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 four renewal requests for RoHS 2 Annex III exemptions no. 7(b), no. 9(b), no. 13(a) and no. 13(b). (RoHS Directive)

Report for the European Commission DG Environment under Framework Contract Nº ENV.C.2/FRA/2011/0020

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Contents

List of Figures

List of Tables

1.0 Background and Objectives

The RoHS Directive 2011/65/EU entered into force on 21 July 2011 and led to the repeal of Directive 2002/95/EC on 3 January 2013. The Directive can be considered to have provided for two regimes under which exemptions could be considered, RoHS 1 (the former Directive 2002/95/EC) and RoHS 2 (the current Directive 2011/65/EU).

Under Framework Contract no. ENV.C.2/FRA/2011/0020, a consortium led by Eunomia Research & Consulting was requested by DG Environment of the European Commission to provide technical and scientific support for the evaluation of exemption requests under the new RoHS 2 regime. The work has been undertaken by Oeko-Institut and Fraunhofer Institute IZM, and has been peer reviewed by Eunomia Research & Consulting.

The approach to adjudicating on the case for exemptions has to take into account some new aspects under the RoHS 2 regime as compared to that of RoHS 1:

- The scope covered by the Directive is now broader as it covers all EEE (as referred to in Articles 2(1) and 3(1));
- The former list of exemptions has been transformed into Annex III and may be valid for all product categories according to the limitations listed in Article 5(2) of the Directive. Annex IV has been added and lists exemptions specific to categories 8 and 9;
- The RoHS 2 Directive includes the provision that applications for exemptions have to be made in accordance with Annex V. However, even if a number of points are already listed therein, Article 5(8) provides that a harmonised format, as well as comprehensive guidance – taking the situation of SMEs into account – shall be adopted by the Commission; and
- The procedure and criteria for the adaptation to scientific and technical progress have changed and now include some additional conditions and points to be considered. These are detailed below.

The new Directive details the various criteria for the adaptation of its Annexes to scientific and technical progress. Article 5(1)(a) details the various criteria and issues that must be considered for justifying the addition of an exemption to Annexes III and IV:

- The first criterion may be seen as a threshold criterion and cross-refers to the REACH Regulation (1907/2006/EC). An exemption may only be granted if it does not weaken the environmental and health protection afforded by REACH;
- Furthermore, a request for exemption must be found justifiable according to one of the following three conditions:
  - Substitution is scientifically or technically impracticable, meaning that a substitute material, or a substitute for the application in which the restricted substance is used, is yet to be discovered, developed and, in some cases, approved for use in the specific application;

- The reliability of a substitute is not ensured, meaning that the probability that EEE using the substitute will perform the required function without failure for a period of time comparable to that of the application in which the original substance is included, is lower than for the application itself;
- The negative environmental, health and consumer safety impacts of substitution outweigh the benefits thereof.

➢ Once one of these conditions is fulfilled, the evaluation of exemptions, including an assessment of the duration needed, shall consider the availability of substitutes and the socio-economic impact of substitution, as well as adverse impacts on innovation, and life cycle analysis concerning the overall impacts of the exemption; and

➢ A new aspect is that all exemptions now need to have an expiry date and that they can only be renewed upon submission of a new application.

Against this background, and taking into account that exemptions falling under the enlarged scope of RoHS 2 can be applied for since the entry into force of the Directive (21.7.2011), the consultants have undertaken evaluation of a range of exemptions in this work (new exemption requests, renewing existing exemptions, amending exemptions or revoking exemptions).

The Report includes the following Sections:

Section 2.0 Project Set-up

Section 3.0 Scope

Section 4.0 Overview of the Evaluation Results

Section 5.0 Links from the Directive to the REACH Regulation

Sections 6.0 to 8.0 – Evaluation of the requested exemptions handled in the course of this project.

2.0 Project Set-up

Assignment of project tasks to Oeko-Institut started 29 December 2014. The overall project has been led by Carl-Otto Gensch. At Fraunhofer IZM, the contact person is Otmar Deubzer. The project team at Oeko-Institut consists of the technical experts Yifaat Baron and Katja Moch. Eunomia, represented by Adrian Gibbs, have the role of ensuring quality management.

3.0 Scope

Though originally the scope of the project covered requests for the renewal of four exemptions, one of the applications was withdrawn. Thus, three requests for the renewal of exemptions currently listed in Annex III of the RoHS Directive have been evaluated. An overview of the exemption requests is given in Figure 4-1 below.

In the course of the project, a stakeholder consultation was conducted. In agreement with the European Commission, the consultation was performed along with that of three additional requests for new exemptions (known as Pack 8). The stakeholder consultation was launched on 24 April 2015 and held for a duration of 8 weeks, thus concluding on 19 June 2015.

The specific project website was used in order to keep stakeholders informed on the progress of work: http://rohs.exemptions.oeko.info. The consultation held during the project was carried out according to the principles and requirements of the European Commission. Stakeholders who had registered at the website were informed through email notifications about new steps within the project.

Information concerning the consultation was provided on the project website, including a general guidance document, the applicants' documents for each of the exemption requests, results of earlier evaluations where relevant, a specific questionnaire and a link to the EU CIRCA website. All non-confidential stakeholder comments submitted during the consultation were made available on the RoHS Evaluation website and on the EU CIRCABC website (Communication and Information Resource Centre for Administrations, Businesses and Citizens)[1].

The evaluation of the stakeholder contributions led to further consultation including, *inter alia*, engaging with stakeholders in further discussion, further exchanges in order to clarify remaining questions, cross-checking with regard to the accuracy of technical arguments, and checks in respect of confidentiality issues. This included among others a meeting with Spectaris, the applicant of two requested exemptions (13a and 13b), held on the 28 August 2015, with the purpose of clarifying open issues regarding the evaluation of both requests.

1 EU CIRCABC website: https://circabc.europa.eu (Browse categories > European Commission > Environment > RoHS 2014 Evaluations Review, at top left, click on "Library")

The requests were evaluated according to the various criteria (Cf. Section 1.0 for details). The evaluations of each exemption request appear in the following chapters. The information provided by the applicants and by stakeholders is summarised in the first sections. This includes a general description of the application and requested exemption, a summary of the arguments made for justifying the exemption, information provided concerning possible alternatives and additional aspects raised by the applicants and other stakeholders. In some cases, reference is also made to information submitted by applicants and stakeholders in previous evaluations, in cases where a similar request has been reviewed or where a renewal has been requested of a request reviewed in the past. The Critical Review follows these sections in which the submitted information is discussed, to clarify how the consultants evaluate the various information and what conclusions and recommendations have been made. Further details, i.e. the general requirements for the evaluation of exemption requests, can be found in the technical specifications of the project.[2]

4.0 Overview of the Evaluation Results

The exemption requests covered in this project and the applicants concerned, as well as the final recommendations and proposed expiry dates are summarised in Figure 4-1. The reader is referred to the corresponding section of this report for more details on the evaluation results.

The – not legally binding – recommendations for the requests for renewal of exemption 9b, exemption 13a and exemption 13b were submitted to the EU Commission by Oeko-Institut and have already been published at the EU CIRCA website on 2 February 2016. So far, the Commission has not adopted any revision of the Annex to Directive 2011/65/EU based on these recommendations.

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2 Cf. under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/RoHS_Pack7_Technical_specifications_f.pdf

Figure 4-1: Overview of the Exemption Requests, Associated Recommendations and Expiry Dates

Ex. No.	Requested Exemption Wording	Applicant	Recommendation	Expiry date
7b	Lead in solders for RF switching matrices and associated RF signal distribution equipment for telecommunications	Request withdrawn	Request withdrawn	
9b	Lead in bearing shells and bushes for refrigerant-containing compressors, with a stated electrical power input of only 9 kW or lower for the HVACR industry, with expiry date three years after the publication of the amended RoHS Annex	Emerson Climate Technologies	Lead in bearing shells and bushes for refrigerant-containing hermetic scroll compressors with a stated electrical power input equal or below 9kW for heating, ventilation, air conditioning and refrigeration (HVACR) applications	For Cat. 1 to expire 21 July 2019
13a	Lead in white glasses used for optical applications	Spectaris - Deutscher Industrieverband für optische, medizinische und mechatronische Technologien e.V.	Lead in White Glasses Used for Optical Applications	For Cat. 1-7 & 10: to expire 21 July 2021
				For Cat. 8 and Cat. 9: 21 to expire July 2021
				For Sub-Cat. 8 in-vitro: to expire 21 July 2023
				For Sub-Cat. industrial: to expire 21 July 2024
13b	Cadmium and Lead in filter glasses and glasses used for reflectance standards	Spectaris - Deutscher Industrieverband für optische, medizinische und mechatronische Technologien e.V.	Lead in ion coloured optical filter glass types, or cadmium in striking optical filter glass types or lead and cadmium in glazes used for reflectance standards - excluding applications falling under Ex. point 39 of Annex III	For Cat. 1-7 & 10: to expire 21 July 2021
			Cadmium and lead in filter glasses and glasses used for reflectance standards	For Cat. 8 and Cat. 9: 21 July 2021
				For Sub-Cat. 8 in-vitro: 21 July 2023
				For Sub-Cat. 9 industrial: 21 July 2024

5.0 Links from the Directive to the REACH Regulation

Article 5 of the RoHS 2 Directive 2011/65/EU on “Adaptation of the Annexes to scientific and technical progress” provides for the:

> “*inclusion of materials and components of EEE for specific applications in the lists in Annexes III and IV, provided that such inclusion does not weaken the environmental and health protection afforded by Regulation (EC) No 1907/2006*”.

RoHS 2 does not further elaborate the meaning of this clause.

Regulation (EC) No 1907/2006 regulates the safe use of chemical substances, and is commonly referred to as the REACH Regulation since it deals with **R**egistration, **E**valuation, **A**uthorisation and Restriction of **Ch**emical substances. REACH, for its part, addresses substances of concern through processes of authorisation and restriction:

- Substances that may have serious and often irreversible effects on human health and the environment can be added to the candidate list to be identified as Substances of Very High Concern (SVHCs). Following the identification as SVHC, a substance may be included in the Authorisation list, available under Annex XIV of the REACH Regulation: “List of Substances Subject to Authorisation”. If a SVHC is placed on the Authorisation list, companies (manufacturers and importers) that wish to continue using it, or continue placing it on the market, must apply for an authorisation for a specified use. Article 22 of the REACH Regulation states that: *“Authorisations for the placing on the market and use should be granted by the Commission only if the risks arising from their use are adequately controlled, where this is possible, or the use can be justified for socio-economic reasons and no suitable alternatives are available, which are economically and technically viable.”*
- If the use of a substance (or compound) in specific articles, or its placement on the market in a certain form, poses an unacceptable risk to human health and/or to the environment that is not adequately controlled, the European Chemical Agency (ECHA) may restrict its use, or placement on the market. These restrictions are laid down in Annex XVII of the REACH Regulation: “Restrictions on the Manufacture, Placing on the Market and Use of Certain Dangerous Substances, Mixtures and Articles”. The provisions of the restriction may be made subject to total or partial bans, or other restrictions, based on an assessment of those risks.

The approach adopted in this report is that once a substance has been included into the regulation related to authorization or restriction of substances and articles under REACH, the environmental and health protection afforded by REACH may be weakened in cases where an exemption would be granted for these uses under the provisions of RoHS. This is essentially the same approach as has already been adopted for the re-evaluation of some existing RoHS exemptions 7(c)-IV, 30, 31 and

40,[3] as well as for the evaluation of a range of requests assessed through previous projects in respect of RoHS 2.[4] Furthermore, substances for which an authorisation or restriction process is already underway are also reviewed so that future developments may be considered where relevant.

When evaluating the exemption requests, with regard to REACH compliance, we have checked whether the substance / or its substitutes are:

- on the list of substances proposed for the adoption to the Candidate List (the Registry of Intentions);
- on the list of substances of very high concern (SVHCs- the Candidate List);
- in the recommendations of substances for Annex XIV (recommended to be added to the Authorisation List);
- listed in REACH Annex XIV itself (The Authorization List); or
- listed in REACH Annex XVII (the List of Restrictions).

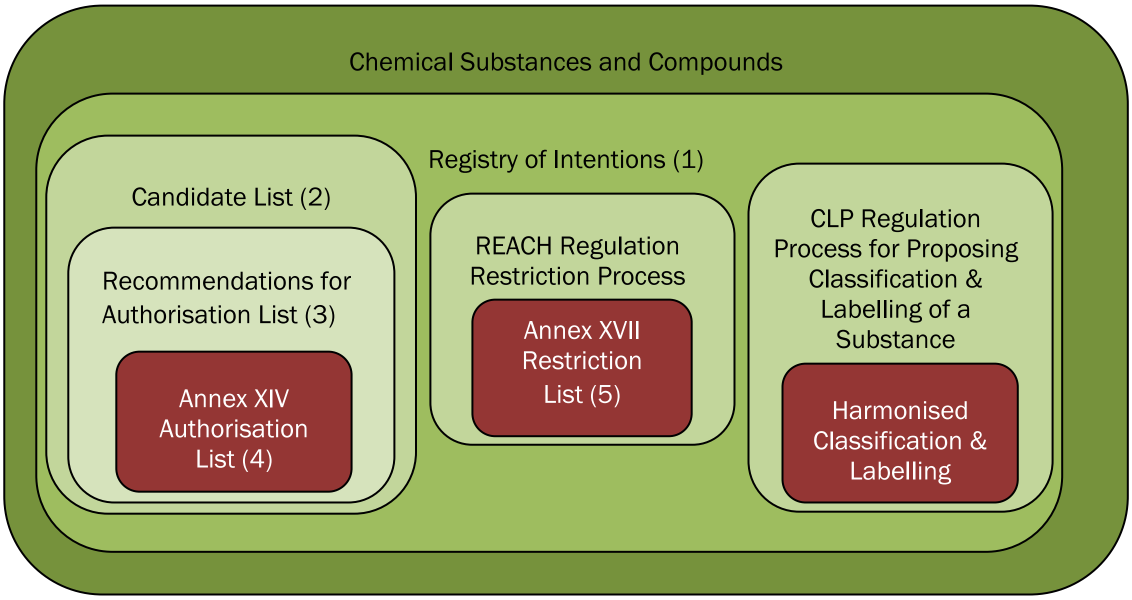
As the European Chemicals Agency (ECHA) is the driving force among regulatory authorities in implementing the EU's chemicals legislation, the ECHA website has been used as the reference point for the aforementioned lists, as well as for the exhaustive register of the Amendments to the REACH Legal Text.

Figure 5-1 shows the relationship between the two processes and categories. Substances included in the red areas may only be used when certain specifications and or conditions are fulfilled.

3 See Zangl, S.; Blepp, M.; Deubzer, O. (2012) Adaptation to Scientific and Technical Progress under Directive 2011/65/EU - Transferability of previously reviewed exemptions to Annex III of Directive 2011/65/EU, Final Report, Öko-Institut e. V. and Fraunhofer IZM, February 17, 2012, http://rohs.exemptions.oeko.info/fileadmin/user_upload/Rohs_V/Re-evaluations_transfer_RoHS_I_RoHS_II_final.pdf

4 Gensch, C., Baron, Y., Blepp, M., Deubzer, O., Manhart, A. & Moch, K. (2012) Assistance to the Commission on technological, socio-economic and cost-benefit assessment related to exemptions from the substance restrictions in electrical and electronic equipment (RoHS Directive), Final Report, Öko-Institut e. V. and Fraunhofer IZM, 21.12.2012 http://rohs.exemptions.oeko.info/fileadmin/user_upload/Rohs_V/RoHS_V_Final_report_12_Dec_2012_final.pdf

Figure 5-1: Relation of REACH Categories and Lists to Other Chemical Substances



The following bullet points explain in detail the above-mentioned lists and where they can be accessed:

- Member States Competent Authorities (MSCAs) / the European Chemicals Agency (ECHA), on request by the Commission, may prepare Annex XV dossiers for identification of Substances of Very High Concern (SVHC), Annex XV dossiers for proposing a harmonised Classification and Labelling, or Annex XV dossiers proposing restrictions. The aim of the public Registry of Intentions is to allow interested parties to be aware of the substances for which the authorities intend to submit Annex XV dossiers and, therefore, facilitates timely preparation of the interested parties for commenting later in the process. It is also important to avoid duplication of work and encourage co-operation between Member States when preparing dossiers. Note that the Registry of Intentions is divided into three separate sections: listing new intentions; intentions still subject to the decision making process; and withdrawn intentions. The registry of intentions is available at the ECHA website at: http://echa.europa.eu/web/guest/addressing-chemicals-of-concern/registry-of-intentions;
- The identification of a substance as a Substance of Very High Concern and its inclusion in the Candidate List is the first step in the authorisation procedure. The Candidate List is available at the ECHA website at http://echa.europa.eu/web/guest/candidate-list-table;
- The last step of the procedure, prior to inclusion of a substance into Annex XIV (the Authorisation list), involves ECHA issuing a Recommendation of substances for Annex XIV. The ECHA recommendations for inclusion in the Authorisation List are available at the ECHA website at http://echa.europa.eu/web/guest/addressing-chemicals-of-

concern/authorisation/recommendation-for-inclusion-in-the-authorisation-list/authorisation-list;

- Once a decision has been taken, substances may be added to the Authorisation List available under Annex XIV of the REACH Regulation. The use of substances appearing on this list is prohibited unless an Authorisation for use in a specific application has been approved. The Annex can be found in the consolidated version of the REACH Legal Text (see below);
- In parallel, if a decision is made concerning the Restriction on the use of a substance in a specific article, or concerning the restriction of its provision on the European market, then a restriction is formulated to address the specific terms, and this shall be added to Annex XVII of the REACH Regulation. The Annex can be found in the consolidated version of the REACH Legal Text (see below); and
- As of 28 September 2015, the last amendment of the REACH Legal Text was dated from 28 May 2015 (Commission Regulation (EU) No 2015/830), and so the updated consolidated version of the REACH Legal Text, dated 1 June 2015, was used to check Annex XIV and XVII: The consolidated version is presented at the ECHA website: http://echa.europa.eu/web/guest/regulations/reach/legislation.

