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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31.0 Exemption 29: "Lead bound in crystal glass as defined in Annex I (Categories 1, 2, 3 and 4) of Council Directive 69/493/EEC (1)"

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

EDG	European Domestic Glass
EEE	Electrical and Electronic Equipment
HCl	Hydrochloric acid
HF	Hydrofluoric acid
H_2SO_4	Sulfuric acid
LCG	Lead crystal glass
LEU	LightingEurope
Pb	Lead
UVCB	Substance of **U**nknown or **V**ariable **C**omposition, complex reaction products or **B**iological materials

31.1 Background

European Domestic Glass (EDG) and LightingEurope (LEU)[1747] have submitted a joint request for the renewal of exemption 29 of Annex III of the RoHS Directive to allow the use of lead in the manufacture of lead crystal glass to be applied in EEE.

Crystal is a substance characterized by a continuous and essentially non-crystalline or vitreous inorganic macromolecular structure, which is highly insoluble and inert. Obtained by a mineralogical process, resulting in a chemical network (matrix), crystal constituents are closely linked together and are in a specific chemical environment, different from the initial state of the raw materials.[1748]

It is explained by the applicants[1749] that lead oxides (PbO or Pb_3O_4), are used as an intermediate for the chemical synthesis of Lead Crystal Glass (LCG). LCG is used in EEE applications because their unique combinations of processing and optical/decorative properties and characteristics allow the manufacture of EEE articles which could not be produced otherwise. Substitutes are said to have been sought over the latest two decades without success. The performance of alternative materials is worse and does not allow the production of articles with comparable properties, notably because of the insufficient workability time made possible by the lead oxide component. Various articles are named as types of EEE in which LCG is used (see Figure 31-1 for examples):

- Fixed/portable luminaires;
- Lamps;
- Electrified mirrors;
- Horology (clocks, watches etc.);
- Display cases;
- Digital photo frames;
- Tablet and smart phone docking stations;
- Furniture and home décor items (carrousel, tables etc.);
- Building materials (illuminated bricks).

Thus EDG & LEU request the renewal of the exemption with the following wording:

"*Lead bound in crystal glass as defined in Directive 69/493/EEC*"

[1747] EDG & LEU (2015a), European Domestic Glass and LightingEurope, Original Dossier Requesting the Extension of Exemption 29 in Annex III of Directive 2011/65/EU, submitted by the European Domestic Glass Association and by LightingEurope on 16.1.2015 to the EU COM, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/29_EDG_LE_RoHS_Exemption_Req_final.pdf

[1748] EDG & LEU (2015b), European Domestic Glass and LightingEurope, Answers to 1st Clarification Questions regarding Exemption 29 in Annex III of Directive 2011/65/EU, submitted on 14.08.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/20150814_Ex_29_EDG___LEU_1st_round_of_Clarification-Answers_final-Public.pdf

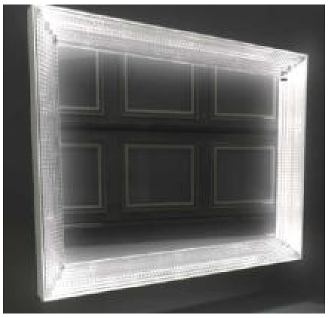
[1749] Op. cit. EDG and LEU (2015a)

The exemption has been requested for a period of 10 years. In this respect the applicants have specified that the exemption is requested for articles of categories 3 (IT and telecommunications equipment), 4 (consumer equipment), 5(lighting equipment) and 11(other EEE not covered by any of the categories above). Since Article 5(2) of the RoHS Directive limits the maximum duration of the validity of an exemption to 5 years in the case of EEE falling under Cat. 1-7, 10 and 11, the consultants interpret this to mean that the applicant requests the maximum applicable duration.

Figure 31-1: Example EEE in which lead crystal glass is used

Lighting applications (luminaires, chandelieres)

Building materials - illuminated bricks

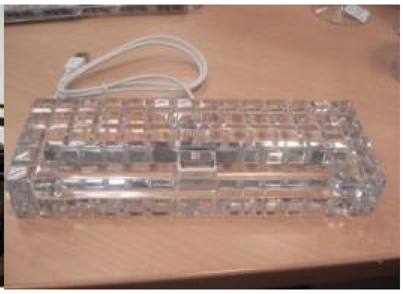


Electrified mirrors

Horology

Display cases

Digital photo frames



Tablet and smart phone docking stations

Furniture and home décor items

Source: EDG & LEU (2015a, 2015b)

31.2 Amount of Lead Used under the Exemption

EDG & LEU[1750] explain that the Crystal Glass Directive 69/493/EEC[1751] defines crystal glass into four categories along three criteria, among them its composition expressed notably as lead oxide up to over 30% by weight. Under the REACH Regulation, glass is considered as a UVCB substance (substance of **U**nknown or **V**ariable **C**omposition, complex reaction products or **B**iological materials). It is not a preparation and does not contain lead metal nor lead compounds as such. EDG and LEU explain that 130 tonnes[1752] of EEE using LCG are placed on the EU market per annum. From the combined declarations of members of EDG who are LCG manufacturers, representing 80% of the EU market share, it can be understood that 40 tons/annum of Pb_3O_4 and PbO are used as an intermediate for the manufacture of LCG applied to EEE applications manufactured for the EU market. Thus 40 tons/annum of Pb_3O_4 and PbO are used to manufacture 104 tonnes of lead crystal electric/electronic articles, representing 80% of the EU market share. On this basis, it is estimated that for the total EU market, 130 tonnes are manufactured, of which 50 tons/annum of Pb_3O_4 and PbO would be used for manufacture.[1753] The Pb comprised in 50 tonnes of Pb_3O_4 and PbO is estimated to amount to 46 tons.[1754]

31.3 Description of Requested Exemption

According to EDG & LEU[1755] lead oxides (PbO or Pb_3O_4), are used as an intermediate for the chemical synthesis of Lead Crystal Glass (LCG), as required by Council Directive 15 December 1969 on the approximation of the laws of the Member States relating to crystal glass (69/493/EEC). The amount of lead in the LCG has to be at a minimum of 24% expressed as PbO for the glass to be called “lead crystal” and above 30% for it to be called “full lead crystal”. EDG & LEU stress that it does not mean that there is PbO nor Pb as such in the articles. It is simply a convenient way to express the result of an elementary composition analysis. It is further explained that under REACH Regulation[1756], Crystal Glass is itself a substance of unknown or variable composition,

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[1750] Op. cit. EDG & LEU (2015a)

[1751] COUNCIL DIRECTIVE of 15 December 1969 on the approximation of the laws of the Member States relating to crystal glass (69/493/EEC), (OJ L 326, 29.12.1969, p.36), available under: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:01969L0493-20070101

[1752] In the application document, both tons and tonnes are referred to. A Uk ton represents 1016 kg and an American one 907 kg, whereas a tonne represents 1000 kg. The consultants assume that the inconsistency is a typo and that tonnes, representing 1000 kg are meant, as this would be consistent with the explained calculation.

[1753] It is further noted that the former submission (exemption renewal request from 2008) indicated 145 tonnes/year, most probably because there was a confusion between lead crystal glass EEE applications and Pb oxide components.

[1754] Op. cit. EDG & LEU (2015a)

[1755] Op. cit. EDG & LEU (2015a)

[1756] Cited as REACH Regulation, Annex V and Guidance for Annex V, Entry 11, pp.38-39 which by convention is expressed as oxides of the constituent elements (SiO_2, Na_2O, K_2O, PbO, etc.). The addition of lead oxide enables:

- The production of exceptional articles otherwise impossible to obtain, through the:
  - increased working time with the glass, via excellent thermal and viscosity properties (melting and forming);
  - unique optical properties needed for:
    - High refractive index nd > 1.56 (responsible for brilliance);
    - High dispersion nf – nc > 0.01, preferably 0.013 (responsible for the refraction and reflection performance);
    - High light transmission (L > 98; -0.5 < a < 0; -0.5 < b < 0.5 (100 mm thickness immersion, light C, 2°, CIELAB);
    - No grey, but sharp colour transition;
  - unique mechanical (cutting and polishing) process possibility;
  - unique refinement (sustainable surface) process possibility;
  - decorative aspects.
- A better energy efficiency. Measures demonstrate that from a same source (LED), the light flow transmitted through a crystal item is bigger by a factor of at least 10%, compared to the light flow transmitted by the same item in flint glass. The energy efficiency (lumen/watt) of crystal is therefore much better than in flint glass. In certain cases, the ranking Index of energy efficiency (IEE) of an electric lighting device can jump to category A (with crystal) from category B (with flint glass). In other words, less energy is required for lighting.

