applications where it has been verified that feasible alternatives are currently not available without specifying whether these are applications of lead in steel for machining purposes or of galvanizing processes. As the present exemption 6a covers these different uses of lead with different purposes and different entry pathways, possibilities to narrow down the scope differ and will be discussed separately for steel for machining purposes and galvanized steel below.

Steel for machining purposes

The scope of the current exemption is viewed as very wide. However, EUROFER and EGGA only provide a list of typical components and not an exhaustive list. Thus the consultants cannot conclude on specific applications to narrow the scope of the exemption.

The consultants understand that there are alternatives on the market for at least some applications. However, it is not clear in what cases, or on what basis they cannot be used as substitutes for other applications, where, from the information provided by EUROFER and EGGA, leaded steel cannot be substituted. To clarify if they are not used at all or just not for the full range of applications, further information is needed. It can however be followed that the steel producer association is not able to provide such information.

The consultants would expect that the scope could be narrowed based on application groups or based on critical properties and required performance in application groups. This could require a supply chain survey, in order to collect and compile relevant information and to allow conclusions as to relevant properties and performance levels. Time may be needed in order to initiate such a survey along the supply chain to gain this information and screen all relevant applications relevant to arrive at an exhaustive list (of applications or of properties). However, this effort is presumed to be feasible as well as important for communicating to the steel customers where additional effort is needed in the applications of substitutes in the future.

EUROFER[595] claims that "*conventional machinability testing (for example ISO standard for tool life testing) can only be made for a selected system. This explains why each research institute or machining company has its own trials for machinability assessment. And if one parameter is changed (in our case lead or no lead) it may be possible that the whole system consequently has to be adjusted. And this explains why such studies can be made for some special applications but not yet for the whole machining industry.*"

Therefore it might be that an exhaustive list of properties also specifying the required performance level and the relevant performance indicators that are relevant for such properties might not be practicable to refine the scope of the exemption. To support this understanding, however, the complexity of the situation at hand needs to be presented and substantiated. The wide scope currently addressed in the exemption is open to misuse in cases where substitution might be possible. Therefore the consultants conclude that although a comprehensive list of applications may be long for refining the scope of the exemption, this is however of importance for establishing the potential of a change in scope. The consultants consider this to be the first step to further narrow the scope of the exemption, which the industry must be induced to undertake.

Galvanized steel

EGGA[596] argues that the proposed addition in the wording formulation provides a narrowed scope for galvanized steel as the batch hot dip galvanized steel makes up less than 1% of the total galvanized steel.[597] It is however understood that this reduction in scope to batch hot dip galvanized steel has been introduced to the ELV in 2010. Therefore the consultants estimate that this narrowing under RoHS rather describes the current practice.

A split of this part of the exemption for batch galvanized steel into an exemption that covers the unintentional presence of lead and applications where the addition of lead is needed does not seem to be practical against the background that the production of EEE components cannot be separated from the production of components for other product groups. EGGA[598] argues that "*no galvanizing plant is dedicated to EEE and EEE will normally represent a very small proportion of a plant's throughput. To generate an exhaustive 'positive list' of such products would be complex and difficult given EGGA's position in the supply chain; a galvanizing plant may operate with a lead level requiring*

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[595] Op. cit. EUROFER (2016a)
[596] Op. cit. EGGA (2016)
[597] "Oeko report 07.0307/2008/517348/SER/G4 (21 June 2010) [Op. cit. Zangl et al. (2010)] on the adaptation to technical progress of ELV and ROHS directives estimated that 99% of the galvanized steel used in ELV applications was of the continuously galvanized type and that <1% was of the batch galvanized type. We estimate that a similar positon exists for EEE applications, which illustrates the significant narrowing of the exemption as a result of the efforts of zinc suppliers and steel industry and places a suitable to context to the current exemption request regarding batch galvanized steel."
[598] Op. cit. EGGA (2016)

exemption due to requirements of a product or processing characteristic that relates to 'non EEE' products/customers."