Relevant annexes and processes related to the REACH Regulation have been cross-checked to clarify:

- In what cases granting an exemption could "*weaken the environmental and health protection afforded by Regulation (EC) No 1907/2006*" (Article 5(1)(a), pg.1)
- Where processes related to the REACH regulation should be followed to understand where such cases may become relevant in the future;

In this respect, restrictions and authorisations as well as processes that may lead to their initiation have been reviewed in respect of where RoHS Annex II substances are mentioned (i.e. lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE).[5]

Compiled information in this respect has been included, with short clarifications where relevant, in Tables A.1.0-1-5, which appear in Appendix A.1.0

The information has further been cross-checked in relation to the various exemptions evaluated in the course of this project. This has been done to clarify that the Article 5(1)(a) pg.1 threshold-criteria quoted above is complied with in cases where an exemption is to be granted / its duration renewed/ its formulation amended/ or where it is to be revoked and subsequently to expire as an exemption.

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[5] This review currently does not address the four phthalates, DEHP, BBP, DBP and DIBP which, according to Commission Delegated Directive (EU) 2015/863 of 31 March 2015, have been added to the Annex. Information regarding these substances shall be included in future reviews.

The considerations in this regard are addressed in each of the separate chapters in which the exemption evaluations are documented (Chapters 6.0 through 8.0) under the relevant section titled "*REACH Compliance - Relation to the REACH Regulation*" (Sections 6.5.1, 7.5.1 and 8.5.1 respectively).

6.0 Exemption 9b "Lead in Bearing Shells and Bushes for Refrigerant- Containing Compressors for Heating, Ventilation, Air Conditioning and Refrigeration (HVACR) Applications"

Abbreviations

AC	Air Conditioning
EEE	Electrical and Electronic Equipment
Emerson	Emerson Climate Technologies (also abbreviated as ECT)
HVACR	Heating, Ventilation, Air Conditioning, and Refrigeration
OEM	Original Equipment Manufacturer
Pb	Lead
PTFE	Polytetrafluorethylene

6.1 Background

Bearing shells and bushes are used in numerous applications in engines, in transmissions and in air conditioning compressors where components move against each other. Bearing shells and bushes serve to transmit power, reduce friction and prevent wear. There are different kinds of bearings e.g. roller and ball bearings and sliding/sleeve bearings.

The scope of Exemption 9b, the exemption for lead in bearing shells and bushes, was amended in the past as a result of the last revisions. As lead-free bearing shells and bushes had already started to be used in some applications, the scope of exemption 9b) was constricted to the use in refrigerant-containing compressors for heating, ventilation, air conditioning and refrigeration (HVACR) applications. Emerson Climate Technologies stated at that time[6] that in these components, liquid refrigerants are applied which are a strong solvent, thus subsequently resulting in the removal of vital compressor oil from the bearings, causing inadequate lubrication and increased

[6] 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. Freiburg: Accessed 14.7.2015: http://ec.europa.eu/environment/waste/weee/pdf/final_reportl_rohs1_en.pdf

friction to occur. As friction increases, the efficiency of lubrication diminishes and premature failure may ensue.

In all other EEE applications, substitution of lead in bearing shells and bushes had already been achieved at the time of the last review of the exemption in 2008-9. In addition, a similar exemption under the ELV Directive (2000/53/EC) (entry 4b Annex II on lead in bearing shells and bushes in engines, transmissions and air conditioning compressors) expired 1 July 2011.[7]

In 2014, in light of the expiration date of Ex. 9b, Emerson Climate Technologies[8] submitted a request for the renewal of Exemption 9b. Emerson proposed to amend the exemption wording to further narrow the scope of as follows:

> *"Lead in bearing shells and bushes for refrigerant-containing compressors, with a stated electrical power input of only 9 kW or lower for the HVACR industry" with expiry date three years after the publication of the amended RoHS Annex.*

Emerson explained in its request that it would successfully achieve the substitution of lead in bearing shells and bushes for refrigerant-containing compressors, with a stated electrical power input above 9 kW by 2015. However, for refrigerant-containing compressors below 9 kW, substitution has not been achieved yet, and more time would be needed for this to occur. [9]

6.1.1 Amount of Lead Used under the Exemption

Emerson[10] estimates the total amount of lead placed on the EU market annually, through bearings and bushes applied in refrigerant-containing compressors with a rated power input below 9 kW to be between 700 and 800 kg. The figures presented here originate from the Emerson exemption application (see Figure 6-1).

According to Emerson[11], these lead amounts are calculated on the basis of production volume and lead content per compressor, which are indicated to be between 0.1 to 3% by weight. Emerson did not provide detailed information due to confidentiality issues.

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[7] See the latest version of Annex II to Directive 2000/53/EC (ELV Directive); http://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:32013L0028&from=EN

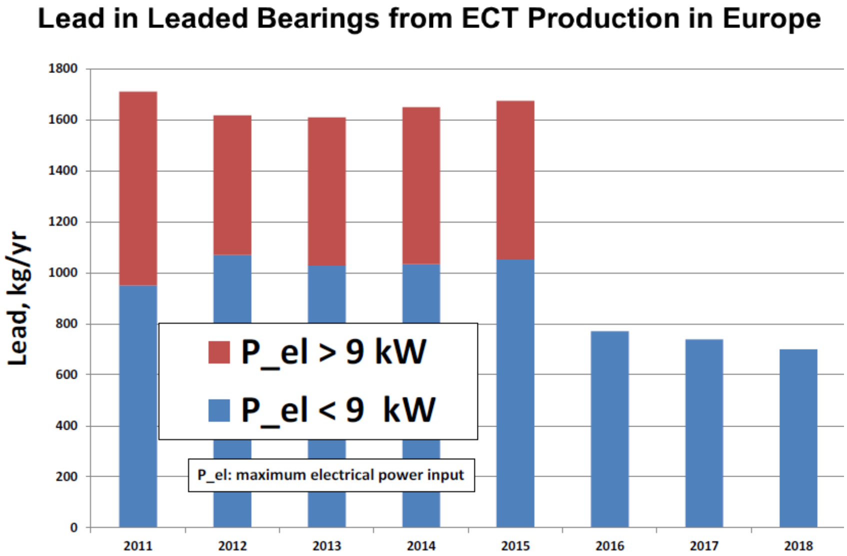
[8] Emerson (2014), Emerson Climate Technologies (2014), Original Application for Exemption, submitted 07.10.2014, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_9b/Emerson_RoHS_Ex9b_renewal_request_7.10.14.pdf

[9] Op. cit. Emerson (2014)

[10] Op. cit. Emerson (2014)

[11] Op. cit. Emerson (2014)

Figure 6-1: Amount of Lead per Year in Bearings of Refrigerant Containing Compressors Produced by Emerson (ECT)



Source: Op. cit. Emerson (2014)

6.2 Description of Requested Exemption

Emerson[12] states that the sliding/sleeve bearings of air and refrigerant compressors need to hermetically seal the system in order to prevent leakage of the refrigerant and thereby to ensure a long and reliable operation as the bearings and lubrication oil are not changed during service life (Emerson 2014).

Lead provides low friction in the bearing by acting as a solid lubricant. This is especially important in times of inadequate lubrication, which occurs due to solvency of the lubricant oil in the refrigerant and which is especially relevant for a dry start after the system was off for some time.[13]

In a recent patent application, Emerson[14] describes a common journal bearing in compressors in more detail as to have an outer steel sleeve with an inner porous bronze layer with a well-dispersed polytetrafluorethylene (PTFE) resin and as also having lead particles dispersed in the resin. The following figure taken from the

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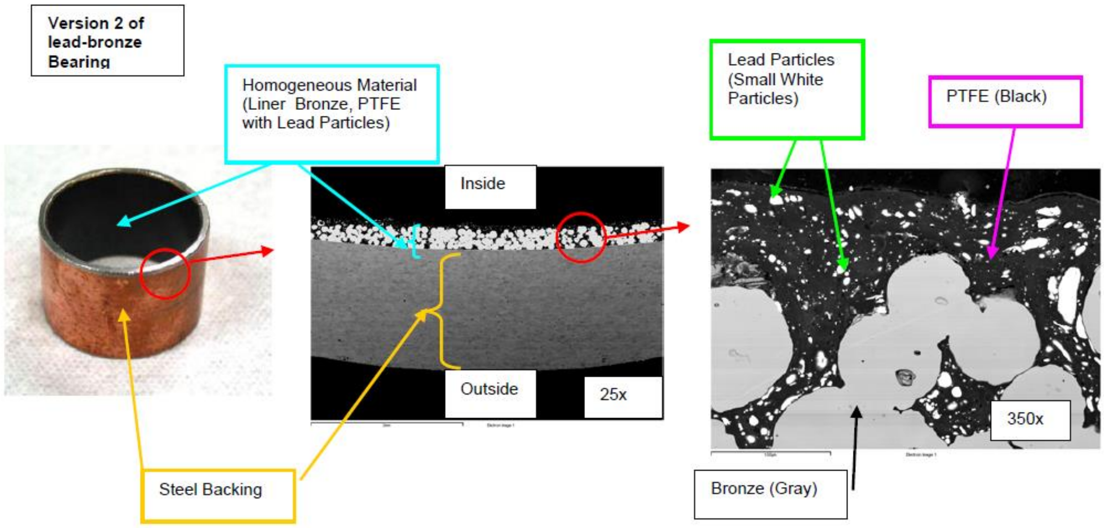
[12] Op. cit. Emerson (2014)

[13] Op. cit. Emerson (2014)

[14] Emerson (2015d), Emerson Climate Technologies (2015d), Applicant for US Patent "Improved Bearing Performance For Compressors Using High Energy Refrigerants With Sulfur-Based Oil Additives"; US Patent US2015147012 (A1) – 2015-05-28; http://worldwide.espacenet.com/publicationDetails/originalDocument?FT=D&date=20150528&DB=EPODOC&locale=de_EP&CC=US&NR=2015147012A1&KC=A1&ND=4

contribution of Emerson[15] submitted during the last revision of exemption 9b) in 2008/2009.

Figure 6-2: Leaded-Bronze Sleeve Bearing Showing its Homogeneous Materials



Source: Emerson (2008)

6.3 Applicant's Justification for Exemption

The applicant argues that challenges on the technical level combined with supply chain challenges hinder accomplishing RoHS compliance by July 2016:

Emerson[16] describes the following technical challenges that are relevant for the smaller size of compressors, with a stated electrical power input of 9 kW or lower:

- The smaller bearing area concentrates forces, which produce a higher unit load. This "*creates more demanding operating conditions where lubricity and friction become exceptionally important.*"[17]
- The smaller compressors are typically used in stationary air conditioning and refrigerator compressors that have a high running time: Emerson[18] specifies a running time of 50,000 to 100,000 hours for stationary air conditioning and

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[15] Emerson (2008), Emerson Climate Technologies (2008), Contribution by Emerson submitted 20.03.2008, available under http://rohs.exemptions.oeko.info/fileadmin/user_upload/Stakeholder_comments/Exemption_9b_Emerson_20_March_2008.pdf

[16] Emerson (2015a), Emerson Climate Technologies (2015a), Answers to Clarification Questions, submitted 03.03.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_9b/Ex_9b_Clarification-Questions_Emerson_Answers_F.pdf

[17] Op. cit. Emerson (2015a)

[18] Op. cit. Emerson (2015a)

refrigeration compressors compared to typically 3,000 hours in automotive applications. This longer service duration needs durable and reliable bearings.

- <9kW compressor models undergo a global proliferation and are applied by many different OEMs. The high variety of compressor models using a variety of lubricants and refrigerants leads to an overall long qualification time, with some OEMs demanding long field pilot testing.

Emerson[19] states that "*the supply-chain for lead-free bearings are not yet robust enough to accommodate the larger global use demands*". Emerson further explains that the lead-free compositions of the different bearing suppliers could not yet be tested for qualification in the different compressor models.

6.3.1 Possible Alternatives for Substituting RoHS Substances

Emerson[20] states that substitutes are already available. It is understood that they are to be applied by Emerson in all compressors with a stated electrical power input of > 9 kW from 2016 on.

Emerson[21] details the following alternatives: "*As far as replacements for lead other than metallic elements, there exists the following options: Molybdenum Disulfide, Graphite, Tungsten Disulfide, Hexagonal Boron Nitride, Carbon Fiber, Calcium Fluoride, Zinc Sulfide and PTFE. This is not an exhaustive list, but represents main ones. Not all these materials are individually equivalent to lead and sometimes it requires a combination of them to satisfy the tribologically[22]-equivalent performance of Lead. Although it is possible to achieve performance parity with the aforementioned non-metallic options, most of these potential replacements for Lead are more expensive and less commonly available relative to Lead.*" Emerson[23] explains that its focus in substitution efforts is on the following materials and substances: PTFE, molybdenum disulfide, calcium fluoride, aluminium oxide, carbon fibres, copper and iron.

Emerson[24] explains that the search on possible alternatives also includes the structural composition of the bearing such as e.g. impregnation or lining.

6.3.2 Environmental Arguments

Emerson[25] provides an estimation of the impacts of the key materials mentioned above and additionally iron oxide, zinc sulphide, bismuth and silicon. Emerson does

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19 Op. cit. Emerson (2015a)

20 Op. cit. Emerson (2014)

21 Op. cit. Emerson (2014)

22 Science of friction, lubrication and wear between moving surfaces

23 Op. cit. Emerson (2014)

24 Op. cit. Emerson (2014)

25 Op. cit. Emerson (2014)

not expect environmental, health or consumer safety impacts to be associated with any of these substances[26]. To support this estimation, Emerson[27] has submitted a preliminary report about bearing constituents shortly describing substance properties of the substances in the focus of Emerson's substitution efforts.

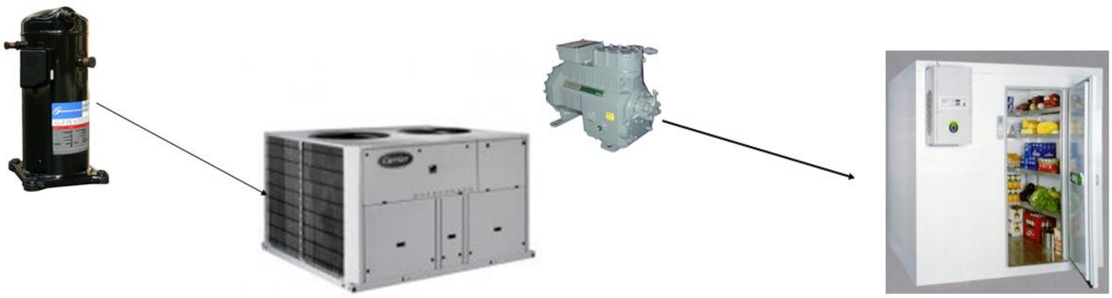
6.3.3 Socio-economic Impact of Substitution

Emerson[28] considers the price of the substitute to be a problem for the availability. Emerson[29] further claims that substitution would increase the fixed costs (depending on the substitute, region and product). Emerson does not provide any details to support this statement (e.g. actual costs or estimations on the difference in the price of the final product).

6.3.4 Road Map to Substitution

According to Emerson[30], the substitution of lead in bearings with an electrical input above 9 kW shall be completed by 2015. Application examples of this product group given by Emerson[31] are e.g. medium size and large commercial chillers, cold room applications, environmental chambers and supermarket racks with scroll or reciprocating compressor technology. The following figure shows two application examples of Emerson compressors with an electrical input above 9 kW.