On this basis, EDG & LEU[1757] conclude the crystal glass is a component of high quality lighting and decoration applications (see Section 31.1), and is used for the very production of these articles otherwise impossible to manufacture, for enhancing light distribution or transparency thereof and for enabling specific decoration (shape and finishing).

In a later communication[1758] it is elaborated that in the hot process, the use of lead for the synthesis of crystal increases the working range. It reduces the viscosity of the melt for the same temperature, rendering it more fluid than ordinary glass. The viscosity of glass varies radically with temperature. This results in a few practical developments:

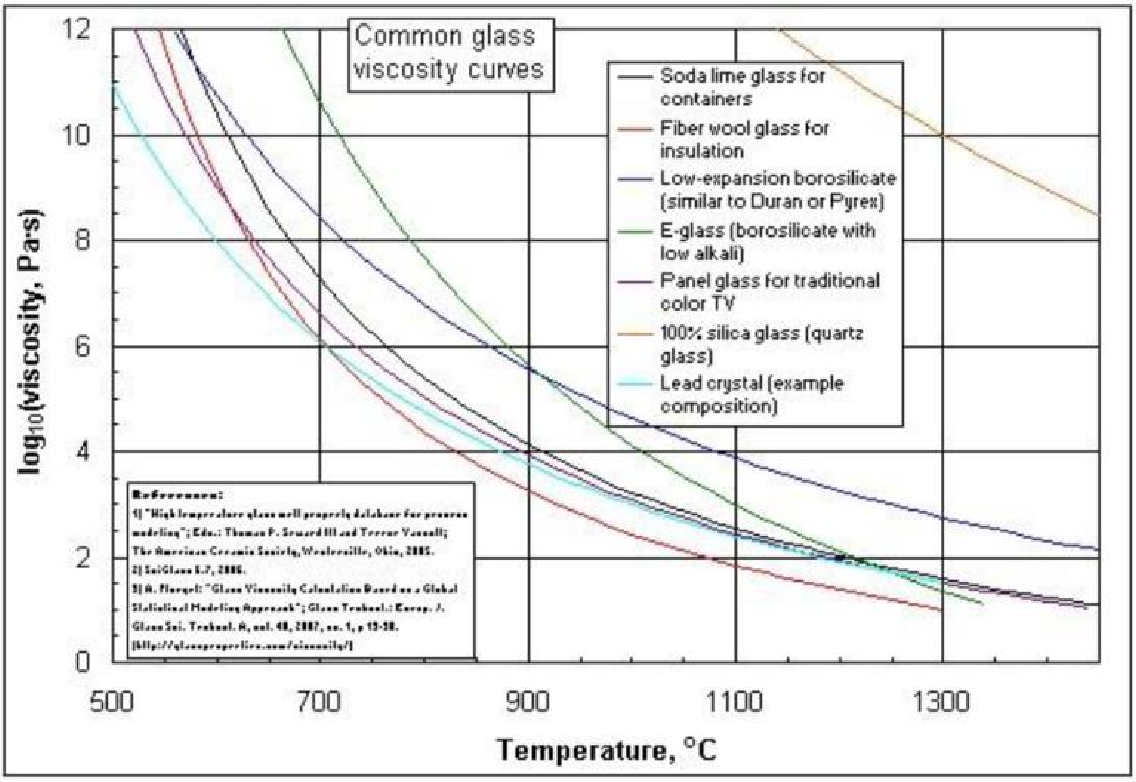
- Lead glass may be worked at a lower temperature, making possible the shaping of sophisticated items. Design is therefore determined by the cooling time: complex forms are not possible to produce in a glass (without lead) with a short working range – see Figure 31-2 representing viscosity as function of temperature for several types of glass. Simply stated, the working range of

[1757] Op. cit. EDG and LEU (2015a)
[1758] Op. cit. EDG and LEU (2015b)

glass is that range of temperatures that corresponds to the point where glass just begins to soften up to the point where glass is too soft to control. The ASTM and the American Ceramics Society committees on glass definitions summarize the definition now widely used in today's glass industries[1759]: WORKING RANGE: "The range of temperatures in which glass is formed into ware in a specific process. For comparison purposes, when no specific process is considered, the working range of glass is assumed to correspond to a viscosity range from the working point to the softening point. (4 to 7.6 Log10 Poise)". A LONG glass will have a significantly longer temperature range from the working point to the softening point than a SHORT glass. Since glass blowers hand work (or hand process) glasses in this range they are able to readily distinguish a long glass from a short glass.

- The working range also has a direct impact on manufacturing cost due to reheating requirements (additional energy consumption, timing and defective items).
- Properties of the crystal are also key-factors for tools design; therefore any change in the properties may lead to major change requirements for the associated tools.

Figure 31-2: Viscosity as a function of temperature for several glass types



1759 EDG and LEU (2015b) refers to pp. 677-680 in The Handbook of Glass Manufacture by Tooley and pp. 72-74 in Technical Glasses by Volf

Source: EDG & LEU (2015b)

31.4 Applicant's Justification for Exemption

EDG & LEU[1760] provide more detail as to the function of lead in LCG, explaining that "*lead oxide or tetroxide is added to achieve the following characteristics:*

- *Refractive index: ratio of the speed of the light in vacuum in a dimensionless number that describes how light propagates through a medium. The higher the refractive index, the more lighting effects (rainbow).*
- *Abbe number: Abbe number is a measure of the variation of refractive index with wavelength so that the refractive index of a glass with a low Abbe number varies across the visible spectrum less than a glass with a high Abbe number. Lead crystal glass has a low Abbe number which reduces chromatic aberration in parallel to displaying a high refractive index.*
- *Dispersion: phenomenon in which the phase velocity of a wave depends on its frequency. The bigger the dispersion, the more visible spectrum of colours (rainbow).*
- *Cooling time: lapse of time between two viscosity states below and above which glass cannot be shaped. The more time is possible, the more specific (longer, thinner, and complex) shapes can be designed. This specificity enhances the skills of the craftsman to elaborate high end products.*
- *Working range: range of temperature with the same purpose of the cooling time, expressed in °C, instead of time.*
- *Vickers' Hardness: measure of hardness of the material. The lower the hardness, the more possibilities for cutting and engraving complex artistic designs on exceptional and prestigious items which can only be achieved by handcrafting.*
- *Better energy efficiency[1761] because of less energy consumption together with a better lighting effect*."

31.4.1 Possible Alternatives for Substituting RoHS Substances

EDG & LEU[1762] explain that research has been conducted for over two decades, but that no viable substance substitute exists. There are a limited number of elements in the periodic table available that can be combined to form certain kinds of crystal glass in EEE applications (BaO, ZnO, SrO, CaO, MgO). Combinations that exist form glasses only

[1760] Op. cit. EDG and LEU (2015a)
[1761] When asked to quantify this aspect, EDG replied that "A confidential study made by one of our stakeholders shows that for a light source of 30,9 lm/W, crystal gives 10% more light than glass leading to an 'A' category for crystal item and 'B' for some glass items." As it was not possible to understand how this study was performed from information in the public realm and as other argumentation was found to provide a relevant basis on which the review can be judged, this aspect has not been further pursued.
[1762] Op. cit. EDG & LEU (2015a)

within relatively small composition ranges. Many combinations have been tested but a viable alternative has not yet been found. Research has provided patterns achieving some of the Pb-bound in crystal properties, but none of these patterns achieve all of the same essential properties, especially the main one: thermo-mechanical-optical properties to elaborate the product. EDG & LEU provide a comparison as presented in Table 31-1 below. The results obtained show that the required properties are not provided by investigated candidates, which displayed inferior thermal, mechanical and optical properties (cooling time, Vickers hardness, Abbe number) and that would thus not allow the manufacture of the same applications.