Generally, EGGA stated that there is much pressure from the customer's side to remove lead so that the intentional addition would phase out with time, irrespective of the fact that other product groups besides EEE and automotive components do not have the same lead restrictions.

18.5.7 Exemption Wording Formulation

The present Exemption 6a covers completely different uses of lead in steel with different purposes that could also be specified with different thresholds. A split of the exemption in the opinion of the consultants is possible.

The first part of the exemption should cover the use of lead as an alloying element in steel. For this part, the consultants agree with KEMI that there is a need to narrow the scope of the exemption. However, the consultants cannot conclude a list of exhaustive applications of lead in steel on the basis of the available information. The consultants agree that such an exhaustive inventory is needed in the future in order to further specify possibilities to narrow down the exemption to specific applications. Further steps that the consultants deem necessary for a future review are explored in Section 18.5.8.

Concerning batch hot dip galvanized steel, EGGA[599] agreed to lower the threshold down to 0.2% provided that the wording formulation makes it clear that this threshold is calculated for the entire steel item.[600] This reduced threshold of 0.2% has been proposed based on consultations across the industry according to EGGA.[601]

EUROFER and EGGA explain that "*Pb levels range from <0.03% up to 0.8% Pb in the coating if this is considered the 'homogeneous material'. Steel items that have been batch hot dip galvanized would therefore readily comply with the upper exemption limit of 0.35% Pb previously established for machining steels*".[602] It is thus concluded that specifying a threshold for the presence of lead would depend on whether this threshold would relate only to the coating or to the complete steel part.

The current wording of ELV Annex II Exemption 1(a) is "*Steel for machining purposes and batch hot dip galvanised steel components containing up to 0,35 % lead by weight*". Thus, should it be decided to renew the exemption in relation to the amount of lead in

[599] EGGA (2015), European General Galvanizers Association (EGGA) (2015), Answers to 2nd Clarification Questions, submitted 14.12.2015.
[600] EUROFER and EGGA (2015a) also state in this regard:
"Lead has a low solubility in the zinc-iron alloys that are formed during the galvanizing reaction. Hence, the quantity of lead present in the coating is normally significantly lower than the lead present in the process bath – typically half as much. For a given bath composition, the variations of lead concentrations in the coating mainly depend on the steel type (reactivity with molten zinc)."
[601] Op. cit. EGGA (2016)
[602] Op. cit. EUROFER and EGGA (2015a)

the entirety of the galvanised part, reference to "*batch hot dip galvanised steel components"* should be made. In this case the threshold could be lowered to 0.2%.

Otherwise, the formulation should refer to the presence of lead in the coating of components, whereas the threshold may need to be adjusted to accommodate the higher levels of lead (i.e., up to 0.8%). EUROFER and EGGA[603] explain that the batch hot dip galvanizing process allows the complete coverage of manufactured steel components with a metallurgically-bonded metallic coating that is formed through diffusion of iron and zinc, giving no clear delineation between coating and steel substrate. It is thus not clear if reference to the coating would be feasible in terms of market surveillance.

As further decrease in the lead content would only be expected in the long term due to the unintentional presence of lead in zinc scrap or irrespective of the requirement under RoHS, the consultants propose the exemption to be granted for the longest review period which is possible under RoHS.

18.5.8 Conclusions

Article 5(1)(a) provides that an exemption can be justified if at least one of the following criteria is fulfilled:

- their **elimination or substitution** via design changes or materials and components which do not require any of the materials or substances listed in Annex II is scientifically or technically impracticable;
- the **reliability** of substitutes is not ensured;
- 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.

Overall, it seems important to differentiate in the future between the different uses in steel where lead provides necessary properties in steel alloy and is intentionally added and between galvanizing processes where lead is mostly unintentionally present.

As for lead in steel for machining purposes

- Substitution with bismuth containing steel might not be reliable and might cause negative environmental impacts. For the latter, not enough data is available to comprehensively conclude on this.
- Substitution via steel that does not contain lead is scientifically or technically practicable at least for some applications as shown by examples of PennEngineering with lead-free rephosphorised and resulfurised steel used for the production of specialty fasteners and of NSSMC with resulfurised steel used for the production of printer rails and printer shafts.