Figure 6-3: Medium Size Chiller and Cold Room Application both with their Respective Compressors on the Left Side



Source: Emerson (2015c)

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26 Op. cit. Emerson (2014)

27 Emerson (2015b), Emerson Climate Technologies (2015b), Preliminary Report on Bearing Constituents, third party document available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_9b/Preliminary_Report_on_Bearing_Constituents.pdf

28 Op. cit. Emerson (2014)

29 Op. cit. Emerson (2014)

30 Op. cit. Emerson (2014)

31 Emerson (2015c), Emerson Climate Technologies (2015c), Answers to 2nd Round of Clarification Questions, submitted per email on 05.08.2015.

As for the refrigerant-containing compressors, with a stated electrical power input of 9 kW or lower, Emerson[32] explains that they have received samples of lead-free bearings that were introduced in the reliability tests in the refrigeration compressor environment. According to Emerson[33], "*Compressor testing for substitutes for which the exemption renewal is requested will not be completed until December 2015.*" Emerson further explains "*Once suitable alternatives are proven, process changes in some cases may take up to 3 years.*"

Emerson indicates the durations for the different tests that are necessary for one bearing material candidate in its application. The duration of the tests ranges from 3 weeks (test on the compatibility of the bearing material with refrigerant and lubricant) to more than one year (test on ability to resist wear-out over 15 years).

According to the time schedule presented by Emerson,[34] these tests on technological features are being carried out and are to be completed for the different product families in 2015. The extension time of the requested exemption (2016 to 2019) is necessary to complete the process successively for eight different product families[35] the compressor reliability testing, validation of the manufacturing process, production change over and supply chain change over.

6.4 Stakeholder Contributions

No contributions concerning this request have been obtained during the stakeholder consultation.

After the consultation, several manufacturers, delivering refrigerant compressors within the EU market were contacted to find out if some or all of these other manufacturers support the exemption request or alternatively do not need the requested exemption renewal. Two manufacturers were urged to provide a statement:

- Bitzer[36] has completed substitution with lead-free bearings in its products, however stresses that the product range is different from Emerson. The bearing design that Bitzer applies differs from the hermetic compressors Emerson mentions.
- Danfoss[37] supports the renewal application of Emerson stating that they are working on the implementation of two types of lead-free bearings; despite the understanding that with these components costs will increase e.g. DP31 (see

32 Op. cit. Emerson (2014)

33 Op. cit. Emerson (2014)

34 Op. cit. Emerson (2015a)

35 The eight different product families (see table on page 4 of Emerson 2015c) are not detailed further; Emerson (2015c) claimed confidentiality for the actual products behind the product family codes.

36 Bitzer (2015), Bitzer Kühlmaschinenbau GmbH, email communication of Dr. Heinz Juergensen, 22.09.2015.

37 Danfoss (2015), Danfoss A/S (2015), email communication of Bjarne Westerberg, 25.09.2015

Section 6.5.2 for further explanation). Danfoss also states that substitution is to "*take a long time, because it need constantly pilot test to meet the functional requirements.*" Please also see Appendix A.2.0 for further details.

6.5 Critical Review

6.5.1 REACH Compliance - Relation to the REACH Regulation

Appendix A.1.0 of this report lists entry 28 and 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 28 and entry 30 of Annex XVII does not apply to the use of lead in this application. Pb used in bearing shells and bushes for refrigerant-containing compressors, 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. Pb is part of an article and as such, entry 30 of Annex XVII of the REACH Regulation would not apply.

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

In parallel, the possible substitutes and alternative materials relevant to the exemption request as named by Emerson have also been checked for specific provisions under REACH, e.g. conditions of restriction in REACH Annex XVII and Annex XIV, to ensure that promoting substitution shall not create a situation which would weaken the protection provided by REACH. No entries have been found for these substances. The results are compiled in the following table.

Table 6-1: Check of Conditions of Restriction and Authorisation in REACH Annex XVII and Annex XIV, for Possible Substitutes in Alphabetical Order.

Substance or compounds	CAS Number	Specific provisions etc. under REACH
Aluminium Oxide	1344-28-1	None
Bismuth	7440-69-9	None
Calcium Fluoride	7789-75-5	None
Carbon Fiber	308063-56-1	None
Graphite	7782-42-5	Multi-Wall Carbon Nanotubes (MWCNT), synthetic graphite in tubular shape is set on the Community Rolling Action Plan (CoRAP) by Germany and will be evaluated from 2017 on.
Hexagonal Boron Nitride	10043-11-5	None
Iron Oxide	1332-37-2	None
Molybdenum Disulfide	1317-33-5	None
PTFE	9002-84-0	None. In general, polymers are exempted from the provisions on registration of Title II of REACH.
Silicon	7440-21-3	None
Tungsten Disulfide	12138-09-9	None
Zinc Sulfide	1314-98-3	None

Source: European Chemical Agency, September 2015

6.5.2 Scientific and Technical Practicability of Substitution

Through the last revision of exemption 9b in 2009, it became clear that a dynamic phasing out of lead-containing bearing shells and bushes was underway, leading to the recommendation that only in very specific cases a prolongation would be necessary. A similar exemption under the ELV Directive (2000/53/EC) (entry 4b Annex II on lead in bearing shells and bushes in engines, transmissions and air conditioning compressors) expired 1 July 2011.

Emerson had already pointed out during the last revision of the exemption, that for e.g. stationary residential air conditioning and commercial refrigeration (environmental cooling or heating systems for households) there would be major obstacles for lead-free bearings because of the long qualification time required to assure reliability and durability and the absence of an adequate lead-free candidate for several applications. However, Emerson at that time estimated that an extension of the exemption to October 2013 would give "*in particular the HVACR industry, enough time to convert products in a reliable manner to lead-free*."

Since then, it can be understood that Emerson achieved substitution in the larger compressors with an electrical input of above 9 kW. These compressors are used in e.g. medium size and large commercial chillers, roof top cold room applications, environmental chambers and supermarket racks.

As for the refrigerant-containing compressors, with a stated electrical power input of 9 kW or lower, it is understood that substitution is not completed and is expected to require a few more years, though testing has apparently been completed on the component level.

In a recent patent application, Emerson[38] explains that lead-free self-lubricating bearings consist of a backing layer of steel or bronze that is overlaid with an intermediate layer of porous bronze material of copper and tin in varying compositions (75 to 95% by weight copper and 5 to 25% by weight tin). The porous material is impregnated with a PTFE resin and other particles that act as a lubricant e.g. calcium fluoride, molybdenum disulfide, carbon fibres or zinc sulphide. Emerson[39] provides some examples of suitable commercially available self-lubricating bearing materials in the compressor machines (see Table 6-2). Though it can be understood that Emerson is already testing the candidate substitutes for performance, it is understood that more time is needed to fulfil this process.

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[38] Op. cit. Emerson (2015d)

[39] Op. cit. Emerson (2015d)

Table 6-2: Non-limiting Examples of Commercially Available Lead-free Self-lubricating Bearing Materials for Use in Compressor Machines

Bearing	Manufacturer	Bearing Materials
DP4 ™	GGB, L.L.C.	A lead-free self-lubricating layered sleeve bearing having: 1) a steel backing layer; 2) a porous bronze intermediate layer; 3) a sliding layer composite filling pores of the porous bronze layer that has a polytetrafluoroethylene (PTFE) resin with alkali earth metals (CaF_2) and polymer fillers (aramid fibers).
DP31 ™	GGB, L.L.C.	A lead-free self-lubricating layered sleeve bearing having: 1) a steel backing layer; 2) a porous bronze intermediate layer; 3) a sliding layer composite filling pores of the porous bronze layer that has a polytetrafluoroethylene (PTFE) resin filled with calcium fluoride (CaF_2), fluoropolymer, and other fillers.
DP10 ™	GGB, L.L.C.	A lead-free self-lubricating layered sleeve bearing having: 1) a steel backing layer; 2) a porous bronze intermediate layer (Cu at 89% and Sn at 11%); 3) a sliding layer composite filling pores of the porous bronze layer that has a polytetrafluoroethylene (PTFE) resin filled with molybdenum sulfide (MoS_2).
P141	Schaeffler KG (INA Brand)	A lead-free self-lubricating layered sleeve bearing having: 1) a steel backing layer; 2) a porous bronze intermediate layer; and 3) a sliding layer composite filling pores of the porous bronze intermediate layer comprising: i) Polytetrafluoroethylene (PTFE) resin at 75 vol. % ii) Perfluoroalkoxy at 5 vol. %; iii) ZnS particles at 17 vol. %; and iv) Carbon fibers at 3 vol. %.
P14	Schaeffler KG (INA Brand)	A lead-free self-lubricating layered sleeve bearing having: 1) a steel backing layer; 2) a porous bronze intermediate layer; and 3) a sliding layer that has a resin filling pores of the porous bronze layer comprising: i) Polytetrafluoroethylene (PTFE) resin at 75 vol. %; ii) Perfluoroalkoxy at 5 vol. %; and iii) ZnS particles at 25 vol. %.

Source: Op. cit. Emerson (2015d)

Information published by GGB[40] also confirms that the lead-free bearings are available on the market since at least 2010:

- "DO10™ metal-polymer materials are introduced for superior performance under marginally lubricated and dry running conditions, brought on the market in 2010"; and
- "DP31™ metal-polymer material with improved performance under lubricated conditions, wear resistance, fatigue strength and low friction was brought on the market in 2003".

Emerson explains that "*Compressor testing for substitutes for which the exemption renewal is requested will not be completed until December 2015… Once suitable alternatives are proven, process changes in some cases may take up to 3 years*." It is understood that this process must be completed for eight different product families and will include:

- the compressor reliability testing;
- validation of the manufacturing process;
- production change over; and
- supply chain change over.

It further appears that other manufacturers may also need more time to complete the last testing phases and to achieve substitution in products to come on the market.

Danfoss[41] explains that they are still testing lead-free bearings as replacement for lead-based ones in two cases. In one case, the substitute is expected to have better lubrication properties than the lead-based one, though substitution will increase costs. In the second case, though the inner material of the two bearings is different, Danfoss does not expect the change to influence the compressor performance, though costs will probably also increase.

Danfoss mentions that the substitution is expected to raise costs, however this would not be relevant in terms of fulfilling one of the RoHS Article 5(1)(a) criteria in terms of justifying the exemption renewal. Danfoss support the request for exemption with the amended wording and requested time, and it is understood that for the two cases mentioned above, they still need to establish the reliability of substitutes. Please also see Appendix A.2.0 for additional details.

Bitzer [42] can also support that demanding application conditions might hamper the use of lead-free bearings. In this respect, their view is understood to be, that more time may be needed to complete substitution in the full product range. To conclude, it

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[40] GGB; http://www.ggbearings.com/en/company/history

[41] Op. cit. Danfoss (2015)

[42] Op. cit. Bitzer (2015)

is understood that bearing manufacturers are working towards replacing lead-based bearings and bushes with lead-free self-lubricating sleeve bearings.[43]

Though substitute bearings appear to have become available on the market, and are understood to have already been tested in some cases on the component level, it is yet to be verified, whether these lead-free bearings meet the specific performance requirements of products in which the compressors are used.

6.5.3 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.

It has been shown that lead-free self-lubricating bearings are commercially available since at least 2010. In a recent patent application, Emerson lists three lead-free bearings from the bearing manufacturers GBB that are on the market since 1995, 2003 and 2010. From the contribution made by Danfoss it is also understood that testing of available substitutes is underway and appears to be satisfactory from a technical perspective. It is thus concluded that substitutes have become available.

However, special requirements for hermetic compressors require a longer time to verify reliability in order to allow the transfer to a new material. This aspect is understood to be relevant for testing the compatibility of alternatives in compressors when they are used within specific HVAC applications. The consultants understand this to mean that the reliability of substitutes may not be ensured at present, meaning that, on the basis of fulfilling the second criterion, an exemption could be justified. In a later communication, Emerson[44] confirmed that the exemption is requested "*only for bearings in hermetic scroll compressors with a stated electrical power input equal or below 9kW*"

Concern however is raised regarding Emerson's[45] statement in 2014 that "*actions are currently underway to finalize testing, prepare for customer communication and*

[43] See also e.g. Glyco®97 Lead-free dry sliding bearings and elements for high stress; http://glycodur.com/downloads/GLYCO97_PI_EN.pdf and AST®; http://www.astbearings.com/bushings-and-plain-bearings-overview.html

[44] Emerson (2015e), Email Communication Related the Scope of Articles in which Substitution is not Complete, sent per email 16.12.2015

[45] Op. cit. Emerson (2014)

reduction of leaded bearing inventory (supplier, Emerson Climate and OEM)" for the refrigerant-containing compressors, with a stated electrical power input of only 9 kW or lower for the HVACR industry. The last part of this statement suggests that the exemption may have been requested for a duration of 3 years to complete reliability testing, but also to allow stocked compressors containing lead to be applied in new product to be placed on the market. This is particularly of concern as the applicant requests an "expiry date three years after the publication of the amended RoHS Annex" and it is thus understood that certain stages related to substitution may first be carried out after it is clear what the duration of the exemption shall be.

The consultants' can follow that the last stages of substitution may require more time than estimated for some parts of the product range, for which the exemption renewal was requested, in light of the need to ensure the reliability of substitutes. This would justify an exemption. Supply-chain limitations may also be taken into consideration where deciding about the duration of an exemption. However, information suggests that the requested duration of the exemption may partly be needed to reduce inventory of leaded bearings throughout the supply chain, after substitution will have been completed. Inventory aspects are not understood to be aspects that could justify an exemption, and in this sense it should be considered if the requested duration is justified, as it is possible that reliability testing and redesign could be completed before the three year period is over. To conclude, though it can be followed that finalising testing and redesign may need up to 3 years, however this timeframe is expected to be independent of the date of a decision as the substance restrictions, which are in force, are the motivator for substitution and not the expiration of the exemption. Thus a period of three years could be granted from the date of a decision prior to the current expiration date or, at the latest, starting from the current expiration date of the exemption.

A shorter period was also contemplated, however, if the exemption is to be granted, with a duration of only 2 years, this would barely allow stakeholders time to request the exemptions renewal should the full three years indeed be needed for products with lead-free bearings to reach market readiness, since a request to renewal needs to be granted at least 18 months before expiration. In such a case, it is also possible that the time proximity to the current review would also mean that manufacturers would not be able to supply more detailed information or estimations as to the time needed for competing substitution, beyond the initial information that is currently available. Such a case would add to the administrative burden and would enlarge environmental benefits if substitution is indeed completed within two years.

In light of the uncertainties as to the actual time needed, were the exemption not to be renewed, it would be recommended to provide stakeholders with the maximum transition period of 18 months, to allow the last stages of substitution to be completed. In this case, compressor manufacturers would have until January 2018 to complete substitution. Additionally, after the expiration, leaded bearings could still be used in spare parts for applications placed on the market before the expiration date. As some models might finalise substitution earlier than others, it is possible that that such a decision would only prevent a small number of models from coming on the market, in light of non-compliance.

6.6 Recommendation

If the EU COM can follow that completing the last stages of substitution could indeed need close to 3 years, it is recommended to grant and exemption with the following wording:

"Lead in bearing shells and bushes for refrigerant-containing hermetic scroll compressors with a stated electrical power input equal or below 9kW for heating, ventilation, air conditioning and refrigeration(HVACR) applications"

The exemption, to remain in Annex III, should be granted until 21 July 2019 for category 1, which according to the applicant is the only category of relevance for this exemption.

If the EU COM cannot follow the argument that a renewal is needed, and prefers to revoke the exemption, it would be recommended to provide the maximum transition period of 18 months, ending 21 January 2018, with a decision taken closer to the current expiry date. As explained above, with the understanding that this period might suffice for substitution to be completed for most relevant applications, it may provide a compromise in terms of:

- positive impacts to the environment (lead reduction related to bearing and bushes); and
- possible negative impacts for industry and consumers (related to applications which will need more time for market readiness).

6.7 References Exemption Request 9b

Bitzer (2015)	Bitzer Kühlmaschinenbau GmbH, email communication of Dr. Heinz Juergensen, 22.09.2015.
Danfoss (2015)	Danfoss A/S (2015), email communication of Bjarne Westerberg, 25.09.2015
Emerson (2008)	Emerson Climate Technologies (2008), Contribution by Emerson submitted 20.03.2008, available under http://rohs.exemptions.oeko.info/fileadmin/user_upload/Stakeholder_comments/Exemption_9b_Emerson_20_March_2008.pdf
Emerson (2014)	Emerson Climate Technologies (2014), Original Application for Exemption, submitted 07.10.2014, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_6/2014-1/Mocon-Exemption_Request_Public.pdf http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_9b/Emerson_RoHS_Ex9b_renewal_request_7.10.14.pdf
Emerson (2015a)	Emerson Climate Technologies (2015a), Answers to Clarification Questions, submitted 03.03.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS

_Pack_7/Exemption_9b/Ex_9b_Clarification-Questions_Emerson_Answers_F.pdf

Emerson (2015b) Emerson Climate Technologies (2015b), Preliminary Report on Bearing Constituents, third party document available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_9b/Preliminary_Report_on_Bearing_Constituents.pdf

Emerson (2015c) Emerson Climate Technologies (2015c), Answers to 2nd Round of Clarification Questions, submitted per email on 05.08.2015.