Table 31-1: Comparison of properties of lead crystal to lead-free crystal and and sodalime crystal

	lead crystal	lead free crystal 1	lead free crystal 2	lead free crystal 3	sodalime glass
Refractive Index	1,559	1,555	1,547	1,554	1,521
	discrepancy	0%	-1%	0%	-2%
Abbe Number	43,8	55,7	53,6	55,4	59,4
	discrepancy	27%	22%	26%	36%
Dispersion (656,27nm-768,2nm) (10E-3)	4,2	na	3,2	3,2	3,1
	discrepancy		-24%	-24%	-27%
Dispersion (589,3nm-656,27nm) (10E-3)	3,7	na	2,7	2,7	2,6
	discrepancy		-26%	-26%	-29%
Dispersion (435,84nm-486,13nm) (10E-3)	7,3	na	5,1	5,1	4,8
	discrepancy		-30%	-31%	-34%
Dispersion (404,66nm-435,84nm) (10E-3)	6,3	na	4,3	4,2	4,0
	discrepancy		-32%	-32%	-36%
Working Range (T Log4 - T Log 7,65) (°C)	333	271	290	254	298
	discrepancy	-19%	-13%	-24%	-10%
Cooling time (s)	130	106	113	104	100
	discrepancy	-19%	-13%	-20%	-23%
Vickers' Hardness (MPa)	4799	5319	5038	5431	5586
	discrepancy	11%	5%	13%	16%

Source: EDG & LEU (2015a)

Notes: Lead-free crystal 1&2 : formulations investigated during R&D works (thesis conducted by Baccarat until 2003, confidential, references upon request), Lead-free crystal 3 : US patent 2007/003237A1, Lead-free is based on US Patent. Holder is Swarowski Sodalime glass: commercial formulation used for tableware production

On this basis EDG & LEU[1763] conclude that lead-free glass does not fit with the required combination of essential properties.

- "*Shorter cooling time/working range would not permit the production of complex items any more.*
- *Higher Vickers hardness will trigger musculo-skeletal disorders for the workers because the cutting difficulty will dramatically increase. In addition, quicker damage and need to replace industrial tools will drastically increase. It will*

[1763] Op. cit. EDG and LEU (2015a)

become impossible to make very intricately engraved articles as employers are required to protect the health of their workers.

- *The combination of optical properties (refractive index, Abbe number, dispersion) generated by the use of lead bound in crystal glass are unique and unmatched by other materials (the latter are unable to obtain the same low value of chromatic aberration).*"

According to EDG & LEU[1764] there are no industrial processable substitutes with comparable thermo-mechanical-optical properties enabling the manufacture of handmade high end articles. There is no single element or combination of elements known to substitute Pb in crystal glass in all its properties (workability, optical properties, chemical resistance, etc.). Tested combinations of elements such as Ti, B, Zn, Bi, Sb, Ba, Sr, Li, have only allowed reaching some of the above-mentioned properties. It is further explained that it is difficult to estimate if and when further research shall allow achieving the demanding combinations of essential characteristics. It is therefore not possible to predict how long this type of R&D would take or whether substitutes could be found for all the lead bound in crystal EEE applications.

31.4.2 Environmental Arguments

According to EDG & LEU[1765] **the hazard represented by glass depends** on the intrinsic properties of the substance glass and not on the intrinsic properties of the individual substances that went into the batch as intermediates for making the glass. By definition, glass is an amorphous, inorganic solid material made by fusing silica with basic oxides. Glass is called amorphous because it is neither a solid nor a liquid but exists in a vitreous (or glassy) state. From a chemical point of view, glass is both a unique material and a material state respectively. The chemical and physical material characteristics and behaviour cannot be derived from the properties of the raw materials (e.g., PbO or Pb_3O_4) used as intermediates. The melting process leads to a complete chemical transformation forming a new chemical compound: crystal glass. Lead bound in crystal glass waste is a non-hazardous waste according to EC Decision 2003/33/EC. Criteria for acceptance of non-hazardous waste at landfills have been introduced in Council Decision 2003/33/EC, also including leaching thresholds for various substances. According to EDG & LEU, LCG has been tested and lead bound in crystal complies with the leaching values of the landfill directive (see Appendix A.5.0) and is classified as non-hazardous material in the Waste Framework Directive (2008/98/EC).

It is further explained that lead crystal EEE applications are prestigious and expensive items which are kept, transferred, inherited or resold. The repairing or replacement of the broken parts, of these prestigious and expensive items (e.g. one branch or prism of a luminaire), prevents the discarding of the full EEE application. Crystal manufacturers provide inherent assistance via an after-sales service by which they collect and replace

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[1764] Op. cit. EDG and LEU (2015a)
[1765] Op. cit. EDG&LEU (2015a)

the broken parts of EEE crystal items which have been brought back by the customer, sometimes via the distribution chain. In addition, there are second-hand shops and specialized repair workshops, privately collecting, repairing and replacing spare parts of EEE applications made of lead bound in crystal glass. In this sense EDF & LEU argue the **probability of LCG EEE articles to reach the waste stream** to be very small. The number of discarded spare parts is negligible, given that EEE applications made of lead crystal glass are prestigious and expensive items which the consumer has all interest to keep and repair.[1766]

Finally, during the visit at the Saint-Louis manufacturing facility (see Section 31.5), both representatives of Saint-Louis and of Baccarat explained that the use of lead in the glass affects its workability and subsequently the **energy consumption of various manufacturing stages**. Saint-Louis were asked to substantiate this aspect and provided the following detail as a follow-up to the visit:

Saint-Louis[1767] explains that lead oxide included in a glass recipe has a significant contribution towards lowering the melting temperature of the different oxides, and towards extending the working range. The time within this working range is critical for handmade work, because it corresponds to the temperatures where the thermal and viscosity behaviour of the glass is suitable for glass shaping. Typically the lead oxide glasses will have longer working range by about 60-80°C (about +30% longer)[1768] in comparison to lead-free glasses. Consequently workers have more time to shape the glass before heating it again. Moreover, the thermal behaviour of lead oxide glass is shifted towards lower temperature, which means a lesser high reheating process when needed. All in all a lead oxide recipe needs less energy than a lead-free one. Saint-Louis[1769], estimates that typically the orders of magnitude of energy consumption savings and advantages for lead-glass recipes versus lead-free recipes, in relation to various processing stages are as follows:

- **Fusion**: with a nominal temperature setting of at least 50°C less for fusion in pot & tank furnaces, this translates to at least 10% less energy consumption for lead glass vs lead-free glass.
- **Blowing/glass art**: during shaping processes, glass is regularly reheated in different side gas furnaces, to allow the completion of all the different shaping gestures (blow gestures +hand shaping gestures) to achieve the right

[1766] Op. cit. EDG&LEU (2015a)

[1767] Saint-Louis (2015a), Answers to clarification questions following visit at the Saint-Louis manufacturing facility, sent per email 15.1.2016

[1768] In this regard please note the reference in Section 31.3: “The range of temperatures in which glass is formed into ware in a specific process. For comparison purposes, when no specific process is considered, the working range of glass is assumed to correspond to a viscosity range from the working point to the softening point. (4 to 7.6 Log10 Poise)”. See also Figure 31-2: Viscosity as a function of temperature for several glass types .

[1769] Saint-Louis (2015a), Answers to clarification questions following visit at the Saint-Louis manufacturing facility, sent per email 15.1.2016 design. Lead oxide glass recipes, which have a longer working time, do not need to be reheated as often, and the needed temperature (relevant for reheating) is lower. Though it is difficult to quantify the differences in light of the diversity in the various pieces typology, it is however clear that the energy consumption relevant for making the same amount of pieces per time unit is less (estimated as about 15%).

- **Annealing**:with a nominal temperature setting of at least 50°C less for annealing in belt furnaces (after glass shaping and cup removing), it is estimated that as a minimum 15% less energy is consumed for lead-glass in comparison to lead-free glass.
- Every **mechanical operation** is affected by the change of hardness of the glass. Lead-glass is less hard than lead-free glass. As a consequence, the needed effort to modify the surface of the material is lower:
  - Handmade cutting: 20-50% less time is needed for completing tasks (depending on product's typology), with non-evaluated impacts on skeleton & muscular diseases.
  - Machine cutting: 15% less power is needed for the completing the same tasks.
  - Flat surfacing & final polishing: surface polishing is highly dependent on the hardness; lead glass flat surfacing time as compared to lead-free recipes is estimated to be about 75% less energy intensive, and for final polishing and reparation this difference is estimated to be about 35% less. Consequently, energy saving is expected to greater in lead glass.
  - Etching - acid polishing: The acid polishing process is comprised of a succession of dipping into different baths of hydrofluoric (HF) & sulfuric (H_2SO_4) acids, enabling chemical attacks of the glass surface and cleaning ones. This process occurs at 50°C. The chemistry of a lead glass reacts differently to the acid attacks of lead-free glass because of the atoms network bonding and chemical affinities, which influences the chemical reactions at the surface. For lead-free glass, it has been observed that the cleaning of the chemical substances from the acid attack is favourable when hydrochloric (HCl) acid is added to the HF and H_2SO_4, which means higher costs and energy, not yet quantified. According to the tests carried out, for the global etching process, typically 60% less time is needed for lead glass as compared to lead-free glass, which means directly 60% less energy consumption.
- **Decoration**: the firing process of gold palladium coatings is done in batch furnaces at temperatures which are at least 50°C lower for lead-glass recipes in comparison to lead-free glass, which means about 15% less energy.