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[603] Op. cit. EUROFER and EGGA (2015a)

- The remaining applications have to be specified by performing and integrated survey of the supply chain in order to narrow the scope of the exemption to a comprehensive list of applications. This would need the engagement of EEE component manufacturers. As EUROFER and EGGA clarify the complexity of the supply chain, the consultants can follow that this would be time consuming. However, the consultants think that the current scope is not justified and recommend a short termed exemption to allow performing such a survey.
- The set-up of a comprehensive list of applications would also allow deciding, whether the lead content can be further reduced. Though the steel producers[604] object to this approach due to decreased tool life and higher cutting forces, these machinability conditions seem to be adaptable in specific cases as the example of CETEHOR shows.

As for lead in galvanized steel, the consultants understand that lead does not provide a function in the coating of parts used in EEE. It is understood that there are two cases for the presence of lead. In some plants, lead is present at the bottom of galvanisation baths as it precipitates from secondary zinc added to the process, and may thus be present in galvanised products. In other cases, lead may be added to facilitate the galvanising process of certain parts (for example steel mesh used for construction). Such practices were explained not to be directly relevant to EEE parts. However, as the galvanisation of parts for EEE is performed in the same baths, the presence of lead in some cases cannot be excluded. In both cases, lead is understood not to serve a functional purpose in the galvanisation of steel parts for EEE, but to be a result of the use of secondary zinc or of the manufacture of other parts: "*Lead is present in the zinc coating of galvanised steels. Lead has no beneficial (or adverse) effect on the coated product, but may have a technical influence on the galvanizing process in a small number of plants*".[605] The consultants conclude that the lead is mostly not intentionally added (or not added for itentions of relevance to the EEE part properties), but a result of the use of zinc scrap or of galvanizers' ashes. The intentional addition of lead to a galvanizing bath where it is technically required could not be separated for EEE specific processes or products, which are understood to have only a small share of all galvanised parts.

18.6 Recommendation

Based on the above considerations, it is recommended to split the exemption and provide different review periods for each entry.

A short review period of three years is proposed for applications where lead is present for machining purposes. The overall picture where substitution efforts are promising is not clear enough at present to allow an adjustment of the scope. In parallel it is

[604] Op. cit. EUROFER and EGGA (2015b)
[605] Op. cit. EUROFER and EGGA (2015a)

established that substitutes are practical at least for some applications. The aim of a future review should therefore be to evaluate results of a comprehensive survey of the supply related to the applications of leaded steel alloys together with their technical requirements. The aim should be to check the applicability of a more narrow scope for the exemption. The consultants would further recommend cancelling the exemption, should industry fail to provide detailed and substantiated information in the future.

As for the exemption for batch hot dip galvanized steel, a lower threshold is proposed in agreement with the applicant for lead in batch hot dip galvanized steel items and a review period of the maximum permissible validity of five years is proposed for this part of the exemption, as the lead is mostly an unintentional impurity in the galvanizing bath.

Exemption 6a	**Duration***
I) Lead as an alloying element in steel for machining purposes containing up to 0,35 % lead by weight	For Cat. 1-7 and 10 and 11: 21 July 2019
II) Lead in batch hot dip galvanized steel components containing up to 0.2% lead by weight	For Cat. 1-7 and 10 and 11: 21 July 2021
III) Lead as an alloying element in steel for machining purposes and in galvanized steel containing up to 0,35 % lead by weight	For Cat. 8 and 9: 21 July 2021; For Sub-Cat. 8 in-vitro: 21 July 2023; For Sub-Cat. 9 industrial: 21 July 2024;

Note: As it can be understood that the exemption duration may vary for various categories on the basis of Article 5(2), expiration dates have been specified here for all categories either on the basis of the requested duration in the exemption request which the consultants perceive to be justified, or on the basis of the validity periods specified in Article 5(2) for categories, which are newly in scope.

18.7 References Exemption 6a

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