Emerson (2015d) Emerson Climate Technologies (2015d), Applicant for US Patent "Improved Bearing Performance For Compressors Using High Energy Refrigerants With Sulfur-Based Oil Additives"; US Patent US2015147012 (A1) — 2015-05-28; http://worldwide.espacenet.com/publicationDetails/originalDocument?FT=D&date=20150528&DB=EPODOC&locale=de_EP&CC=US&NR=2015147012A1&KC=A1&ND=4

Emerson (2015e), Emerson Climate Technologies, Email Communication Related the Scope of Articles in which Substitution is not Complete, sent per email 16.12.2015

Gensch et al. (2009) 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. Freiburg: Accessed 14.07.2015. http://ec.europa.eu/environment/waste/weee/pdf/final_reportl_rohs1_en.pdf

7.0 Exemption Request No. 13a: Lead in White Glasses Used for Optical Applications

Abbreviations

Cat.	Category
CTE	Coefficients of thermal expansion
DSLR	Digital single lens reflex
EEE	Electric and electronic equipment
IED	The Industrial Emission's Directive
LCOS	Liquid crystal on silicon projectors
MTF	Modulation transfer function
R.I.	Refractive index
Pb	Lead
Spectaris	The German High-tech Industry Association (Der Deutsche Verband der Hightech Industrie)

7.1 Background

According to Spectaris[46], lead is used in optical glass, which is applied in a wide variety of electric and electronic equipment (EEE), such as photographic lenses; lenses for video and television equipment; lenses for binoculars and telescopes; lenses for microscopes and endoscopes and other medical and monitoring equipment, and other electric and electronic equipment.

The applicant explains that lead-based glasses are used because they have unique combinations of properties and characteristics that cannot be achieved by lead-free optical glass of alternative designs. Spectaris details some of these properties including the light transmission performance, optical dispersion, thermal conductivity, birefringence and others. It is explained that alternatives exist in the form of lead-free glass, plastic lenses and alternative equipment design. Nonetheless, Spectaris states that alternatives are not available for the uses of optical glass where lead-based glasses are currently used and thus substitution of the full application range is not possible. On this basis, Spectaris applies for the renewal of Ex. 13a, which appear in Annex III of the Directive with the following wording:

> "*Lead in White Glasses Used for Optical Applications*"

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[46] Spectaris (2014a), The German High-tech Industry Association, Original Application for Exemption 13a, submitted 11.11.2014, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/Spectaris_Exemption_Renewal_Request_13a_Final.pdf

The request does not apply for changes to the current exemption wording, but for an exemption without an expiry date. The consultants understand this request to target an exemption with maximum allowed duration, which according to Article 5(2) of the Directive is between 5 to 7 years, depending on the Annex I category of applications of relevance.

7.2 Description of Requested Exemption

Sections 7.1 through 7.4 are heavily based on information provided by the applicant and other stakeholders and do not necessarily reflect the view of the consultants.

Spectaris[47] explains that glasses are usually transparent solid materials that can be manufactured with many different compositions. Glasses are traditionally known as clear non-crystalline inorganic materials based on silicates that are used for windows, drinking vessels and decorative objects. Among others, glasses are applied for optical components such as lenses, which are used in cameras, microscopes, projectors and many other different applications – see further details in Table 7-1.

The composition of glasses is very varied to achieve the desired combination of properties. For most technical applications, it is necessary that the glass provides a combination of several specific characteristics. Various additives are used to control the combination of properties that is required for each application and colourless transparent glasses may contain, apart from sodium and silica, also potassium, boron (e.g. boro-silicate glasses), arsenic, antimony, calcium, barium and lead. Some amorphous (non-crystalline) polymeric materials that are hard and optically transparent are referred to as "glass polymers" and have unique combinations of properties, although these are different to traditional silicate based glasses.

Each ingredient in a glass is added to achieve specific combinations of properties although each individual optical property, such as high refractive index, can be obtained by several different glass formulations. There are however, certain combinations of optical properties, which can be achieved by only one or a few formulations and some combinations of characteristics are only possible in glass formulations that contain lead. Lead-based glass has disadvantages such as higher density, which makes the optics heavier, and it is softer than lead-free glass and so it is more easily scratched. However, in some cases, the combination of optical properties cannot be achieved by any lead-free glass. [48]

Table 7-1 details various applications in which lead optical glasses are used and for which it is understood that substitutes are currently not available.

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[47] Op. cit. Spectaris (2014a)

[48] Op. cit. Spectaris (2014a)

Table 7-1: Examples of Applications Using Lead Optical Glasses Covered by Ex. 13a

Category	EEE Application
Cat. 3	Optical systems designed for telecom applications in the near IR spectral range
Cat. 4	Professional photographic cameras; video and television cameras; cine photography; high performance binoculars and telescopes;
Cat. 6	Endoscopes used for inspection of engineered products; Temperature compensated high end optical imaging systems for printing and photolithography applications used for industrial tools
Cat. 8	Medical endoscopes; Fibres for high quality illumination units for operation microscopes; Light guides and lenses for optical microscopes, endoscopes and in IVD equipment.
Cat. 9	Spectrometers (visible and UV light) used for analysis and for environmental monitoring; Light guides and lenses for optical microscopes, endoscopes and in IVD equipment.
Other categories	Lead-glass may also be used in many other types of equipment, such as lighting applications (crystal glass which may be used in lighting applications is covered by exemption 29), toys and leisure products and automatic dispensers (e.g. Automatic Teller Machines / ATMs).

Spectaris[49] explains that most optical glasses (among others those benefiting from Ex. 13a), contains 40 – 70% by weight of lead oxide, meaning that they contain between 37 to 65% lead. Nonetheless, manufacturers report that glass containing 20% Pb (for light guides) and 80% Pb (for optical glass lenses) are also used. Spectaris estimates that the global production of lead-based optical glass used in EEE is 1250 tonnes per annum. Since about 40% of EEE is placed on the EU market, Spectaris concludes that such EEE will contain 500 tonnes of lead-based optical glass. Estimating that the average lead content is ca. 55%[50] lead, this represents around 275 tonnes of Pb placed on the EU market per annum through optical glass applications.

7.3 Applicant's Justification for Exemption

Lead is added to types of optical glasses that are used in a wide variety of electrical equipment to achieve the following characteristics, usually more than one of these properties are needed for a specific application and often many are necessary:[51]

- **Medium to high refractive index** – important for optics used in microscopes, camera lenses, etc.

49 Op. cit. Spectaris (2014a)

50 It was later explained that this is a weighted average (i.e. taking into account the quantities of each type) – see Spectaris (2015a), Answers to 1st Round of Clarification Questions, submitted per email 11.3.2015 and available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/150311_Ex_13a_Clarification-Questions_Answers.pdf

51 Op. cit. Spectaris (2014a)

- **Specific 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-based glasses can be formulated to have low Abbe numbers, which reduces chromatic aberration, in parallel to having a high refractive index.
- It is important to be able to control the Abbe number so that by using combinations of lenses of different materials with different characteristics, very precise optical effects can be obtained. Professional camera lenses and microscopes include several lenses made of several different glass formulations to achieve the required high performance.
- **Colour aberration** – There are two types of colour aberration that are affected by glass composition: lateral and axial. *Axial chromatic aberration* is due to differences in focal length of different colours whereas *lateral chromatic aberration* is affected by image size. Axial chromatic aberration is resolved by combining lenses of two different types of glass, one having a larger refractive index than the other does. High refractive index lenses are made of lead-based glass for the best optical quality. Chromatic aberration occurs because all optical glasses that are used for lenses have a refractive index that varies with the wavelength of transmitted light (this property is related to the Abbe number). As a result, each colour focuses at a different convergence point, so that colour images appear with coloured fringes and this effect is more pronounced with high refractive index materials.
- **Transmission of light with a high proportion of blue / indigo / violet light** – most types of lead-free glasses tend to absorb a high proportion of light having shorter wavelengths (<450 nm) whereas lead-based glasses transmit a high proportion of short wavelength visible light to achieve accurate colour reproduction which is important for many applications (more details below).
- **Low stress birefringence (low stress optical constant)** – birefringence is a property of transparent materials where light travelling in one axis is refracted differently to light travelling in an axis at 90˚ to the other axis and this is due to the material having different refractive indices in perpendicular directions. Some types of calcite crystals (e.g. "Iceland Spar") clearly show this effect; if a crystal is placed onto a printed page, two distinct images can be seen, one being shifted sideways from the other. Clear plastics such as polycarbonate and acrylics are very susceptible to birefringence and this can be seen as rainbow colours when the plastic items are stressed when viewed by polarised light (each wavelength is refracted differently so that incident white light is transmitted as separated colours).
- **Partial dispersion** – Glasses having identical refractive index and Abbe number can have different partial dispersion properties and this can significantly affect image quality. Modulation transfer function (MTF) of a lens is a measure of image quality where a MTF of 1 is perfect quality with no loss of contrast (see

additional information[52] for a more detailed explanation of why partial dispersion is an essential criterion).

- **Achromatism** - see additional information[53].
- **Petzval number** - see additional information[54].
- **Abnormal dispersion** – this is a quality used to compensate for chromatic aberration.
- **Low photoelastic constant (β)** – important to minimise distortion due to birefringence when stress is imposed on the glass optics. Related to low stress birefringence, described above.
- **Press moulding characteristics** – aspherical lenses are made by forming in moulds before grinding and polishing. The moulded shape needs to be as close to the required dimensions as possible to minimise grinding wastes and this is easier with leaded glass because the melting temperature is lower than with lead-free glasses. This has a positive effect of requiring less energy in such press moulding processes due to up to an up to 200˚C lower process temperature.
- **Thermal properties** – Some optical systems require the use of two lens elements that are cemented together (cemented doublets). It is important that both lenses have similar thermal coefficient of expansion to allow for any temperature changes. This is sometimes impossible without lead-based optical glass. Some lens systems are required to maintain focus when the temperature changes (such as due to the presence of hot lamps in the operation environment) and this is sometimes possible only with lead-based glass.

Spectaris[55] explains that applications usually need many of the above characteristics. Some examples need a combination of high refractive index, a high percentage of short wavelength light transmission and low stress birefringence and these are all achievable only with optical glasses containing lead. Lead-free glass types are available which exhibit one or two of these properties only, but none exhibit all three. There is a vast amount of different optical systems each with a manifold of requirements. Present day applications can have up to 40 or more functional requirements which have to be met simultaneously (creating a need for a large number of glass types with property variations). Requirements can be e.g. focal length

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52 Spectaris (2014b), The German High-tech Industry Association, Additional Technical Information for exemption 13a renewal request – Charachteristics of optical glass needed for high performance systems, submitted 11.11.2014, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/Spectaris_Exemption_Renewal_Request_13a_Additional_Facts_Final.pdf

53 Ob. Cit. Spectaris (2014b) – see link

54 Ob. Cit. Spectaris (2014b) – see link

55 Op. cit. Spectaris (2014a)

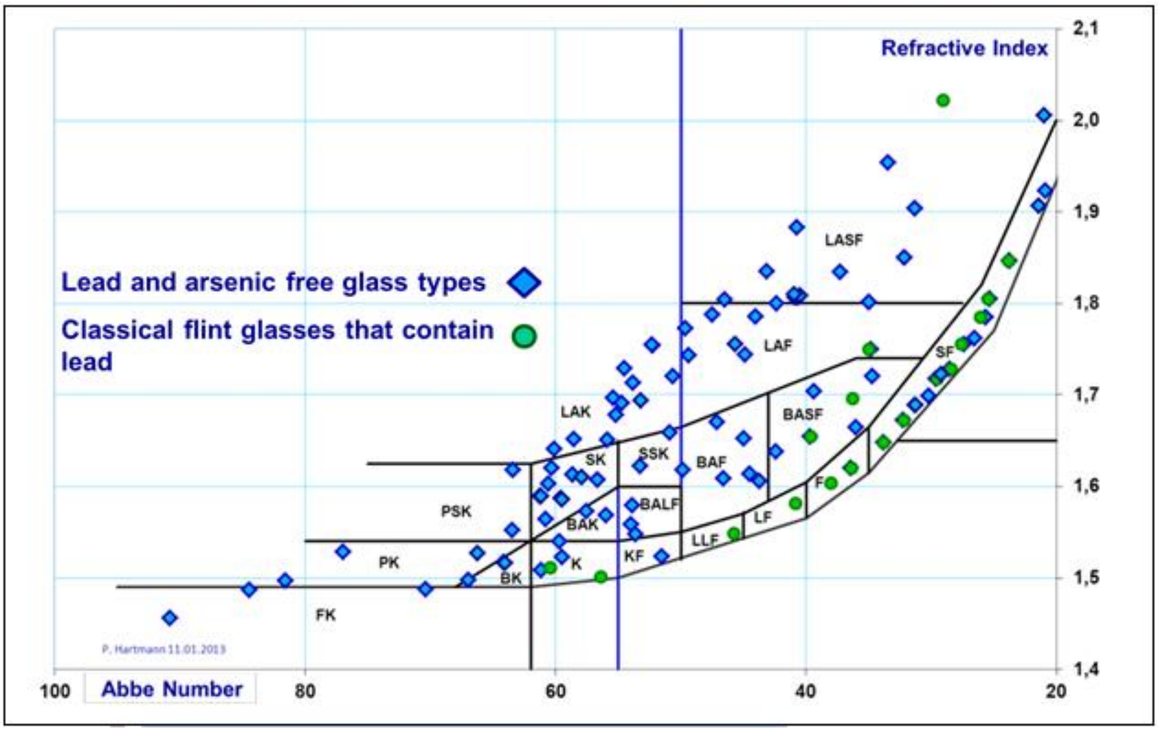
or focal length range for zoom lenses, aperture, image resolution (MTF at all focal lengths), colour trueness, high contrast, high overall transmission, field flatness (sharp image over the total area of the flat sensor chip), low intrinsic fluorescence. Many of these requirements are subdivided into detailed requirements on the different types of aberration effects (monochromatic and colour aberrations). This means that the optimization of 40 or more parameters within one design is required. There are not many degrees of freedom than can be adjusted in order to achieve the overall optimum. In optical systems, degrees of freedom include: lens curvatures, thicknesses, inter-lens distances and lens materials i.e. optical glass types.

A few examples are described below. Additional examples are explained in the original application for exemption renewal[56].

- **Refractive index and Abbe number** - The chart below shows the full range of glasses manufactured by Schott who are the only optical glass manufacturer in Europe. Marked on the chart are glasses that contain lead. Note that these include glasses with both low Abbe number and high refractive index. The figure shows several types of optical glass with high refractive index and low Abbe number. There are a few lead-free glasses with high refractive index and low Abbe number, but their other properties are different to the lead-based glasses and so are not always suitable as substitutes. Figure 7-1 shows that at most refractive index values, the lead-based glasses have the lowest Abbe number; the lead-based glasses mainly being at the right hand edge of the spread of results.