Saint-Louis[1770] concludes that all in all, the estimated energy saving along the production stages of crystal lead glass in comparison to lead-free glass is between 20-30%. Concerning possible differences in the maintenance of equipment, the frequency at which cutting wheels need to be sharpened and replaced is around twice less (Saint-Louis's terminology).

31.4.3 Socio-economic Impact of Substitution

EDG & LEU[1771] argue that the ban of lead crystal in electric and electronic equipment would lead to the disappearance of some mainly lead crystal manufacturing companies. In Europe there are many companies whose business is devoted entirely to the production and sale of lead crystal chandeliers and allied lighting products (e.g. in UK approximately 10). A larger group of companies have lead crystal products as part of a wider range of products (e.g. in UK approximately 25) and there are a number of specialist antique restoration companies that refurbish and restore lead crystal chandeliers and rely on the manufacture of spare parts made from the same quality of crystal glass (e.g. in UK approximately 5). LCG is manufactured mostly through artisanal work, requiring unique and specific knowledge, with some European companies benefitting in this respect from national recognition for this via a status of patrimonial knowledge. EEE applications represent about one third of the turnover for some of these companies. Should the exemption not be renewed, it would mean:

- Loss of economic and patrimonial wealth.
- Loss of circa one third of turnover of related manufacturing companies and in the medium/long term, their disappearance.
- Loss of 1,000 direct jobs and 3,000 indirect jobs[1772] in Europe.

If lead crystal were to be banned in the EU the high quality market for chandeliers and other allied lighting products would be severely affected as the distinction between high quality chandeliers (some costing 10s of thousands of EUR) and poorer quality items will not exist. As a result the market for high quality crystal lighting will be damaged and some companies may be forced out of business with a resulting loss of jobs. A similar damage will affect the restoration and refurbishment market as lead crystal parts matching the originals would not be available rendering their work as poor restorations (bearing in mind that refurbished lighting products need to comply with relevant regulations). If the market does not exist there would be no replacement part available.[1773]

[1770] Op. cit. Saint-Louis (2015a)
[1771] Op. cit. EDG & LEU (2015a)
[1772] Indirect jobs are understood to be related to enterprises which use lead crystal in their work, however which do not manufacture the lead crystal themselves. For example, manufacturers of articles who rely on lead crystal producers as suppliers, enterprises who repair items (e.g. through replacement of single items that have broken, etc.).
[1773] Op. cit. EDG & LEU (2015a)

In a later communication it is understood that a large share of the manufacture of LCG for EEE articles relies on hand crafting and manual processing. Chandeliers, floor lamps, candelabras, table lamps, wall sconces, luminaires are made in crystal glass. Those lead crystal glass items are mainly hand crafted even if some parts could be industrially processed. For example a chandelier requires from 500 to 1,750 worked hours.

Hand crafting is said to represent 85% of work time, of the cold processing parts, for chandeliers, floor lamps, candelabras, table lamps, wall sconces and luminaires, . The remaining 15% of the work time utilises an automated tool. Equivalent additional worked hours should be taken into account for forming the part – all these additional hours are hand-crafted. Even for items where the main blank shape is produced by machine (picture frames, clocks etc.), the manual work content is approximately 80% of the manufacturing cost. Besides, most of the items manufactured by EDG-Member factories and workshops are unique. Each of them is a creation or issued in a limited edition. There is no mass production: [1774]

- For horology, production is about hundreds per year per producer;
- For chandeliers, total production volume is a little more than a thousand per year in Europe.

31.4.4 Roadmap to Substitution

General statements were made by the applicant as to the lack of available substitutes despite the research efforts that had been carried out in this area over the years. Following the visit at the Saint-Louis manufacturing facility (see Section 31.5) and the understanding from both Saint-Louis and Baccarat that manufacturers were actively researching possible alternatives to the use of lead in lead-crystal handmade articles, Saint-Louis were asked to substantiate the various aspects of their research.

In this respect, Saint-Louis[1775] explains the production of a lead crystal piece to be a succession of different sub-processes, gathered in hot and cold areas. In total, this includes more than 20 sub-processes, with flows depending on the product typology. The table below illustrates 3 different production flows (in green) for 3 typical luminaire crystal parts.

The complexity (i.e. of the research of potential substitutes) takes place intrinsically in the different flows that need to be tested but also in the interactions between the different sub-processes. In other words, the evaluation/development of a sub-process n+1 may necessitate the modification of a sub-process n or of the glass recipe itself,

[1774] EDG & LEU (2015b), European Domestic Glass and LightingEurope, Answers to 1st Clarification Questions regarding Exemption 29 in Annex III of Directive 2011/65/EU, submitted on 14.08.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/20150814_Ex_29_EDG___LEU_1st_round_of_Clarification-Answers_final-Public.pdf

[1775] Op. cit. Saint-Louis (2015a)

which would require to check / adjust again other sub-processes: setting the recipe is an iterative development which needs to be proved for repeatability and reproducibility regarding handmade and product diversities. [1776]

hot processes ability ← impacts glass recipe → cold processes ability

At each stage, on one hand the product parameters are evaluated according to Saint-Louis quality standards expected by customers (Norme de Choix), and on the other hand in respect to the process performances (reject levels, energy consumption, maintenance impacts). For instance, the thermal and viscosity behaviour of one recipe could be found suitable for blowing processes, but not for injection/pressing processes, which means a correction of the recipe and a new check of the blowing performance would be needed. However, a change of the recipe also affects the fusion properties, particularly the refining process, which is key aspect for producing a high quality glass without bubbles. Another example of interaction is the impact of a recipe modification on the chemical behaviour during the etching process (acid attack), and on the aptitude of gold or platinum decoration (decor adhesion on the glass substrate during the firing decoration process).[1777]

[1776] Op. cit. Saint-Louis (2015a)
[1777] Op. cit. Saint-Louis (2015a)

Table 31-2: Example of 3 different production flows (in green) for 3 luminaire pieces

Product	Fusion		Hot processes					Cold processes					
glass or hurricanes for luminair	composition raw material mixing	fusion tank furnace	blowing	glass annealing tunnel oven	cup removing laser	cut edges flame polishing	glass annealing	flat polishing	chemical engraving	acid polishing	final polishing reparation	Gold/palladium decoration application & firing	
			injection					handmade cuts					
								machine cuts					
		fusion pot furnaces	pressing	glass annealing batch oven	cup removing saw			engraving					
			paperweight					drilling / neck tooling					
			glass art					sand blasting					
colored hurricane holder for luminair	composition raw material mixing	fusion tank furnace	blowing	glass annealing tunnel oven	cup removing laser	cut edges flame polishing	glass annealing	flat polishing	chemical engraving	acid polishing	final polishing reparation	Gold/palladium decoration application & firing	
			injection					handmade cuts					
								machine cuts					
		fusion pot furnaces	pressing	glass annealing batch oven	cup removing saw			engraving					
			paperweight					drilling / neck tooling					
			glass art					sand blasting					
branch for luminair	composition raw material mixing	fusion tank furnace	blowing	glass annealing tunnel oven	cup removing laser	cut edges flame polishing	glass annealing	flat polishing	chemical engraving	acid polishing	final polishing reparation	Gold/palladium decoration application & firing	sealing to metal holder + electrification
			injection					handmade cuts					
								machine cuts					
		fusion pot furnaces	pressing	glass annealing batch oven	cup removing saw			engraving					
			paperweight					drilling / neck tooling					
			glass art					sand blasting					

Source: Saint-Louis (2015a)

Fusion is the key starting process, which cannot be tested directly with final production furnaces (tank or pots). Indeed recipes evaluation and pre-validation must start with crucibles at the laboratory and in small size pots with limited trials, enabling the production of some pieces for testing performance in respect to shaping and cutting and challenging their hot/cold processes ability, leading finally to real size pots and extensive validations. Consequently, the use of a tank furnace ought to be done at the end of the development of all the sub processes with the final glass recipe selected, with the help of the tank furnace supplier where designing of the right furnace is of relevance.[1778]

Colours development is also a key issue for the product portfolio in relation to expectations of customers and designers, for luminaires as well as for decoration and tableware. A dozen colours are currently made available by Saint-Louis on the market. Many coloured products are made of overlaid glass colours. The glass colours must be developed on the basis of the clear recipe, for dilatation coefficient and fusion compatibility reasons. Furthermore, the effect of the colorant oxides strongly depends

[1778] Op. cit. Saint-Louis (2015a)

on the glass matrix. Therefore the development of the different colours must be synchronized once the clear recipe is known, and this cannot be fully anticipated and induces a time shift as well in respect to the time needed for enabling substitution.[1779]

Saint-Louis[1780] explains that as indicated in the presentation held during the visit on 3 December 2015 (detailed in Section 31.5), the overall recipe development for a substitute is thus based on a progressive, iterative and focusing approach following several criteria which must be validated with each other. So far, after desk-research (of between 1 to 600 recipes) and experimental tests with crucibles (of between 1 to 20 recipes), between 1 and 10 recipes are currently being tested in small pots, and Saint-Louis has initiated real pot evaluation of between 1-5 recipes. It took about 5 years to arrive at the mapping of results for processes performance, shown in the presentation for the hot and cold areas. On this basis it is expected that at least 10 more years shall be needed to achieve the final focus on one recipe and its optimization, in order to cope with the different sub-processes relevant for producing the product portfolio of the luminaires and other pieces manufactured by Saint-Louis. Against this background, Saint-Louis however also notes that there is no guarantee of success at this stage.