[56] Op. cit. Spectaris (2014a)

Figure 7-1: Chart Showing Schott's Range of Optical Glass,

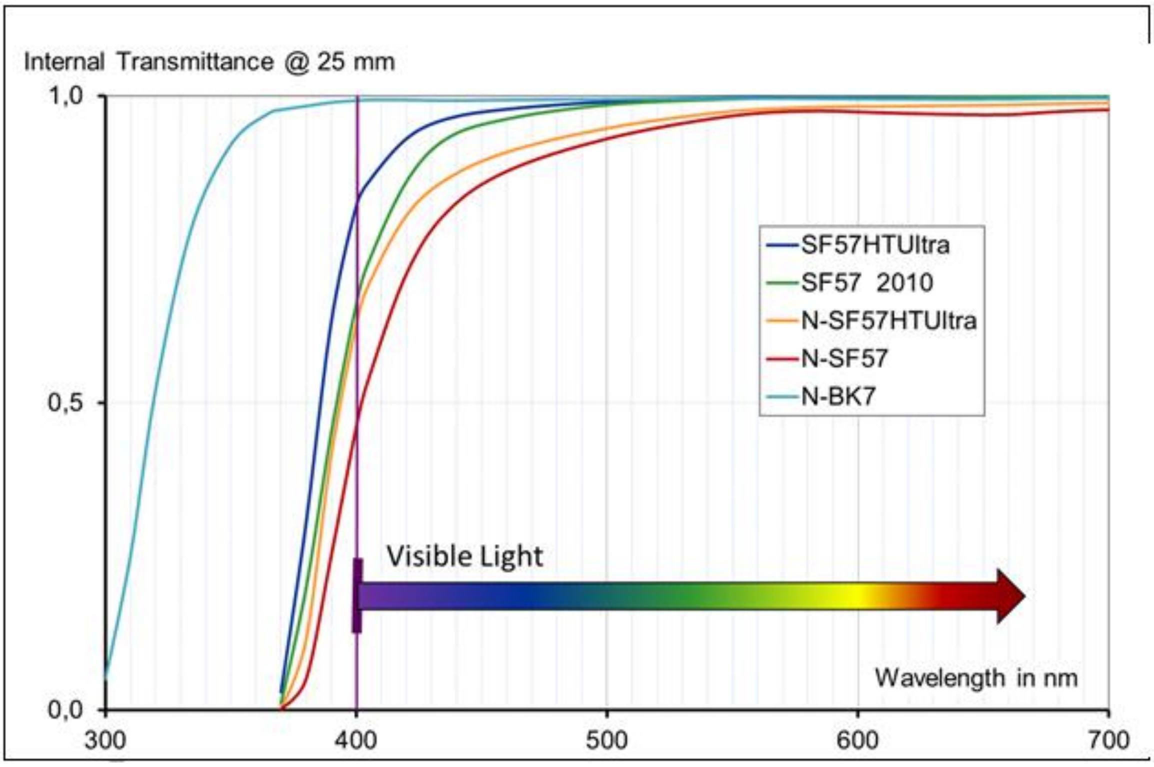


Source: Spectaris (2014a)

High percentage of light transmission at shorter wavelengths - Figure 7-2 below shows the light transmission percentage curve of five examples of glasses. SF57 and SF57HTUltra glass contain lead, whereas N-SF57 and N-SF57HTUltra are the lead-free equivalents, which have similar refractive index and Abbe number to the SF 57 versions, but with inferior blue light transmission. N-BK7(lead-free) is shown for comparison to show that even better blue light transmission can be achieved, but the other essential optical characteristics of N-BK7 make this unsuitable for many optical applications. The combinations of properties of these glasses are shown below (data from datasheets published by Schott in

Table 7-2).

Figure 7-2: Illustration of Light Transmission Versus Wavelength of Light



Source: Spectaris (2014a)

Figure 7-2 shows that SF57HTUltra has the best overall combination of optical properties: high proportion of shorter wavelengths visible light transmission, high refractive index and low Abbe number. Only glass containing lead has all of the essential characteristic needed for many optical applications.

Table 7-2: Comparison of Properties of Two Lead-based and Three Lead-free Optical Glasses

Property	SF57	SF57HT Ultra	N-SF57	N-SF57HT Ultra	N-BK7
% Light transmission at 400nm	0.847	0.924	0.733	0.830	0.997
Refractive index (589.3nm)	1.8464	1.8464	1.8464	1.8464	1.5167
Abbe number	23.83	23.83	23.78	23.78	64.17

Source: Spectaris (2014a)

7.3.1 Possible Alternatives for Substituting RoHS Substances

Spectaris[57] explains that the exemption is required because no substitute materials or designs are available that provide the required performance. Three options are considered here as potential alternative substances or designs.

- Lead-free optical glass;
- Plastic lenses;
- Alternative equipment designs;

The following detail is provided[58]:

Alternative lead-free glass - There are a limited number of elements in the periodic table available that can be combined to form optical glasses. Those combinations that exist form glasses only within relatively small composition ranges. After many decades of research, all possible combinations of elements have been prepared and evaluated and this has shown that for many applications, there are no alternatives to compositions that contain lead. As a result, the only feasible alternative for each application is to search for alternative designs, but this is usually not possible. As later explained, the glass composition does not affect reliability of EEE, only the performance and ability to provide the required functions.

Plastic lenses have very different optical and physical properties to lead-based glass. One of their limitations for many applications is their inferior heat stability when compared to glass; for example, the temperature inside projectors can reach well over 100˚C and many polymers will distort or melt at these temperatures. High refractive index (R.I.) spectacle lenses are generally stable <120˚C. The plastic lens material with the highest refractive index is MR174 (made by Mitsui) with R.I. of 1.74, though this has a heat distortion temperature of 78˚C.

Polymers also have much higher coefficients of thermal expansion (CTE) than glass so that temperature changes can cause dimensional changes altering the optical characteristics. Typical linear CTE values are:

- Glass SF57HT Ultra 9.2 × 10-6/K
- Polycarbonate 70 × 10-6/K

Most clear transparent polymers such as polycarbonate and acrylics have relatively low refractive indices (<1.6) making them unsuitable for high performance magnification applications.

A summary of the main differences between lenses made of glass and plastic lenses is provided by Spectaris in Table 7-3[59].

[57] Op. cit. Spectaris (2014a)

[58] Op. cit. Spectaris (2014a)

[59] See Spectaris (2014a)

Table 7-3: Differences between Lenses Made of Glass with Plastic Lenses

Property	Glasses	Plastics
Refractive index	1.44 to 2.1 achievable (highest for lead is 2.1)	1.49 to 1.74
Tolerance (i.e. variation in characteristics of commercial lenses)	Low (±0.0001) can be achieved, so variation is very small	Estimated at ±0.001
Abbe number	Broader range (20 to >80) especially to low dispersion values	23 – 58 is possible
Transmittance (through 3mm)	>99% achievable	85 – 91% typically
Birefringence	2 to 10 nm/cm	2 to >40 nm/cm
Density	Lead-based are ca. 5 g/cm^3. This offers advantages and disadvantages	1 – 1.2 g/cm^3
Water absorption	Zero (so moisture has no effect on performance)	All plastics absorb water causing changes to properties (as they swell) and also potentially degradation can occur. From 0.01% to 0.3%
Thermal expansion	SF57HT Ultra is 9.2×10^{-6}/K, all glasses 4.5 to 13×10^{-6}/K.	Range is 47 to 80×10^{-6}/K. This causes optical changes with temperature and thermal degradation
Refractive index thermal dependence	Smaller range of - 0.7 to + 1.2 $\times 10^{-5}$/˚C	-8 to -14 $\times 10^{-5}$/˚C
Resistance to damage	Relatively hard, so not easily damaged	Soft so easily scratched
Exposure to UV light	No effect	Discolours and degraded
Heat resistance	Resistant to temperatures created by lamps and laser light sources	Lamps and lasers can easily cause deformation or even make holes
Medical sterilisation	Completely resistant	May be damaged at sterilisation temperature. Viruses and bacteria can survive within scratches which plastics are more prone to than glass
Thermal conductivity	Lead-glass is relatively high so equilibrates faster than lead-free glass and plastics	Slow to equilibrate so can distort due to uneven heating

Source Spectaris (2014a)

Different designs of equipment, which do not include leaded glass, may provide the same function and performance as that of equipment including leaded optical glass, but such alternatives are not always available. As described, leaded glass is used in a very wide variety of applications and alternative designs are not available (and are also not likely to become available) with equivalent performance for a large variety of applications. One example described above is of LCOS projectors. Alternative designs of projectors are widely used, but it is acknowledged that LCOS designs give the best optical performance.

Spectaris[60] summarizes that for all applications, research has already been carried out, and where lead-free substitutes were found, they have been applied to enable substitution. Further research into alternative designs is uncertain and may never be successful, due to the demanding combinations of essential characteristics. Therefore, it is not possible at present to predict how long this type of R&D will take or whether substitutes can be found for all of the diverse applications. It is very possible that it will never be possible to replace leaded glass in all applications.

Spectaris[61] explains in a later communication why it assumes that alternatives have been applied where possible, and particularly in applications purchased primarily by private consumers. In the 1990s, all large optical manufacturers introduced lead-free glass types with optical properties as close as possible to those of the preceding lead-containing glass types. The lead-free glass types were required by the consumer optics market, which asked for eco-friendly cameras. By the end of the 1990s there was hardly any lead-containing glass used for consumer optics, which has the largest share of glass usage by far. Companies, which could not afford developing the lead-free glasses, went out of business. Nowadays lead-containing glasses are used only for cases, where there are no alternatives to achieve the optical performance. This restricts their use to special high-end applications. The production of lead-free glasses since then is larger than that of lead-containing glasses by far. In this respect, the following examples are detailed:

- All consumer optics from pocket cameras to DSLRs (digital single lens reflex) uses only lead-free glasses.
- Industrial optical systems without special performance requirements also use lead-free glasses.
- A large part of pocket cameras has been replaced by smartphone cameras using mainly plastics optics. However, this has nothing to do with lead since this had been replaced already before.

7.3.2 Environmental Arguments

Spectaris[62] explains that electrical equipment sold primarily to consumers contains very little optical glass in which Pb is present, as such materials are primarily used in B2B products. WEEE from used EEE devices is collected and treated according to the WEEE Directive. Specific collection systems for optical glass, not to mention closed loop systems, do not exist, due to the very large variety of applications. Optical glass is used as small components of electrical equipment, which follows a variety of routes at end of life. Some EEE are refurbished and then sold to second users and some will

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60 Op. cit. Spectaris (2014a)

61 Op. cit. Spectaris (2015a)

62 Op. cit. Spectaris (2014a)

be recycled, although glass parts are usually not removed before metal recovery processes. A small remaining proportion might be landfilled.

Spectaris[63] notes that optical glass containing Pb is used for spare parts to repair and refurbish equipment. The availability of these types of glass depends on a healthy market for new products, as optical glass production cannot be scaled-down. Manufacture of lead-based optical glass on a small scale is impractical as it is too difficult to precisely control the glass composition and the optical properties of the glass. If lead-based optical glass were permitted for use only to make spare parts, this glass would have to be made in much larger batch sizes than the amount of glass needed for spares to ensure that optical properties do not change. This would consume energy and raw materials to make glass that may never be used, and so additional waste would be created. If no more lead glass is to be manufactured as a result of the expiration of exemption 13a, it will not be possible to repair used equipment that requires these types of glass as replacement spare parts and so these would become waste.

Spectaris[64] further provides details as to the impact of lead in the various life cycle phases as follows. Detailed information is available in the exemption application:

- Up-stream impacts are not expected in the mining and extraction phase in light of the negligible amount of Pb used for optical glasses in EEE in comparison with the total global consumption (0.01%).
- Emissions are also not to be expected from manufacture to any significant degree, as such emissions are controlled to comply with regulation for the prevention of such impacts (e.g., the Industrial Emission's Directive (IED) 2010/75/EC).
- During the use phase, optical glass is very stable and inert, with 100% of the Pb content remaining within the glass under normal use conditions of EEE.
- At end of life, optical glass from WEEE may be either landfilled with the WEEE (i.e. no recycling), or subject to the WEEE recycling process with other electrical equipment. Glass is relatively heavy so after dismantling, shredding, physical separation by density, etc. the glass is likely to occur in the metals fraction. Scrap metals have a value and so are usually recycled thermally. Scrap metals may simply be heated to melt them or are heated with reducing agents such as carbon to convert oxides to metals. Simply heating will melt the glass, which will mix with other non-metallic and non-volatile materials, to form a "slag" that is inert and sent to landfill. Lead will not leach out of this material. Under reducing conditions such as in a smelter used to recover copper from printed circuit boards, some lead compounds may be reduced to lead metal, which is volatile and thus collected and treated as a hazardous waste. Lead is present in feedstocks of WEEE recycling from many materials other than optical glass

[63] Op. cit. Spectaris (2014a)

[64] Op. cit. Spectaris (2014a)

filters, thus collection and disposal are expected to occur whether there is lead present in optical glass or not.

- The behaviour of lead in landfill is very complex as it (and other metals) can react with other constituents to form various compounds. A report by the European Environment Agency states that measurements of leachate from EU landfill sites have found that lead is… “not generally present at significant concentrations”.

7.3.3 Socio-economic Impact of Substitution

Spectaris[65] expects that a revocation of the exemption would be likely to result in negative impacts on the environment (where equipment is used for monitoring environmental compliance) and on health (as many applications are used in medical equipment). It is also explained that if all current optical designs would have to be redesigned (i.e. revocation of exemption 13a), since alternatives currently do not exist and cannot be envisaged from current technology, a huge effort in R&D would be required from the optical industry to develop useful and long lasting products for users of optical glass. If this is to be the case, it is estimated that significant money would have to be withdrawn from R&D funds that were intended for innovative new products (such as Horizon 2020 funds) to look for substitutes, without a guarantee of success.

Spectaris also notes that it considers it preferable to look for new optical solutions (instead of alternative materials, which have been extensively researched), since optical techniques and products are a key enabler for many other industries.

7.4 Stakeholder Contributions

During the stakeholder consultation, contributions were made by three stakeholders:

- **Bosch Security Systems GmbH**[66] supports the exemption request. Bosch is a specialist for safety and security solutions, fire and intrusion detection, video surveillance, and other applications. In this area, a large variety of cameras are needed with different or combined properties like indoor, outdoor, high temperature ranges (e.g. -60 °C to +60 °C), day-and night, high resolution and fast moving detection (e.g. car number plate detection at night and day up to 225km/h) or long distance detection up to 3.9 km. For all cameras, excellent lenses are needed. Those cameras need to have compact and at the same time fast and high translucent object lenses. To achieve this high refractive glasses are required because otherwise object lenses will become bigger and less translucent (using glasses with a lower refraction index need more lens combinations which makes the object lens bigger, heavier and less

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65 Op. cit. Spectaris (2014a)

66 Bosch (2015), Bosch Security Systems GmbH, Contribution to Stakeholders Consultation Regarding Ex. 13a, submitted per email 21.5.15, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/20150521_Bosch_Stakeholder-contrubution-Exemption-request-13a.pdf

translucent). To achieve lenses with higher refractive index, lead additives are mixed in the glass used at present. Based on the information of our supplier, there are today no alternatives available.

- **Fraunhofer Institute for Applied Optics and Precision Engineering** (FH IOF)[67] also fully agrees with the scope and the text proposed by the applicant. FH IOF explains that Photonics is indispensable – not only to our society, but also to innovations and growth in Europe. Photonics is an enabling technology in nearly all application areas; it is used in production, security, consumer products, space applications, automotive, health, mobility, sensing, digital communication, IT, lighting and much more. Photonics needs optical systems, which mostly contain optical glasses with specifically defined physical properties. These properties (dispersion, refractive index, etc.) are determined exclusively by the chemical composition of the glass. Lead-oxide based glasses have particular properties and are absolutely indispensable in many applications. In fact, lead glasses are an enabler to achieve defined optical properties and functionality. Without these properties, many applications could not be realized. Thus lead is essential for photonics and its ongoing economic success in Europe. In fact, advances in optical technologies are strongly driven by the desire for more resource efficiency in economic and societal processes and are thus linked to the reduction of the resource footprint to Europe's society as a whole. As already described in the exemption request, for most applications there exists no alternatives for using lead-containing optical lenses. There is ongoing research (since years) to find substitutes, but up to now no substitutes for all lead-containing optical glasses have been found.
- The **Japan Business Council in Europe (JBCE)**68 also supports the request and mentions the lack of substitutes for many applications. Furthermore, JBCE highlights that exemption 13(a) in annex III can be applied to category 8&9 products for seven years from the identified date s, from which such categories needs to comply with the substance restrictions, at the earliest this period shall end in July 2021. JBCE refers in this respect to the EU COM FAQ document.[69]

[67] Fraunhofer IOF (2015), Fraunhofer Institute for Applied Optics and Precision Engineering, Contribution to Stakeholders Consultation Regarding Ex. 13a, submitted per email 15.6.15, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/Contribution_FhG_13a.pdf

[68] JBCE (2015), Japan Business Council in Europe, Contribution to Stakeholders Consultation Regarding Ex. 13a, submitted per email 19.6.15, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/20150619_JBCE_Ex_13a_comment_on_public_cousulation_of_Exemption_request_2015-1_13a.pdf

[69] JBCE refer to Q 9.1 "What is the difference between RoHS 1 and RoHS 2 regarding requirements for exemption?" of "RoHS2 FAQ" as follows: http://ec.europa.eu/environment/waste/rohs_eee/pdf/faq.pdf

7.5 Critical Review

7.5.1 REACH Compliance - Relation to the REACH Regulation

Appendix A.1.0 of this report lists entry 28 and 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 28 and entry 30 of Annex XVII does not apply to the use of lead in this application. Pb used in white glasses for optical applications, 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. Pb is part of an article and as such, entry 28 and entry 30 of Annex XVII of the REACH Regulation would not apply.

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

7.5.2 Scientific and Technical Practicability of Substitution

Spectaris' main argumentation relates to the lack of substitutes for lead in in white[70] glasses used for optical applications. Although three possible routes for substitution are described, it is explained that possible substitutes that have been found are still not sufficient to allow for the elimination of the need for lead in white optical glasses in the full product range. Though substitutes are said to have been applied where they were found, it is also communicated through a long list of applications, that there is still a wide range of applications in which the use of lead is currently unavoidable. This is explained to be a result of the very diverse range of properties that the use of lead as an additive in various glass mixtures enables,

as detailed in Section 7.5.2. The consultants can follow that in certain cases, a unique combination of properties which depend on the use of lead in the formulation of white glasses, may not be obtainable with the use of other substances or when using plastic lenses or technological alternatives. However, as it can also be

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70 The reference to white glasses is based on the use of this term in the current exemption formulation. At a Stakeholder Meeting held with Spectaris on 28.8.2015, examples of such glasses were shown among others also demonstrating that glasses, when observed from the side are translucent but not transparent (or appear to be „white“ or frosted) as opposed to filter glasses addressed under Ex. 13b which remain transparent.

understood that in many cases, where substitutes were found, they have been applied, it has been assumed that the wording of the exemption could be amended to reflect the actual areas of application, where the use of lead is still indispensable. Spectaris was thus asked to explain if the scope of the exemption could be adjusted to reflect the current market situations through the exclusion of consumer products or through the specification of a refractive index threshold.

Spectaris[71] explains that it is not possible to exclude consumer products as a whole, based on the assumption that they do not rely on lead-based glasses. For instance, a sophisticated photographic lens, which may be used by a professional photographer and which contains lead-based glasses, may also be used by a consumer as a consumer optical device. The same is true for binoculars, digital projectors etc. It would also not be feasible to exclude specific sub-groups or products (e.g., other-than-professional photography equipment) since many products containing lead-based glass and used by professionals may also be used by normal consumers. See also Appendix A.3.0 for additional examples.
Spectaris[72] also explains that specifying a refractive index range would also not be possible, since the optical designers need the whole parameter range from the Abbe Diagram (as presented in Figure 7-1), meaning the full range of glasses in the glass map with respect to refractive index and Abbe number. Further technical information is detailed in the exemption application and the separate technical document accompanying the exemption application.

A meeting was held with Spectaris on the 28 August 2015 to discuss the various aspects of the exemption that were still open. Among others, Spectaris was asked to explain if certain properties could not be identified as critical for applications of lead in white optical glasses, and if for such properties a performance threshold could not be specified above or below which lead would need to be applied to fulfil the respective requirements. Spectaris explained that this would not be practical in light of the long list of relevant properties, that wold make this task very complex. In this regard, it was elaborated that the different performance requirements in relation to such properties in various applications and the further inter-dependencies that exist between some of these properties in some cases would make this task even more complex. To further support this view, Spectaris[73] submitted the following table:

71 Spectaris (2015b), Answers to 2nd Round of Clarification Questions, submitted per email 7.8.2015

72 Op. cit. Spectaris (2015b)

73 Spectaris (2015c), Answers Regarding Last open Issues Following Stakeholder Meeting of the 28.8.2015, submitted per email 4.9.2015

Table 7-4: Lead-containing Optical Glasses – Optical Systems Applications Depending on the Special Properties of Lead-containing Optical Glass Types,

Applications in optical systems requiring the special properties of lead-containing optical glasses, which cannot be replaced by lead-free types:
xx – critical for function;
x – must also be fulfilled together with critical requirement, e.g.: High transmission together with specific index of refraction and dispersion;

	High refractive index	Special Dispersion characteristics	High change of refractive index with temperature	High trans-mission in blue to UV range	Very low birefringence at high temperature gradients	Producibility in large sizes (> 250 mm)	Extremely high homogeneity in large items	High Faraday effect (Verdet-constant)	High density	Thermal expansion coefficient
Fluorescence microscopy	x	x		xx						
Surgical microscopes	x	x		xx						
Laserscanning microscopy	x	x		xx						
Digital projection	x			xx	xx					
Binoculars, telescopes	x	x		xx						
Temperature stabilized lenses (printing machines)	x	x	x	xx	xx	xx	x			x
Photographic lenses	x	x		xx						
Cinematographic lenses television lenses	x	x		xx						
Photolab equipment	x	x		xx	x					
i-line microlithography	x	xx		xx		xx	xx			
x-ray imaging optics	x	x		xx					x	
Endoscopes medical and technical	x	x		xx						
Ophthalmic instruments	x	x		xx						
Microbiology optical instruments	x	x		xx						
Spectrometers for food watch and environment surveillance	x	x		xx						
Polarimeters	x	x		x				xx		
Glass fibres for high quality illumination	xx			xx						
Atmospheric dispersion correction (Astronomy)	x	xx		xx		xx	xx			
Astronomical telescopes transfer optics	x	x		xx		xx	xx			
Periscopes	x			xx		xx	xx			
CNC video measuring systems (bright illumination)	x	x		xx	xx					
Laser optics for commercial printers	x	x		xx	xx	xx	x			

Source: Spectaris (2015c)

7.5.3 Environmental Arguments

Spectaris[74] provides some information regarding environmental impacts related to the manufacture, use and end-of-life of lead in white optical glasses. As the information does not compare the performance of lead-based glasses with possible alternatives, it would not allow concluding as to how lead-based glasses compare to possible alternatives. In this respect the information does not allow concluding if the third criterion specified in Article 5(1)(a) of the Directive (see Section 7.5.5 below for detail) is fulfilled and is not further discussed here.

7.5.4 Stakeholder Contributions

Three stakeholders have expressed their support of the requested exemption renewal, including its proposed exemption wording and duration. Though some of the contributions provide detail as to applications for which the exemption is understood to be indispensable at present, it does not add to the information regarding possible substitution candidates that exist at present or that may be developed in the future. In the case of Bosch and JBCE, this is understood to be a result of the stakeholders being users of lead-based optical white glasses. Though it is possible that FH IOF also participate in optical research and thus also in research into possible substitutes, detailed information has not been provided in this regard. The supporting contributions are thus noted but not further discussed.

7.5.5 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, based on the information provided by the applicant, it can be concluded that the elimination and the substitution of Pb in white optical glasses is currently not practical for the full range of applications. Though it is explained that where possible, alternatives have been developed and applied, it is understood that a large part of the potential for substitution has already been realised and that the development of further alternatives, and their implementation as such, is likely to prove more challenging and more time-consuming. In this sense, the first criterion mentioned above is fulfilled, and would justify the renewal of an exemption.

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74 Op. cit. Spectaris (2014a)

Though it can be understood that in many areas substitutes have been found and applied, it can also be accepted that this does not provide a basis for restricting the scope of the exemption to a more narrow range of applications. Existing applications rely on lead to provide a wide range of properties. For these properties, various performance levels may be required and interrelations between the properties needed for specific applications also vary widely, so that amending the scope on this basis would be complicated and impractical. It was also not possible to determine a certain group of applications such as consumer applications that could be excluded as even with professional equipment, in many cases, there may still be cases where private consumers purchase professional equipment.

As for the requested duration of the exemption, it can be followed that where finding substitutes was relatively straightforward, this has occurred in the past and substitutes have been implemented instead of Pb based white optical glasses. It can also be followed that finding alternatives for remaining applications shall be more complicated and more time consuming in the future. On this basis, the requested duration of 5 years, for category 1-7, 10 and 11 is perceived as justified.

At present, EEE falling under categories 8 and 9 has only started to come into scope. According to Article 5(2) it can be understood that the duration of exemptions listed in Annexes III and IV, for these categories, only begins once the categories come into scope, subsequently valid for 7 years, as long as substitutes cannot be determined that could be applied, making the exemption obsolete. In the consultants' perspective, a distinction could currently not be made between applications falling under these categories and applications falling under categories 8 and 9 in terms of properties enabled through the use of Pb and in terms of the applicability of substitutes. In this sense it would be recommended in the future to perform joint evaluations of the exemption for all categories, and where applicable to arrive at mutual recommendations regarding exemption wording and duration. As in this case, it can be understood that the state of substitution would not allow for changing the exemption scope (excluding certain product groups), the consultants currently do not see a need to discuss possible change to the exemption duration for these categories other than those prescribed in article 5(2) of the Directive. It is however worth noting; that consideration should be given in future reviews to the possibility of aligning exemption durations of all categories with time, to allow the evaluation process to be more efficient and to be carried out less often.

7.6 Recommendation

As explained, the consultants can follow that in light of the lack of sufficient alternatives to allow for substitution or elimination of the need for lead in white optical glasses in the full product range, an exemption would be justified in line with the Article 5(1)(a) criteria. The consultants thus recommend granting a renewal of exemption 13a as follows:

Exemption	Duration*
Lead in White Glasses Used for Optical Applications	For Cat. 1-7 & 10: to expire 21 July 2021
	For Cat. 8 and Cat. 9: to expire 21 July 2021
	For Sub-Cat. 8 in-vitro: to expire 21 July 2023
	For Sub-Cat. industrial: to expire 21 July 2024

*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 have been newly included into the scope.

7.7 References Exemption Request 13a

Bosch (2015) Bosch Security Systems GmbH (2015), Contribution to Stakeholders Consultation Regarding Ex. 13a, submitted per email 21.5.15, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/20150521_Bosch_Stakeholder-contrubution-Exemption-request-13a.pdf

Fraunhofer IOF (2015) Fraunhofer Institute for Applied Optics and Precision Engineering (2015), Contribution to Stakeholders Consultation Regarding Ex. 13a, submitted per email 15.6.15, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/Contribution_FhG_13a.pdf

JBCE (2015) Japan Business Council in Europe (2015), Contribution to Stakeholders Consultation Regarding Ex. 13a, submitted per email 19.6.15, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/20150619_JBCE_Ex_13a_comment_on_public_cousulation_of_Exemption_request_2015-1_13a.pdf

Spectaris (2014a) The German High-tech Industry Association (2014a), Original Application for Exemption 13a, submitted 11.11.2014, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/Spectaris_Exemption_Renewal_Request_13a_Final.pdf

Spectaris (2014b) The German High-tech Industry Association (2014b), Additional Technical Information for exemption 13a renewal request – Charachteristics of optical glass needed for high performance systems, submitted 11.11.2014, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/Spectaris_Exemption_Renewal_Request_13a_Additional_Facts_Final.pdf

Spectaris (2015a) The German High-tech Industry Association (2015a), Answers to 1st Round of Clarification Questions, submitted per email 11.3.2105 and available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13a/150311_Ex_13a_Clarification-Questions_Answers.pdf

Spectaris (2015b) The German High-tech Industry Association (2015b), Answers to 2nd Round of Clarification Questions, submitted per email 7.8.2015

Spectaris (2015c)	The German High-tech Industry Association (2015c), Answers Regarding Last open Issues Following Stakeholder Meeting of the 28.8.2015, submitted per email 4.9.2015

8.0 Exemption Request No. 13b: Cadmium and Lead in Filter Glasses and Glasses Used for Reflectance Standards

Abbreviations

Cat.	Category
Cd	Cadmium
EEE	Electric and electronic equipment
Pb	Lead
Spectaris	The German High-tech Industry Association (Der Deutsche Verband der Hightech Industrie)

8.1 Background

According to Spectaris[75], optical filter glasses, containing cadmium and lead, are used in a wide variety of optical applications and in many types of electrical and electronic equipment. There are many types of optical filter glasses which contain cadmium, but only a few which contain lead. Spectaris raises a few key characteristics that make the use of these two elements indispensable for certain filter glass applications:

- Cd and Pb are used because of the unique optical properties that their use enables, such as "sharp cut-off" in the visible spectrum that is unaffected by viewing angle. Most of the alternatives to glass containing cadmium and / or lead do not exhibit such sharp wavelength "cut-offs". Interference filters do have sharp cut-offs but the wavelength at which this occurs is viewing angle dependent and so these are unsuitable for many applications.
- Both Cd and Pb allow manufacturing optical glasses that remain very stable in harsh environments, such as heat, moisture, UV light, etc. In comparison, most of the apparent alternatives are detrimentally affected by such harsh environmental conditions, making them unsuitable for many applications.

In light of the lack of substitutes, Spectaris requests the renewal of Ex. 13b of Annex III of the RoHS Directive as follows:

> *"Cadmium and lead in filter glasses and glasses used for reflectance standards"*

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75 Spectaris (2014a), The German High-tech Industry Association, Original Application for Exemption 13b, submitted 11.11.2014, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13b/Spectaris_Exemption_Renewal_Request_13b_Final.pdf

The exemption is requested with the same wording, however Spectaris[76] explains that the application does not describe reflectance standards, which are also included in the scope of the existing exemption, as these are different to optical filters in terms of applications, materials and function. Spectaris expects justification for renewal of the part of the exemption scope relevant to reflectance standards to be provided by manufacturers of such standards. Concerning the duration of the exemption in the future, an exemption without an expiry date is requested[77]. The consultants understand this request to target an exemption with maximum allowed duration, which according to Article 5(2) of the Directive is between 5 to 7 years, depending on the Annex I category of applications of relevance.

8.2 Description of Requested Exemption

Sections 7.1 through 8.4 are heavily based on information provided by the applicant and other stakeholders and do not necessarily reflect the view of the consultants. Spectaris[78] explains optical filter glasses to be clear transparent non-crystalline materials with a variety of compositions. Traditionally "glass" has been understood to consist of complex inorganic silicates based on a variety of ingredients such as sodium, barium, calcium, potassium, boron, arsenic, antimony and lead but there are many diverse compositions of materials that meet the definition of "glass". Filter glasses are used in many types of EEE (as well as non-electrical applications) and a selection of illustrative example applications based on the information provided by Spectaris[79] is listed in Table 8-1 below.

Table 8-1: Examples of Applications Using Cadmium or Lead in Filter Glasses Covered by Ex. 13b

Category	EEE Application
Cat. 3	Attenuation or separation of undesired wavelengths in telecommunication by separation of undesired wavelengths transmitted by coated filters; Spectral filters for photographic cameras; Security and surveillance applications, e.g. infrared illumination with filters that suppress visible light (specified as possibly cat. 9)
Cat. 4	Colour channel separation for colour television; High performance cameras
Cat. 5	Airport runway lamps that indicate the runway location (specified as possibly cat. 9)
Cat. 6	Bar code readers; Light barriers for motion control in electrical machinery
Cat. 8	Fluorescence microscopes; Medical colposcopes
Cat. 9	Environmental monitoring equipment; Traffic monitoring-cameras (speed limit) and toll monitoring systems; Fluorescence microscopes
Other categories	Cadmium and lead filter glasses may also be used in many other types of equipment, such as lighting applications, toys and leisure products and automatic dispensers

Compiled on the basis of information provided in Spectaris (2014)

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76 Op. cit. Spectaris (2014)

77 Op. cit. Spectaris (2014)

78 Op. cit. Spectaris (2014)

79 Op. cit. Spectaris (2014)

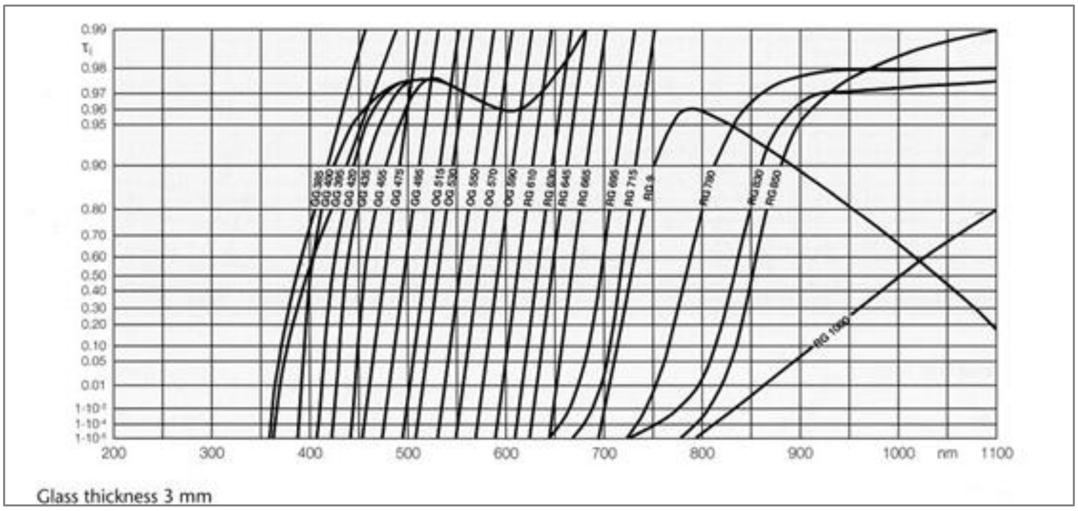
In filter glasses, Spectaris[80] explains Cd to be present at up to 1.5% by weight and Pb to be present at up to 40% by weight. It is estimated that 172 kg of cadmium and 14kg of lead are placed on the EU market per annum through such applications. These quantities are calculated on the basis of the total glass manufactured globally per annum (containing Cd or Pb, respectively) and the share of this glass placed on the EU market per annum. The cadmium content of filters varies from 0.4 to 2% and on average is 0.43%. The lead content is estimated to be 15% PbO or 14% Pb and is associated with only one type of glass filter (VG9, based on the Schott name for this glass).