31.5 Visit of LCG Manufacturing Facility

During the evaluation period EDG coordinated a visit of the consultants at the manufacturing facility Saint-Louis[1781], located in the Lorraine region of France. During the visit the various stages of the manufacturing process were observed, including:

- Manufacture of pots from special clay, used for the fusing of the lead crystal glass in the second stage in the “multi-pot” furnaces – the composition of the clay is specifically determined for the LCG composition and will need adaptions should the composition of the glass change;
- First fusion in furnace of the intermediate ingredients into clear lead crystal glass. Most facilities will have a unique glass composition making separation of manufacture to lead-free articles and lead-based articles impractical;
- Second fusion in multi-pot furnaces of the lead crystal glass as preparation for hot processing of articles. In this stage metal oxides can be added to the clear crystal glass to determine the colour of a specific batch of glass;
- Hot processing of lead crystal – glass blowing as well as glass pressing (manufacture of articles with moulds). In the process of forming, the articles are reheated as necessary to provide sufficient forming time – the working range of the glass determines how many times the article is to be reheated until the hot process forming is completed;

[1779] Op. cit. Saint-Louis (2015a)
[1780] Op. cit. Saint-Louis (2015a)
[1781] The visit at Saint-Loius (See http://www.saint-louis.com/en/ for details) took place on the 3.12.2015 and was also attended by representatives of EDG, the French Federation of crystal manufacturers and Baccarat (another French lead crystal manufacturer).

- Belt and static furnaces are used to anneal articles after they are blown/pressed to relieve inner tensions and “relax” the material;
- Cold processing of lead crystal articles - depending on the type of article being produced, this stage may include: cutting, engraving, polishing, etching and gold decoration. At this stage the hardness of the glass impacts the processing time, subsequently determining the wear of machinery.

It was explained that the refraction of lead glass plays an important role for lighting products and thus that engraving and cutting processes, which are easier when lead is present, are more common to create more intense refraction effects. From the current research it can already be seen that certain types of cutting processes are impossible to achieve with lead-free crystal, as lead-based crystal glass is softer.

Furthermore, Saint-Louis presented results of their on-going research efforts into alternatives. It is understood that the search for lead-free recipes was motivated years ago by the regulation of lead, e.g. under RoHS and by the ongoing discussions about food contact and REACH. According to Saint-Louis, the general goal is to find an alternative glass recipe which shall allow manufacturing products with the unique properties relevant both for manufacture and for the end product. A new composition needs to show similar properties throughout all stages of manufacture and processing while also resulting in articles with the same qualities as LCG (refraction of light, the clearness of the glass, etc.). To begin with, candidate substitutes need to have a similar density and to exhibit similar refraction properties. Furthermore, candidates will need to be tested to see their performance through the various production phases, to ensure that the same articles can be manufactured with comparable quality. Saint-Louis have identified over 20 sub-processes within the manufacture for which potential compositions need to be checked, as well as checking the internal relations between these processing stages. The need to use a single composition for manufacturing a relatively wide product portfolio further complicates the search for a suitable alternative, as a potential substitute composition shall need to enable manufacture of a wide variety of different products[1782]. Aside from ensuring the technical comparability of candidate substitutes, it is also necessary to ensure that negative health and environmental impacts shall not be a result of substitution. In this respect, if the weight or the hardness of the material

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[1782] In this respect, the consultants can follow that the use of both the first fusion furnace and of the multi-pot furnace in the manufacturing process may limit the practicability of manufacturing in separate batches. This is because for each batch, all furnaces would need to be cleaned from any residues, which may affect the recipe composition and thus the properties of the crystal in subsequent production stages and in the final products. Furthermore, Saint-Louis has also mentioned the need to optimise the composition of the clay used for the pots in the multi-pot furnace, should a new composition be found to be a practical substitute. It has also been communicated that possibly the machines used from cold processing would need to be adapted in light of differences in the hardness of the material. In this sense, it can be followed that batch production that may allow using a lead-free or lead-reduced formula for certain articles and lead based for others, would not be practical. Though theoretically it is possible that multiple production lines could be constructed, this would only be practical in facilities above a certain size of production.

change, this may influence the workability of articles for employees, as well as influencing the time needed for certain processes and thus the energy consumption or the wear of machinery. If the composition shall have a higher fusing temperature and/or a shorter work range, this would also increase the time needed for various process stages as well as the energy consumption. Furthermore, depending on the substances that shall compose the substitute, toxicity aspects may also need to be considered.

31.6 Stakeholder Contributions

The following stakeholders contributed to the stakeholder consultation regarding Ex. 29 and all support the renewal of the exemption:

- Academie de Clermont- Ferrand, Lycée Jean Monnett (Academie de C-F);[1783]
- Assemblée Nationale, Jacques Lamblin, Député de Meurthe et Moselle, Maire de Lunéville (Maire de Lunéville);[1784]
- Assemblée Nationale, Céleste Lett, Député de la Moselle, Maire de Sarreguemines (Maire de Sarreguemines);[1785]
- Assemblée Nationale, Gérard Cherpion, Member of the French Parliament, Member of the regional Council of the region Lorraine (Gérard Cherpion);[1786]
- Association of the Glass and Ceramic Industry of the Czech Republic (ASKPCR);[1787]
- Canning Design Ltd (Canning Design);[1788]
- Cerfav, CRT- Verre (Cerfav);[1789]

[1783] Academie de CF (2015), Academie de Clermont-Ferrand, Lycée Jean Monnett, submitted 19.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_lycee_Jean_Monnet_zusammengefuegt.pdf

[1784] Maire de Lunéville (2015), Assemblée Nationale, Jacques Lamblin, Député de Meurthe et Moselle, Maire de Lunéville, General comments related to RoHS exemption package 9, submitted 12.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Courrier_RoHS_anglais.pdf

[1785] Maire de Sarreguemines (2015), Assemblée Nationale, Céleste Lett, Député de la Moselle, General comments related to RoHS exemption package 9, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/contribution_by_celeste_LETT.pdf

[1786] Gérard Cherpion (2015), Assemblée Nationale, Gérard Cherpion, Member of the French Parliament, Member of the regional Council of the region Lorraine, General comments related to RoHS exemption package 9, submitted 15.10.2015, available under: • Assemblée Nationale, Gérard Cherpion, Member of the French Parliament, Member of the regional Council of the region Lorraine

[1787] ASKPCR (2015), Association of the Glass and Ceramic Industry of the Czech Republic, submitted 16.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_ASKPCR_16102015.pdf

[1788] Canning Design (2015), Canning Design Ltd., submitted 16.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_CanningDesign_Consultation_Document151015.pdf

[1789] Cerfav (2015), CRT- Verre, submitted 19.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_Cerfav_20151016.pdf

- CFE-CGC Chimie (CFE- CGC);[1790]
- Confédération française des métiers d'art de l'exellence et du luxe- French Confederation of Arts and Crafts (CFMA);[1791]
- Fédération CFTC Chimie Mies Textile Energie (CFTC- CMTE);[1792]
- Institut Universitaire de France, Ecole Nationale Supérieure de Chimie de Clermont- Ferrand (Institut Universitaire de France);[1793]
- John Rocha, CBE (John Rocha);[1794]
- José Lévy, Design expert (José Lévy);[1795]
- Parlament Européen, Députée Européene ADLE/ Grand Est- France (Députée au Parlament européen);[1796]
- Direction de l'Economie Solidaire et de l'Insertion, Conseil Départemental de Meurthe-et-Moselle (Meurthe et Mosselle)[1797];
- La Région Lorraine, Le Président du Conseil Régional de Lorraine, Sénateur de la Moselle (Région Lorraine);[1798]