8.3 Applicant's Justification for Exemption

The essential characteristics that Cd and Pb give to glass optical filters are as follows:

Cadmium in filter glasses – Coloured filter glass is obtained by a variety of metallic additives, but a steep cut-off as shown in Figure 8-1 can be obtained only by cadmium compounds. [81]

Figure 8-1: Optical Transmission Spectra of Cadmium-based Glass Filters



Source: Spectaris (2014);
Note: Vertical Axis = internal transmission (t), horizontal axis = wavelength (nm)[82]

Spectaris[83] states that the function of Cd in optical glass is to absorb light at wavelengths shorter than a specified value and to allow all light of longer wavelengths to

[80] Op. cit. Spectaris (2014)

[81] Op. cit. Spectaris (2014)

[82] Axis labels confirmed with applicant per email: Spectaris (2015 d) Der Deutscher Verband der Hightech Industrie Answers to 3rd Round of Clarification Questions, submitted per email 14.10.2015.

[83] Op. cit. Spectaris (2014)

be transmitted through the filter. By adjusting the quantities of other constituents (S, Se and Te), red, orange and yellow filter glasses are produced from Cd, which are used to absorb wavelengths from ca. 400nm. A red filter allows only red light to pass whereas an orange filter allows red and orange light to pass. An important characteristic of cadmium-based optical filters is the difference in optical filtering above and below the cut-off wavelength. Cadmium filters can be designed, to absorb almost 100% of light having wavelengths shorter than the cut-off value, and to transmit above 95% of the light with longer wavelengths. Furthermore, the range of wavelengths between 95 % transmission and <1% transmission[84] can be designed to be relatively small, so that these filters are classified as “steep-edge” filters. Spectra obtained from optical filters that contain Cd, manufactured by Schott (Germany) are shown in Figure 8-1 above. Sharp cut-offs can be designed in a filter glass at most wavelength values by control of the Cd compound composition and the heat treatment conditions of the glass. A few of the curves in the figure above have different shapes to achieve specific absorption profiles: these are achieved by adjusting the ingredients in the filter glass. [85]

These types of optical filter are also called "striking" glass and are made by adding the cadmium compounds to molten glass based on K_2O, ZnO and SiO_2. The cadmium compound initially appears to disperse to give a colourless clear glass. This is then heated to nucleate and crystallise very small (sub-micron), coloured cadmium chalcogenide particles that are dispersed in a colourless matrix. The heat treatment temperature, time and cooling rate are all used to control the particle size which, in turn, affects the cut-off wavelength and the steepness of the cut-off. Research has shown that some zinc is present in the cadmium chalcogenide particles and some cadmium remains in the glass matrix, the amounts depending on the cooling rate. As well as giving a steep edge, cadmium compounds give very low transmission at wavelengths shorter than the steep edge and very high % transmission at longer wavelengths. This is important for many applications as this prevents image distortion effects such as “flare” (stray light) and “ghosting” (a second feint image). [86]

Spectaris[87] explains the key property of Cd to be related to its semi-conductor characteristics: The steep slope effect is based on the semiconductor electron band gap characteristic of the microcrystals formed by the cadmium compounds. In order to cross the gap, electrons must have energy higher than the threshold value given by the gap width. For the glass type GG495 e.g. this energy lies at 2.5 eV. All light with

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[84] Absorbing or blocking 100% is understood to translate to a transmission of less than 1% - consultants comment.

[85] Op. cit. Spectaris (2014)

[86] Op. cit. Spectaris (2014)

[87] Spectaris (2015a), Answers to Clarification Questions, submitted on 11.3.2015 and available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13b/150311_Ex_13b_Clarification-Questions_Answers.pdf

higher energy will be strongly absorbed. Just below this energy, electrons do not surpass the gap and light will be fully transmitted. This semiconductor property of its microcrystal lying in the desired energy range (and even allowing adjusting the gap width and thus the absorption edge position with a temper process) is reported to be absolutely unique for the cadmium chalcogenides. No other compounds performing this function have been found.

Lead in filter glasses – The classical way to colour glass is by adding colouring ions to a glass matrix. These are usually metal ions such as iron, copper, nickel, cobalt and chromium. The colour achieved depends on the valence of the metal ion and on its surrounding glass matrix ions. Consequently, there is limited freedom for choice of a metal ion / glass matrix combination for best performing glass filters. The green glass filter VG9 is the last remaining type[88] of a family of VG glasses coloured with chromium III and copper II ions in a lead silicate glass matrix. [89]
Spectaris elaborates that VG9 is a representative of an alkali lead silicate glass type family coloured by a small amount of copper and chromium III ions. It is a band pass green filter glass. A known application is as colour calibration standard in industry. There are many other applications but usually in very small amounts and not retraceable by Schott. Based on the transmission curve, Spectaris concludes that the Hoya glass type G 550 might also be a lead silicate green filter glass.[90]

The lead content of VG9 is 15 % lead oxide. It is the only green filter glass type in a portfolio of 58 glass types. Its usage, at about 250 kg/annum is considered by Spectaris to be very low. To demonstrate the unique qualities of lead-based filter glasses, Spectaris explains that one application of lead-based optical filters is in fluorescence microscopes, where it is used to transmit only the desired wavelengths. This needs to be independent of viewing angle. [91]

Spectaris[92] explains that like all filters, band pass filters such as VG9 should exhibit a very steep edged absorption spectrum profile in order to separate the desired transmitted light from the undesired light, which is to be strongly blocked. The separation should occur at well-defined wavelengths. Comparison of the ideal filter characteristics with real filter glasses shows that they do not reach 100% trans-mittance and edges are smooth. The task in developing such glasses is to find compositions leading to the steepest slopes and thus the highest transmission. Mineral filter glasses consist of a base glass and colouring chemical elements, however choosing combinations cannot be arbitrary and only a few elements exhibit the required light absorption bands.In the case of VG9 these are copper and

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88 The consultants understand this to mean that it ist he last remaining type of glass containing Pb still sold on the EU market at present.

89 Op. cit. Spectaris (2014)

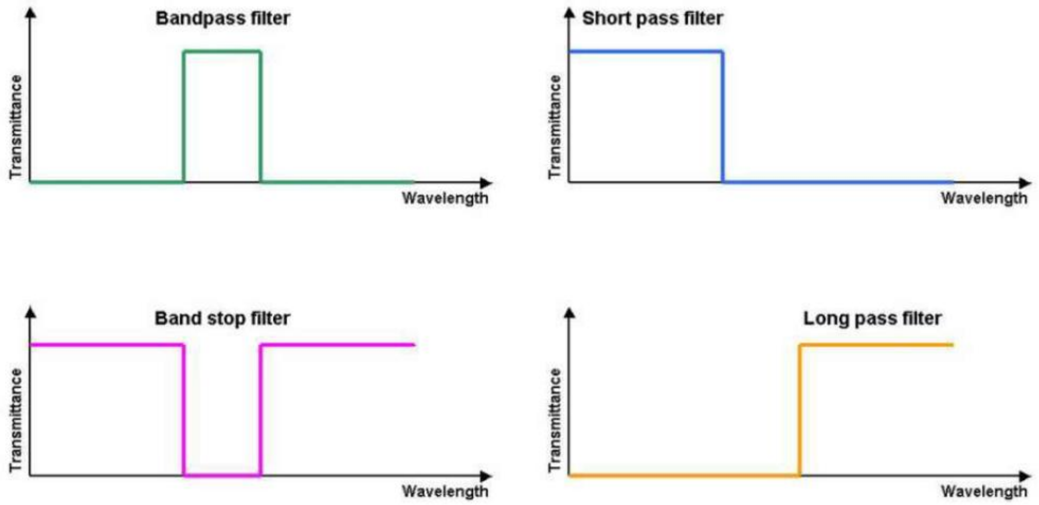
90 Spectaris (2015b), Answers to 2nd Round of Clarification Questions, submitted on 24.8.2015

91 Op. cit. Spectaris (2014)

92 Op. cit. Spectaris (2015a)

chromium III in combination. In different base glasses, the absorption bands of these colouring agents will shift in position and vary in width. For VG9, the optimised base glass is a silicate glass with 15% lead ocide[93] in its composition – other variants decrease the quality of filter characteristics.

Figure 8-2: Ideal Filter Characteristics (in reality all filters are only approximations to these desired characteristics)



Source: Spectaris (2015b)

8.3.1 Possible Alternatives for Substituting RoHS Substances

Spectaris argues that the exemption is required because no substitute materials or designs are available that provide the required performance.

Cadmium in filter glasses: Striking glasses with cadmium are not colloidal dispersions and so the colour of the individual particles is important for the optical characteristics. A steep edge cannot be obtained by colloidal dispersions that are red in appearance. Research has also shown that the steepness of the absorption edge increases during heat treatment and the steepness is a characteristic of the cadmium chalcogenide particles. Alternative sulphides such as antimony, lead, copper, etc. can give ruby red glass but these all form dispersions of colloidal particles and the glass does not exhibit the steep edge obtained only by cadmium compounds. 3d-metals[94] such as Fe, Mn, Ni, etc., when added to glass dissolve in the glass to form ionic complexes within the matrix, the colour depending on both the metal ion and the

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93 Presumably, lead oxide – consultants comment.

94 Explained by applicant in later communication as follows: „3d elements are transition elements in the periodic table of the elements, which are inserted into the 3rd period. The "d" stands for the d-electron shell of these elements.“ Spectaris (2015 d) Der Deutscher Verband der Hightech Industrie Answers to 3rd Round of Clarification Questions, submitted per email 14.10.2015.

structure to which it is bonded. These all however have shallow absorption edges unlike cadmium-based filters. [95]

According to Spectaris[96], there are three types of potential alternative optical filters that are used for some applications, although these cannot replace cadmium-based optical filter glass where it is used, due to its essential characteristics. These are:

- **Alternative additives to the glass** – In order to obtain the same optical properties, alternative inorganic compounds would be needed that are thermally stable at the melting temperature of the types of glass used (therefore all organic pigments cannot be used) and that provide the same optical spectrum with the same steep edge. Research has been carried out for many decades to look for alternatives to cadmium, but with no success. The range of elements and their combinations that are suitable is limited and the following aspects have been addressed:
    - Industry is limited to the naturally occurring non-radioactive elements of the periodic table. The additive must be a compound with two or more elements which must be at least one metal and (to match the performance of cadmium) also one non-metal.
    - The compound must be coloured which eliminates many metallic elements. Many of the transition metals and rare earth metals will colour glass but none give the same optical characteristics.
    - Non-metals could be O, N, S, Se, Te, P, As or Sb. Halides are unsuitable as they are either water soluble or too unstable and so cannot be combined with molten silicate glass.
    - The compounds that are suitable must disperse in molten glass without causing crystallisation of the glass (this would destroy the optical properties) and form clear transparent glassy materials (the coloured phase must enable the glass to be clear and transparent).
    - Research has found that a few compounds can be used as coloured glass additives which are either combinations of group II metals with group VI non-metals (i.e. II-VI compounds such as CdS) or group III metals with group V non-metals (i.e. III-V compounds such as GaAs). However, very few of these compounds are yellow, orange or bright red with sharp wavelength cut-offs.
    - Most coloured compounds that can be added to glass give different colours to cadmium. For example, nickel compounds are green, cobalt compounds are blue, iron are dull red or brown, mercury (as sulphide) is pink, etc. Compounds with three or more elements have also been

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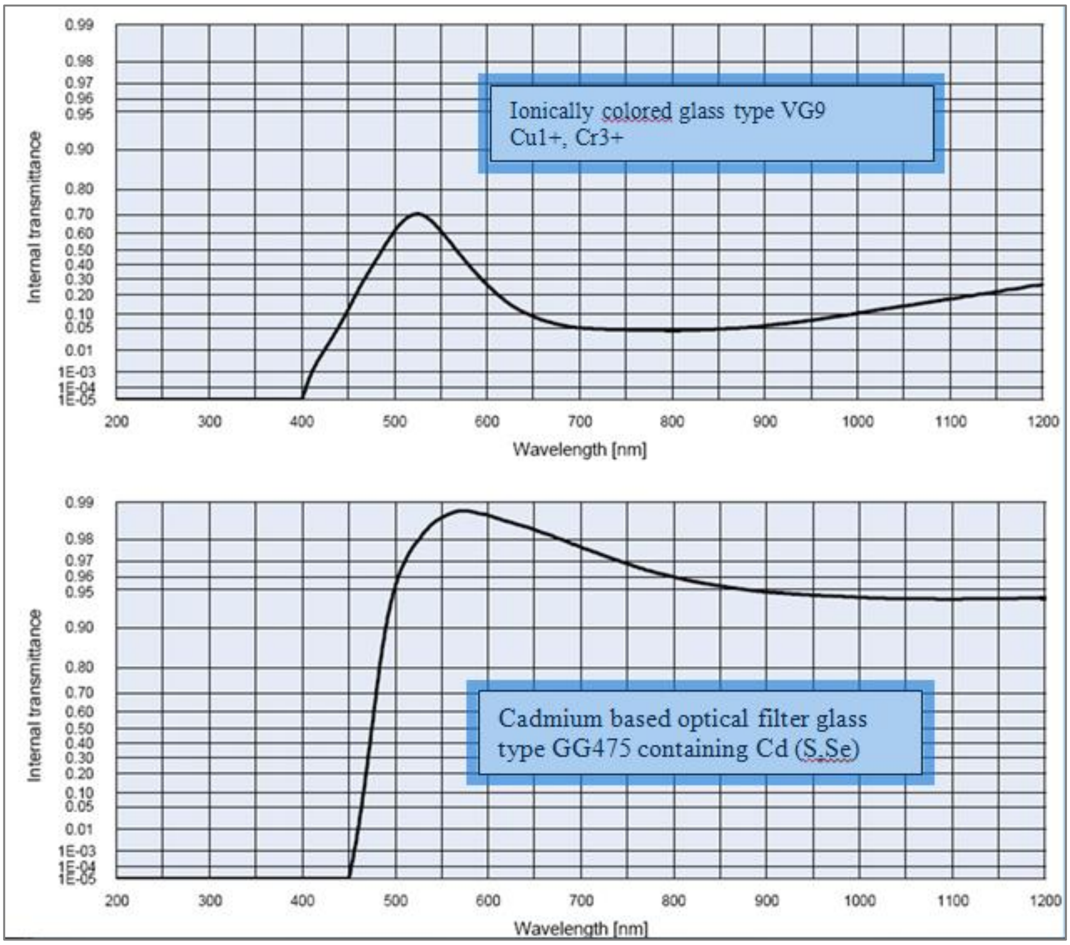
[95] Op. cit. Spectaris (2014)

[96] Op. cit. Spectaris (2014)

evaluated such as CuInSe (a II-III-VI compound), but these also do not give the required steep edge cut-off.

Metal ion coloured glass is another alternative type of coloured glass filter where metal ions (usually transition metals) are inserted into the glass matrix to colour it. In the typical example shown below, Cu+ and Cr3+ ions are added to the glass, but the spectra are very different from Cd steep edge filters.

Figure 8-3: Spectra Comparison: Ionically Coloured Glass (above) Cd Glass (below)



Source: Spectaris (2014a)

Figure 8-3 shows that ionically coloured glasses have different shaped spectra to cadmium based glass with lower % light transmission at longer wavelengths and the slope of the curve of the metal ion coloured glass is shallower than the steeper slope of the cadmium filter.

Colloidal dispersions: Coloured glass, including ruby red colours, can be obtained by adding substances to glass, which form colloidal dispersions. Colloids are produced by several metal sulphides such as Pb, Sb, Cu, etc. and they may also be metals such as gold and silver. The colloid’s particle size controls the colour by diffraction of light but colloids do not give sharp cut-offs, so they are not suitable alternatives to cadmium compounds.

- **Thin film coatings on transparent substrates**:
    - Interference filters, or dichroic filters, are quite widely used for certain applications, but their properties are very different to glass filters based on cadmium compounds. Their main characteristic is that they absorb light within a specific but fairly narrow wavelength range with sharp cut-offs at both ends of this wavelength range. Spectra of light that has passed through this type of filter are quite different to spectra obtained with cadmium glass filters (see exemption application for examples). Interference filters are also viewing angle dependent and can give "ghost" images. Furthermore, interference filters may transmit light in one main band but also in unwanted side-bands at lower intensity.
    - Coloured coatings - For inorganic compounds, unless the coatings are based on cadmium compounds, the steep edge properties, characteristic of Cd filter glass, cannot be achieved. Organic pigment coatings are inferior because these fade when exposed to ultraviolet light and are easily scratched.
- **Transparent plastics with organic pigments** are used as optical filters and have advantages and disadvantages, but these disadvantages make them unsuitable for many applications. The addition of organic dyes and organic pigments to molten glass is impossible as all are thermally unstable at glass melting temperatures. Only heat stable inorganic compounds such as the cadmium chalcogenides (e.g. CdS/Se) can be used.