[1790] CFE- CGC (2015), CFE- CGC Chimie, French trade union, submitted 19.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_CFE-CGC_Chimie_reponses_questions_20151016.pdf

[1791] CFMA(2015), Confédération française des métiers d'art de l'exellence et du luxe- French Confederation of Arts and Crafts, Application to exemption No 29 of crystal glass a part of the directive RoHS 69/493/EEC, submitted 13.10.2015, available under:http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Contribution_by_confederation_francaise.pdf

[1792] CFTC- CMTE (2015), Fédération CFTC Chimie Mies Textile Energie, submitted 19.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_FEDERATION_CFTC-CMTE_Position_20151016_ENG.pdf

[1793] Institut Universitaire de France (2015), Ecole Nationale Supérieure de Chimie de Clermont- Ferrand, submitted 15.10.2015, available under:http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Contribution_Exe_29.pdf

[1794] John Rocha (2015), Designer, CBE, 10 Ely Place, Dublin, Ireland, submitted 16.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_John_Rocha_Contribution__20151016.pdf

[1795] José Lévy (2015), Design expert, General comments to RoHS exemption package 9, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Lettre_Jos_Levy_V2__2_.pdf

[1796] Députée au Parlament européen (2015), Parlament Européen, Députée Européene ADLE/ Grand Est- France (Députée au Parlament européen, Renouvellement d'exemption- Référence Exemption No 29, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/20151012_-Consultation_publique_-_Exemption_Request_For_Exemption_no._29_ROHS.pdf

[1797] Meurthe et Mosselle (2015), Direction de l'Economie Solidaire et de l'Insertion, Conseil Départemental de Meurthe-et-Moselle, Application to exempt No 29 of Crystal Glass as a Part of the Directive RoHS 69/493/EEC, submitted 29.9.2015, available under http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Contribution_by_Direction_de_l_Economie_Solidaire_et_de_l_Insertion.pdf

[1798] Région Lorraine(2015), Le Président du Conseil Régional de Lorraine, Sénateur de la Moselle, General comments to RoHS exemption package 9, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/translation.pdf

- La Fédération Chemistry - Energy of the CFDT Group (Cfdt);[1799]
- Lyceé Dominique Labroise, The Headmaster, F. Vignola (Lyceé Dominique Labroise);[1800]
- Ministry of Industry and Trade of Czech Republic, Vice Minister, Ing. Eduard Muricky (Ministry of Industry/ Trade of Czech Republic);[1801]
- Moselle Department Council, Le president (Moselle Department);[1802]
- Noé Duchaufour Lawrance, pour Néonata S.A.R.L. (Noé Duchaufour Lawrance);[1803]
- Test and Measurement Coalition (TMC);[1804]
- Jackie Pierre, Senat (Le Senateur de Vosges);[1805]
- Philippe Leroy, Senat (Le Senateur de la Moselle);[1806]
- PRECIOSA- LUSTRY, a.s., President of Managing Board (PRECIOSA).[1807]

[1799] Cfdt (2015), La Fédération Chemistry - Energy of the CFDT Group, Consultation Questionnaire Exemption no. 29, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_CFDT_ROHS_20151015_.pdf

[1800] Lyceé Dominique Labroise (2015), The Headmaster, F. Vignola, General comments to RoHS exemption package 9, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/20151015094719390.pdf

[1801] Ministry of Industry / Trade of Czech Republic (2015), Vice Minister, Ing. Eduard Muricky, General Comments to RoHS exemption package 9, submitted 16.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_Ministry_of_Industry_and_Trade_of_the_Czech_Republic_contribution_20151016.pdf

[1802] Moselle Department (2015), Moselle Department Council, Le president, General comments to RoHS exemption package 9, submitted 14.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_Department_Moselle_Council_14102015_Oko-Institut.pdf

[1803] Noé Duchaufour Lawrance (2015) pour Néonata S.A.R.L., General comments to RoHS exemption package 9, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Ex_29_NOEDUCHAUFOURLAWRANCE_20151015.pdf

[1804] TMC (2015), Test and Measurement Coalition, General comments related to RoHS exemption package 9, submitted 16.10.2016, 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

[1805] Le Senateur des Vosges (2015), Jackie Pierre, Senat, Exemption Request for Exemption No 29 (renewal request), submitted 07.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/051015_Directive_ROHS_-_CONSULTATION_CE_cabinet_Oeko_exemption_29.pdf

[1806] Le Senateur de la Moselle(2015), Philippe Leroy, Senat, Application to exemption No 29 of crystal glass a part of the directive RoHS 69/493/EEC, submitted 13.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/contribution_by_philippe_leroy.pdf

[1807] PRECIOSA (2015), PRECIOSA- LUSTRY, a.s., Lucie Karlova, President of Managing Board, submitted 15.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_29/Contribution-Preciosa_EN-ws___2_.pdf

A short summary of the aspects raised by the various stakeholders is provided in Table 31-3.

Table 31-3: Summary of aspects related to Ex. 29 raised in stakeholder contributions

Aspect	Stakeholders
Lack of substitutes for lead oxides in the manufacture of LCG, despite research efforts of manufacturers.	Meurthe et Mosselle; Senateur des Vosges; Maire de Lunéville Senateur de la Moselle; CFMA; Moselle Department; Maire de Sarreguemines; Institut Universitaire de France; PRECIOSA, Cfdt; Ministry of Industry/ Trade of Czech Republic. ASKPCR; Cerfav; CFTC- CMTE
Unique properties obtained through the use of lead in LCG – optical properties, aesthetic properties, improved working properties (increase of the viscosity of the material), allows the production of specific articles.	Meurthe et Mosselle; Maire de Lunéville; CFMA; Région Lorraine; Maire de Sarreguemines; PRECIOSA; José Lévy; Lyceé Dominique Labroise; Noé Duchaufour Lawrance; Cfdt; Ministry of Industry/ Trade of Czech Republic; John Rocha; Canning Design; Cerfav; CFTC- CMTE; Academie de CF
Properties that enable energy savings in the manufacture of LCG related to the use of lead as an intermediate.	Meurthe et Mosselle; Maire de Lunéville; PRECIOSA; Lyceé Dominique Labroise; Cfdt; CFTC- CMTE
Low probability of articles to reach the waste stream (i.e. to reach end-of-life). Subsequently, no significant environmental impact expected related to collection, replacement, repairing.	Meurthe et Mosselle; Senateur des Vosges; Senateur de la Moselle; CFMA; Moselle Department; Députée au Parlament européen; Maire de Sarreguemines; PRECIOSA; José Lévy; Lyceé Dominique Labroise; Noé Duchaufour Lawrance; Cfdt; ASKPCR; Cerfav; CFE- CGC; CFTC- CMTE; Academie de CF
Lead crystal used in EEE is handcrafted (artisanal) and comprises a cultural heritage of importance in various EU countries; the exemption does not relate to articles in mass production.	Meurthe et Mosselle; Senateur des Vosges; Assemblée Nationale; Moselle Department; Région Lorraine; Députée au Parlament européen; PRECIOSA; Lyceé Dominique Labroise; Gérard Cherpion; Cfdt; Ministry of Industry/ Trade of Czech Republic; John Rocha; ASKPCR; CFE- CGC; CFTC- CMTE; Academie de CF
Many individuals depend on the further manufacture of EEE containing lead crystal items for their livelihood – should the exemption be revoked, this could have a high social impact on such individuals, of particular concern in certain peripheral areas where the local population depends on such manufacturing establishments for employment (e.g. Lorraine in France, North of Bohemia (Kamenicky Senov), etc.).	Meurthe et Mosselle; Senateur des Vosges; Maire de Lunéville; Senateur de la Moselle; Moselle Department; Région Lorraine; Députée au Parlament européen; Maire de Sarreguemines; PRECIOSA; Lyceé Dominique Labroise; Gérard Cherpion; Cfdt; Ministry of Industry/ Trade of Czech Republic; ASKPCR; CFTC- CMTE
The validity period of Ex. 29 in relation to articles in sub-category 9, industrial monitoring and control instruments.	TMC

31.7 Critical Review

31.7.1 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 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. Entry 63 restricts the presence of lead and its compounds in various articles. 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 lead compounds under Entry 30 of Annex XVII does not apply to the use of lead in this application. Pb used in lead crystal glass, in the consultants' point of view is not a supply of lead and its compounds as a substance, mixture or constituent of other mixtures to the general public. The lead oxides used to form the glass undergo a change of form when the ingredients are fused together. As the applicants explain, though its constituents are closely linked together, lead crystal is different from the initial state of its raw materials. In this sense lead is encapsulated in the vitreous material and thus not accessible to the public as such. Pb is part of an article and as such, Entry 30 of Annex XVII of the REACH Regulation would not apply.

Entry 63 of Annex XVII restricts the use of lead and its compounds in various articles. Paragraph 1 specifies jewellery in this respect, however paragraph 4(a) specifically excludes "crystal glass as defined in Annex I (categories 1, 2, 3 and 4) to Council Directive 69/493/EEC (*)" in relation to paragraph 1. Paragraph 6 does not allow placing articles on the market which, contain Pb concentrations above 0.05% by weight, where during normal use these could be placed in the mouth by children. Nonetheless, paragraph 7(b) specifically excludes "crystal glass as defined in Annex I (categories 1, 2, 3 and 4) to Directive 69/493/ EEC"; It is thus concluded that this entry would not apply to Pb in lead crystal glass used in EEE. Paragraph 8(k) also further excludes equipment in the scope of RoHS from the paragraph 7 restriction.

No other entries, relevant for the use of lead in the requested exemption could be identified in Annex XIV and Annex XVII (status December 2015).

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.

31.7.2 Scientific and Technical Practicability of Substitution

EDG and LEU have requested the renewal of exemption 29 to allow the use of Pb in lead crystal glass when used in EEE. The applicants argue that lead provides unique properties to the crystal glass, which are of importance both in the manufacture of articles as well as in the performance of the product through its use.

The properties of the lead crystal glass are explained to be of importance for the end product, as the addition of lead affects optical properties and thus the aesthetic properties of the glass, such as the refractive index and the dispersion of light. This is explained to be important, as it allows designers of articles to create unique products, and is also of importance to consumers judging by the demand for such products on the market.

EDG and LEU argue that there are no comparable substitutes for lead crystal glass that would provide the same properties and performance both in the manufacture and in the products themselves. The production of lead crystal glass used in EEE includes a large degree of hand crafting, both in the manufacturing stages, such as blowing and pressing and in the later stages of cold processing such as cutting and polishing. Even when automation is involved in the manufacture, EDG & LEU claim that up to ~80% of the production costs are related to further handcrafting of the articles. The properties of the material are understood to have a large effect on the ability to perform the various stages of the production, particularly in the manual processing stages, and it can be understood that substitutes that have been tested up until now would not allow creating articles of the same complexity. This would also affect the time needed for production and thus respectively the energy consumption (estimated by Saint-Louis to be at least 20-30% lower than were lead-free glass to be applied).

It can be understood that the various lead crystal manufacturers have been researching substitutes for many years, and results of this research also show certain progress in this respect. However, it is also understood that an alternative to lead in the glass which is applicable to all stages of the production, is not yet available and that lead crystal glass is at present still the only material that would allow retaining the diverse product range. Where first attempts (production of articles in small scale and testing of their suitability in various processing stages) have been performed with lead-free glasses, it can be followed that results are not yet sufficiently comparable to allow the substitution of lead, and that such results also suggest that substitution at this stage would result in a significant increase of energy costs and use of resources.

Though one could argue that for the various EEE articles, in which lead crystal is used, that various alternatives exist – e.g. alternative luminaires – the consultants can follow that such articles would not provide a one-to-one replacement in terms of the appearance of the products. Though this aspect is understood to be of aesthetic nature, being difficult to assess in technical terms, some data has been provided to show that should other types of glass be used to create articles of similar appearance, that the optical properties of importance for the aesthetic properties of the products would not be comparable on the crystal level. Alternative types of glass, regardless of their ability to be used for creating products of the same complexity, show inferior levels in terms of e.g. refractive index, abbe number, dispersion, etc.

It is understood that in manufacture, the addition of lead increases the working time of the glass through its impact on the viscosity of the glass and its thermal properties. This facilitates the melting and forming of crystal articles in hot-processing, and more importantly has an impact on the energy consumption related to these production stages as the glass does not need to be reheated (re-melted) as often, and as the temperature for reheating is significantly lower than for lead-free glass types.

It is also understood that the addition of lead results in a glass that is not as hard, and in this respect the glass crystal also facilitates cold processing of the articles such as cutting, engraving, polishing, etc. Since the glass is softer, it can be processed more easily and in less time for the same amount of units, therefore also reducing the energy consumption related to these stages. Another important aspect in this respect is understood to relate to the softer lead-based glass also resulting in less frequent maintenance and replacement of equipment, which would translate to a lower use of resources where equipment or equipment components need to be replaced.

31.7.3 Environmental Arguments

The applicants, as well as some of the stakeholders, who participated in the consultation, explain that in LCG articles, lead is encapsulated within the material and a risk of emissions to the environment during the use and the end-of-life phases is not expected. The risk related to the end-of-life stage is further assessed to be irrelevant, claiming that practices of repair or replacement of the broken parts, of these prestigious and expensive items (e.g. one branch or prism of a luminaire), prevents the discarding of the full EEE application at end-of-life. EDF & LEU thus argue that the probability of LCG EEE articles to reach the waste stream is very small. EDF & LEU have furthermore submitted lead crystal leaching testing results (one report can be viewed in Appendix A.5.0) showing that the risk of lead emissions from such articles is negligible. In the consultants' view, submitted test results sufficiently show that (under normal use/ environmental conditions) emissions from lead crystal during use and during end-of-life are not expected. As long as not treated with strong acids, release of lead from the vitreous matrix would not be expected. The consultants can also follow that lead crystal articles would typically not reach the waste stream in light of their value. Small parts may become waste when broken and repaired; however it can be followed that typically articles will not be disposed of, but rather sold to antique shops and the likes. This is particularly understood to be the case for EEE articles, which as opposed to tableware are less at risk to break during use (chandeliers and luminaires shall usually be fixed to walls and ceilings, etc.). This means that possible emissions at this stage would be less significant in light of the amount of lead crystal potentially disposed of. Possible emissions of lead at these life cycle stages are thus understood to be sufficiently controlled.

A further important aspect raised in relation to environmental impacts is related to the consumption of energy and resources during the manufacture of articles. It is further expected that lower energy consumption would subsequently mean lower emissions related to energy such as greenhouse gases. These aspects have been summarised in Section 31.7.2 and are not discussed here again.

31.7.4 Socio-Economic Impacts

The applicants and the various stakeholders who participated in the consultation also argue that to revoke the exemption could result in significant social costs, as the production of hand-crafted lead crystal is considered a cultural heritage in many areas of the EU (e.g. Alsace Lorraine in France, Bohemia in the Czech Republic, etc.). Furthermore, it is explained that in areas where this traditional form of hand crafting of LCG is performed, that facilities employ a large number of individuals, whose livelihood would be at risk should the use of LCG in EEE be prohibited. Manufacturers claim that respective market shares of LCG articles used for tableware and for EEE are changing, with a growing importance of EEE in the product portfolio. This would further support that a change to the current exemption could have a significant impact on the LCG sector. The consultants can follow that the artisan manufacture of lead crystal articles has importance both as a cultural heritage and as a source of employment for many individuals. However, it is also possible that a reduced manufacture of lead crystal (i.e., LCG applied in EEE) would in parallel lead to increased manufacture of alternative equipment (alternative luminaires, etc.) and thus to an increase of employment in other sub-sectors. Nonetheless it is difficult to estimate the total possible impacts of a revocation of the exemption, and thus the consultants cannot conclude as to the range of such impacts and their severity in terms of costs for society.

31.7.5 Stakeholder Contributions

The stakeholder contributions generally support the request, raising various aspects related to the properties of lead crystal and the unavailability of comparable substitutes. As these aspects are addressed in the summary of information provided by the applicants and by Saint-Louis, further detail is not provided here.

The contribution submitted by TMC raises a legal question as to the availability of the current exemption to category 9 equipment. Regardless of TMCs claims as to the availability of Annex III exemptions to sub-category 9 industrial for 7 years starting in 22.7.2017, in the case of Ex. 29 the wording formulation limits its applicability to crystal glass. Though in theory, such glass could be used in Cat. 9 products, this aspect has not been raised by the applicant or other stakeholders to be an area of application. Furthermore, should such glass be used as a component in such EEE, it would still benefit from the exemption as long as it is valid. Should substitutes become available however, it would be of importance to evaluate their applicability in all possible applications at the same time. In this sense, in the consultants opinion, though some Cat. 9 products could enjoy a validity period of the current exemption up till 2024 (Cat. 9 industrial), it would still be considered beneficial to align the exemption validity of all categories. Further supporting this view is the fact that the applicants who represent manufacturers of the relevant articles have not specified Cat. 9 as a category into which their articles fall.

31.7.6 The Scope of the Exemption

The consultants can follow that the search for lead-free crystal glass alternatives is still on-going. Furthermore, despite the fact that alternatives are not yet sufficiently developed, it can be understood that where tested in small scale, such alternatives would also increase energy and resource consumption related to various production stages. The information made available to support these understandings is, however, based on practices of the artisanal manufacture of lead crystal glass, which involves a large degree of hand-crafting, as practiced for example by Saint-Louis. It is not clear if lead crystal glass articles for which the exemption is needed would also be produced through automated manufacture, nor whether the same argumentation would apply. Furthermore it is currently unclear whether in such articles the same concentration or lower concentrations of lead are present. In this sense, the question arises, whether the exemption should be limited to articles produced through artisanal manufacturing or if different concentrations of lead could be specified.

From the information provided, it can be followed that the various benefits related to the addition of lead would be equally relevant as long as similar glass formulas are used. Though the ease of processing related to glasses with a longer working range and glasses that are softer can be understood to be more relevant to hand-crafting, in light of such processes not being "controlled through automation", the reduced energy and resource consumption are understood to be relevant for both types of manufacture as the production stages would be similar in this respect (fusing temperatures of glass, cold processing with equipment). In this sense if automated production uses similar glass formulas, it can be assumed that the argumentation would apply similarly to such articles. However, if similar formulas are not used and the exemption is not needed for such production, the consultants do not think that it would be practical to exclude such articles from the exemption. The consultants are not aware of a mechanism for differentiating between articles that are hand crafted and articles that are made with automation that could be used by market surveillance to ensure enforcement.

In this sense, though it is difficult to determine to what degree the justification is relevant to articles produced with automation, limiting the exemption to hand-crafted articles would not be considered to be practical in terms of its enforcement. It could also limit the ability of manufacturers to combine automated components in some cases in order to increase competitiveness through the reduction of production costs related to hand crafting where this is possible. The consultants thus do not recommend a change of the current exemption wording formulation.

31.7.7 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.

In the consultants' opinion, it can be followed that substance substitutes for lead in glass are currently not available. Though changes in the ingredients of the glass have been the subject of research for many years, it can be followed that at present such a substitute would not allow sufficient replication of the product portfolio in terms of production of articles with comparable properties. Such a substitute is currently not considered available, early phase-in of a substitution candidate still under investigation would limit both the complexity of articles that could be produced as well as resulting in a significant rise in energy consumption and use of resources related to manufacture. Such a substitution is also not understood to provide comparable products in terms of their optical properties, of importance for the consumer.

In parallel, one could argue that the need for lead could be eliminated through the shift to other articles, i.e. other luminaires (possibly not from glass and of different shape and form). If for example the function of a luminaire is only to provide light or also to provide a certain appearance. In the case of crystal luminaires, the applicants have communicated that certain optical properties of the glass are established in the luminaire through the use of lead: a high refractive index, a high dispersion and transmission of light and sharp colour transition. In this sense, for an alternative luminaire to be considered as a one-to-one replacement, it would need to have similar properties and to perform on a comparable level. Where alternative glass types are used to produce crystals for use in the assembly of similar luminaires, it can be understood from the applicant that such products do not provide similar performance. It has also been communicated that the processing of lead crystal glass further allows creating items of higher complexity in this respect.

31.8 Recommendation

The justification for the renewal of Ex. 29 is based on the observation that alternatives for EEE articles with lead crystal glass do not meet the technical criteria representing the specific optical properties. If these properties can be judged as indispensable, then an exemption would be considered to be justified, as possible (substance) substitutes for lead in glass currently do not allow manufacturing comparable articles and would also result in a higher consumption of energy and other resources. Such alternatives would not compare in terms of optical properties and complexity of design should they be manufactured with lead-free glass. Using lead-free alternatives in the actual hand-crafted manufacture stages of LCG would not allow completing all manufacture stages at sufficient quality, while also resulting in an additional impact in terms of energy consumption and resource use. In this case, other EEE articles fulfilling similar functions (e.g., a luminaire which functions in providing light) would not be considered as one-to-one replacements and thus also not as alternatives. On this basis, it is recommended to grant the exemption renewal for the maximum duration according to Article 5(2), as information suggests that a period of at least 10 years could be needed before substitutes may become available. In this case, the following formulation and duration would be recommended for the exemption.

Exemption n. 29	Duration*
Lead bound in crystal glass as defined in Directive 69/493/EEC	For Cat. 1-10: 21 July 2021
	For Sub-Cat. 8 in-vitro: 21 July 2023**
	For Sub-Cat. 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.*

*** In contrast, the applicants have not specified the exemption to be relevant for EEE of categories 8 and 9, and in the consultants view it would be recommended to align the exemption duration for all EEE, including Sub. Cat. in-vitro and Sub-Cat. 9 industrial, should EEE in these categories make use of the exemption despite lacking evidence thereof.*

31.9 References Exemption 29

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A.8.0 Appendix 8: Leaching Test Results Related to Ex. 29

Test results sent on 26.6.2015 to by EDG to the European Commission, related to the possible leaching of lead from lead crystal.

Stazione Sperimentale del Vetro S.c.p.A.
Venezia - Murano, Via Briati 10
Venezia - Marghera, Via delle Industrie 13 - c/o VEGA Edificio Pegaso

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RAPPORTO DI PROVA / TEST REPORT N. 126760 pag. 1 di 1

Murano	23/04/2015 *rif.* Yr/mail of confirmation dated 11.03.2015
richiedente proposer	FEDERATION DES CRISTALLERIES - VERRERIES A LA MAIN ET MIXTE 112-114 RUE LA BOETIE - 75008 PARIS
campione sample	GLASS
prova eseguita dal / from — test date *al* / to	30/03/2015 — 2/04/2015
contrassegnato reference	CRYSTAL GLASS CHANDELIER Sampling performed by the client
ricevuto il received	18/03/2015 by carrier

UNI EN 12457-2: 2004 (Charaterization of waste : Leaching- Compliance test for leaching of granular waste materials and sludges Part2: One stage batch test at liquid to solid ratio of 10 L/kg for materials with particle size below 4 mm without or with size reduction)

Principle

A sample of glass cullet was crushed and sieved to a grain size between 0.5 and 4 mm and then immersed in water with a liquid to solid ratio of 10 L/kg for 24 h at room temperature (20°C ± 5° C) under agitation. After this treatment the eluate was filtered and analysed using the ENV 12506:2004 and ENV 13370:2004 methods and others.

Results:

Parameters:		
pH	Start	8.8
	End	9.8
Temperature (°C)		22.0
Conductivity (µS/cm)	Start	34
	End	180

Moisture content	(% w/w)	< 0.10
Volume of leachant	(l)	0.900
Mass of test portion	(kg)	0.090
Method of liquid solid separation:		filtering over 0.45 µm membrane

Costituents		Limit of determination (mg/l)	Blank (mg/l)	Eluate concentration (mg/l)	Amount leached (mg/kg)
Arsenic,	As	0.002	< 0.002	0.003	0.03
Cadmium,	Cd	0.0002	< 0.0002	< 0.0002	< 0.002
Chromium,	Cr	0.002	< 0.002	< 0.002	< 0.02
Lead,	Pb	0.002	< 0.002	0.249	2.49
Selenium,	Se	0.002	< 0.002	0.0043	0.043
Antimony,	Sb	0.002	< 0.002	0.060	0.600

Test carried out at Murano Laboratories

THE ANALYST
Dr.ssa Martina Scarpa

THE LABORATORIES DIRECTOR
Dr. Nicola Favaro

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Mod.: PG3-06 REV. 7 02.5.2013

EVALUATION OF THE GLASS SAMPLE

Sample

Crystal Glass obtained from two different pieces of a Chandelier: arm and candle cap

General Classification

Crystal glass: "Glass, oxide, chemicals" (CAS 65997-17-3)

Release of Pb on landfill due to leaching of metal from glass after the disposal in landfill

Leaching test carried out according to EN 12457-2 and TC13 protocol; comparison with limit values set out in Chapter 2.2 "Criteria for landfills for non-hazardous waste" in Council Decision 2003/33/EC

Constituent	Concentration mg/kg	limit value for non-hazardous waste mg/kg
Pb	2,49	10

Evaluation

Pb concentration is below the limit values set out in Chapter 2.2 "Criteria for landfills for non-hazardous waste" in Council Decision 2003/33/EC".

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