  Coloured organic compounds can, however be added to a few types of transparent non-crystalline plastics such as acrylics, to give clear coloured transparent plastics without decomposition of the coloured substance. Achieving optical clarity is, however, not possible for all combinations of coloured compounds and polymers. Most polymers are available only as opaque materials and most pigments will not dissolve, so they create opaque dispersions. Optical transparency requires that the pigment either dissolves in the polymer (i.e. is present as discrete molecules), or that the particle size is sub-micron and smaller than the wavelength of visible light, so that they are not visible to the human eye. Coloured transparent plastics are, however used for low-end optics (e.g. children's toys) where high performance is not required. The main disadvantages are:

    - Plastics are easily scratched.
    - They are affected by humidity as all plastics absorb water from humid air.
    - They are affected by high temperatures (distort, degrade, change colour). Optical filters are used with lamps that can become very hot as well as with laser light sources that heat the filter. Apart from heat transmitted by the lamps, most filters function by absorbing light of certain wavelengths and transferring the absorbed energy into heat.
    - Organic pigments fade when exposed to ultraviolet light and polymers are also affected causing colour changes. Brittle fracture may also occur when exposed to UV light.

- Image quality tends to be poor as the surfaces of plastic filters are easily warped, so that they are not optically flat.
- Some polymer filters with organic pigments have relatively poor maximum transmission percentages at wavelengths of light that should pass through the filter.
- Some polymer filters transmit light at wavelengths where light needs to be blocked.

Several types of “gel filters” are used for photography and other applications. These include polyester gel filters and also the Kodak Wratten range of coloured filters. These are made of gelatine with organic dyes, and therefore will fade in sunlight. They will readily absorb moisture (and distort) at high ambient humidity and as gelatine is a protein, they will be affected by a wide variety of chemicals such as oils, fingerprints, etc. and are prone to degradation by micro-organisms. Gel filters are also heat sensitive so they cannot be used with hot lamps or at high ambient temperature and being relatively soft, they are easily damaged.

The properties of optical glass and optical polymer filters are compared in Table 8-2 below.

Table 8-2: Comparison of Glass and Plastic Materials for Filters

Property	Glass filters	Plastic filters
Tolerance (i.e. variation in characteristics of commercial lenses)	Low (±0.0001) can be achieved, so variation is very small	Estimated at ±0.001
Abbe number	Broader range (20 to >80) especially to low dispersion values	23 to 58 is possible
Transmittance of unfiltered light (through 3mm)	>99% achievable	85 to 91% typically
Density	Lead-based are ca. 5 g/cm^3. This offers advantages and disadvantages	1 to 1.2 g/cm^3
Water absorption	Zero (so moisture has no effect on performance)	All plastics absorb water causing changes to properties (as they swell) and also potentially degradation can occur. From 0.01% to 0.3%
Thermal expansion	CTE(-30°C;+70°C) = 5.1 to 11.9 x 10^{-6} /K	Range is 47 to 80 x 10^{-6}/K. This causes optical changes with temperature and thermal degradation
Refractive index thermal dependence	Smaller range of - 0.7 to + 1.2 10^{-5}/˚C	-8 to -14 10^{-5}/˚C
Resistance to damage	Relatively hard, so not easily damaged	Soft so easily scratched
Exposure to UV light	No effect	Organic pigments fade and plastic discolours and degrades
Heat	Resistant to temperatures created by lamps and laser light sources	Lamps and lasers can easily cause deformation or even make holes

Source: Spectaris (2014)

Spectaris[97] provides some explanation as to cases in which alternatives are applied:

- If the strict tolerances on steep slopes are not required customers change to cheaper alternatives such as yellow glass.
- Coated filters are cheaper than coloured filters. They can be used if transmissive sidebands and the angular dependence of coated filters are acceptable.
- Plastic filters are also much cheaper than the coloured filter glasses. They will be used when filter function tolerances are not stringent and visual colour perception is the more important aspect than strict wavelength separation.
- Plastic and coated filters can block unwanted light only to residual transmission of about 1 %. If this is acceptable, they may be used, instead of filter glasses, which block unwanted light to 0.000001 % and below. The very high blocking is needed in applications where safety and reliability is essential.

Lead in filter glasses – Only one type of filter glass is currently produced that contains lead, this being used because of its unique combination of properties. Research has not identified an alternative material with the same combination of essential properties. For example, chromium III and copper II ions added to a lead-free glass matrix do not give the same light filtering properties so they are not suitable replacements. [98]

According to Spectaris[99], VG9 is presently the last glass type out of a family of green filter glasses, which originally consisted of seven types. The reduction to one single glass type was done with the catalogue issued in 2005 due to low market requirement. A future need for the presently not offered glass types cannot be excluded. Also, VG9 is a Schott proprietary glass type. Other manufacturers may use lead in different glass filter types (these are likely to be similar to VG9). Further restriction to glass families or glass types would not lead to any useful improvement.

To summarize, Spectaris[100] argues that research has been performed for many decades and alternatives to cadmium and lead are already used where these are suitable. It is elaborated that combinations of all of the elements in the periodic table have been evaluated and only cadmium (or Pb in one case) gives all of the essential characteristics for the applications where these filters are used. The only possible alternatives would be completely different designs of optical equipment, but so far, alternatives have not been developed for the applications described in this renewal request and other applications. It is also not possible to envisage alternative designs

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97 Op. cit. Spectaris (2015a)

98 Op. cit. Spectaris (2014)

99 Op. cit. Spectaris (2015a)

100 Op. cit. Spectaris (2014)

so research timescales cannot be planned or estimated in the form of a roadmap. No substitutes are likely to be developed in the foreseeable future and so the maximum validity period is required for this exemption

8.3.2 Environmental Arguments

Spectaris[101] explains that WEEE from used EEE devices is collected and treated according to the WEEE Directive. Specific collection systems for optical filter glass, not to mention closed loop systems, do not exist, due to the very large variety of applications. Optical filter glass is used as small components of electrical equipment, which follows a variety of routes at end of life. Some EEE are refurbished and then sold to second users and some will be recycled, although glass parts are usually not removed before metal recovery processes. A small remaining proportion might be landfilled.

Spectaris[102] provides details as to the impact of Cd and Pb in the various life cycle phases as follows. Detailed information is available in the exemption application.

- Up-stream impacts are not expected in the mining and extraction phase. Cd is not mined as a primary ore, but occurs naturally, as an impurity, with other metals such as zinc, copper and lead that are mined in very large quantities, from which it needs to be removed. Cd is thus recovered during the metals refining process, whether there are industrial uses for cadmium or not. Up-stream impacts are also not expected in the mining and extraction phase of lead in light of the negligible amount of Pb used for optical glasses in EEE in comparison with the total global consumption (0.01%).
- Emissions are not to be expected from mining or from manufacture, as such emissions are controlled to comply with regulation for the prevention of such impacts (e.g., the Industrial Emission's Directive (IED) 2010/75/EC).
- During the use phase, optical filter glass is very stable and inert, with 100% of the cadmium and/or lead content remaining within the glass under all normal use conditions.
- At end of life, optical glass from WEEE may either be landfilled with the WEEE (i.e. no recycling), or subject to the WEEE recycling process with other electrical equipment. Scrap metals may simply be heated to melt them or are heated with reducing agents such as carbon to convert oxides to metals. Simply heating will melt the glass, which will mix with other non-metallic and non-volatile materials, to form a "slag" that is inert and sent to landfill. Cadmium and lead will not leach out of this material. Under reducing conditions such as in a smelter used to recover copper from printed circuit boards, some cadmium compounds may be reduced to cadmium metal and some lead compounds may be reduced to lead metal, both of which are volatile and thus collected and treated as a hazardous waste. Cadmium and lead are present in

[101] Op. cit. Spectaris (2014a)

[102] Op. cit. Spectaris (2014a)

feedstocks of WEEE recycling from many materials other than optical glass filters, thus collection and disposal are expected to occur whether there is cadmium present in optical filter glass or not.

- The behaviour of cadmium and lead in landfill is very complex as they can react with other constituents to form various compounds. A report by the European Environment Agency states that measurements of leachate from EU landfill sites has found that both Cd and Pb are "not generally present at significant concentrations".

8.3.3 Socio-economic Impact of Substitution

Spectaris[103] expects the following impacts to arise should the exemption be revoked:

- Environmental impacts: Reduced ability of analysis of environmental pollutants, as filter glasses are used in various instruments used for pollutant monitoring.
- Health impacts: Medical research would be much more difficult or impossible without fluorescence microscopes and other instruments that use these filters.
- Consumer safety impacts: Facility security survey at night time without dazzling observers (by use of near infrared imaging). Some types of speed enforcement cameras use filter glasses benefiting from Ex. 13b.

8.4 Stakeholder Contributions

Five contributions were made to the stakeholder consultation and are summarised as follows:

- **Lucideon Ltd**[104] have contributed information regarding the use of Cd and Pb in refractive standards. Their information is presented in more detail below.
- **Nanoco Technologies**[105] explain that they are a manufacturer of Cd-free quantum dots and express their concern "*about the possible misinterpretation of Ex. 13(b) as being in some way applicable to the use of cadmium-based quantum dots in lighting and display systems*." It is explained that cadmium-based quantum dots for lighting and display applications:
    - Are not incorporated into glass. They are embedded in plastic resin, which is then encapsulated by glass or by further layers of plastic;

[103] Op. cit. Spectaris (2014)

[104] Lucideon (2015a), Lucideon Ltd, Contribution to Stakeholders Consultation Regarding Ex. 13b, submitted 13.5.2015 (partially amended 18.6.2015), available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13b/20150513_Lucideon_RoHS_Exemption_13b_amended_20150618.pdf

[105] Nanoco (2015), Nanoco Technologies Ltd., Contribution to Stakeholders Consultation Regarding Ex. 13b, submitted 12.6.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13b/Response_RoHS_consultation_Ex_13b.pdf

- Do not exhibit the sharp absorption filter cut-off or reflection cut-off performance that is the justification for 13(b). They absorb over a broad range of wavelengths;
- Do not act as a filter, since they re-emit light;

- **Fraunhofer IOF**[106], support the request and agree with both the scope and the duration proposed by the applicant. It is explained that Cd and Pb in filter glasses are necessary to generate optical filters for multiple applications, which need to provide steep spectral edges for filtering optical data. These steep edges are needed e.g. in medicine, to ensure correct diagnoses. Other materials result in broad spectral edges, which cannot be used for the above-mentioned applications. Without these filters, many diagnostic methods would not be possible.
- **3M Company**[107] supports the request for renewal of Ex. 13b, applied for by Spectaris. 3M explains that it shares interest in the renewal of the exemption for quantum dot technologies that are being developed to enable liquid crystal displays (LCD) to give a technically superior image with a much higher range of colours than is currently possible from other commercially available LCDs. The quantum dots are explained to filter by colour, converting all incident light into light of different wave lengths. 3M has further submitted three independent documents to support that this technology would fall under the scope of the exemption at hand.
- The **Japan Business Council** (JBCE)[108] also supports the request. Furthermore JBCE highlights that exemption 13(b) in annex III can be applied to category 8&9 products for seven years from the identified date of entry into force [of the substance restrictions – consultants addition] for each of the products, at the earliest July 2021. JBCE refers in this respect to the EU COM FAQ document.

Lucideon[109] explains that Ceramic Colour Standards manufactured and supplied by Lucideon are optical reflectance materials used to calibrate and check the measurement performance of spectrophotometers and optical devices (see Figure 8-

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[106] Fraunhofer IOF (2015), Fraunhofer Institute for Applied Optics and Precision Engineering, Contribution to Stakeholders Consultation Regarding Ex. 13b, submitted 15.6.2015, available under http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13b/Contribution_FhG_13b.pdf

[107] 3M (2015), 3M Display Materials & Systems Division, Contribution to Stakeholders Consultation Regarding Ex. 13b, submitted 18.6.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13b/20150618_3M_letter_of_Contribution_-_Exemption_13b.pdf

[108] JBCE (2015), Japan Business Council in Europe, Contribution to Stakeholders Consultation Regarding Ex. 13b, submitted 19.6.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_7/Exemption_13b/20150619_JBCE_Ex_13b_comment_on_public_cousulation_of_Exemption_request_2015-1_13b.pdf

[109] Op. cit. Lucideon (2015a)

4 below). They are not part of the instrument but an accessory, which is momentarily placed against the instruments measuring aperture/in the measurement path, before the instrument is used, and they are usually stored in a separate box. They have no electrical parts or contact with electricity.

Figure 8-4: The Set of Twelve Calibrated Reflecting Ceramic Tiles, Produced by Lucideon Limited

Source: Image used with permission of Lucideon Ltd.

Lucideon[110] clarify that reflectance Standards do not change colour over time, unlike other materials, and so are measured at suitable intervals to calibrate colour related performance: if the results of the measurements are unchanged between measurements, this proves that the instruments are still performing properly and that the results they give are correct. The Colour Standards are also used to determine the differences in measurements taken from different instruments so that colour can be communicated between them.

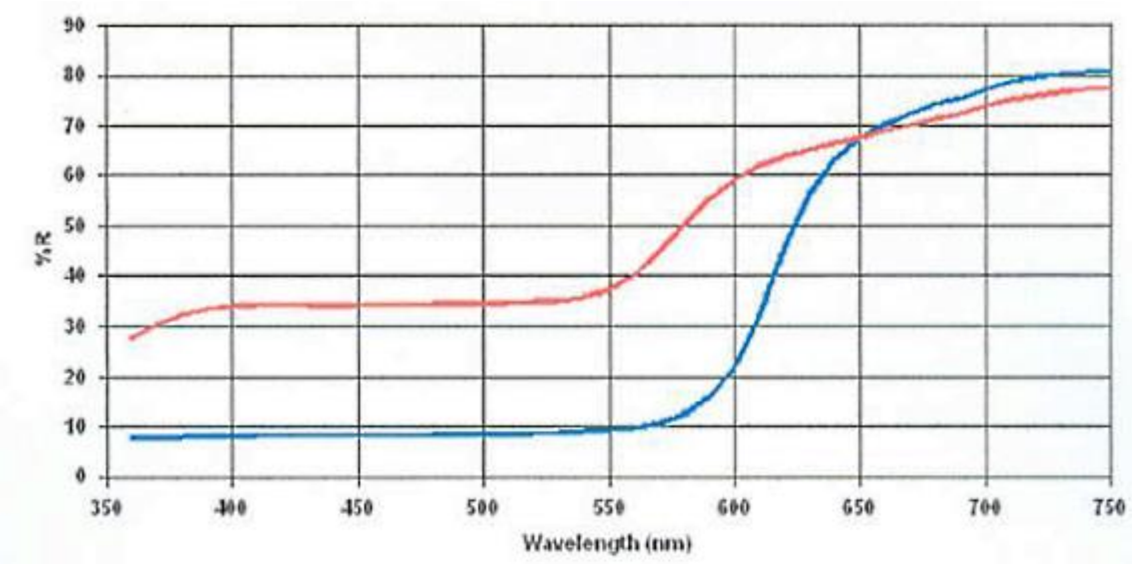
The functional part of the standards is a modified glass (glaze), which is permanently bonded to a porous ceramic substrate by high-temperature heat-treatment. The standards have specific colours with the steepest reflectance slopes practically possible to provide a rigorous test of spectrophotometer performance, while remaining stable in colour. Most such glazes do not require Pb or Cd, and most of the standards contained in the range of Ceramic Colour Standards have eliminated these materials. However, there are two standards, the red and orange ceramic colour standards, which use a combination of lead glaze and cadmium pigment to produce colours, for which there is no suitable lead-free and cadmium-free alternative. The Cd-

[110] Lucideon (2015b), Lucideon Ltd., Answers to 1st Round of Clarificaion Questions, submitted per email 11.8.2015

containing pigment is encapsulated in an inert zirconium silicate crystal. The inert zirconium silicate crystals are encapsulated in the homogeneous glass matrix, which may include lead oxide. [111]

Lucideon[112] explains that it is possible to produce red or orange coloured glass or plastic without Cd and Pb. However, in glass the steep reflectance slopes required cannot be achieved without these elements (see Figure 8-5). Furthermore, the alternatives often have complex reflectance curves, which make results from such standards hard to interpret in terms of instrument performance. In plastics the organic dyes used will produce steep reflectance curves but they are unstable and bleach (lose their colour) under the UV included in spectrophotometer light.

Figure 8-5: Comparison of Lead and Cadmium Reflectance Curve (in Blue) with Alternative without Lead or Cadmium (in Red)



Source: Lucideon (2015a)

In a later communication, Lucideon[113] elaborates that it does not believe that its Colour Standards to be part of an EEE as they are supplied simply as Standards. However, some of Lucideons' customers, who manufacture and sell spectrophotometers, do consider them to be part of an EEE as they supply the Colour Standards along with their spectrophotometers. Thus, an exemption is required so that customers can use supplied Standards. Lucideon further clarify that though they are not aware of the composition of reflectance standards of other manufacturers, it is likely that such standards with red colours shall contain lead and cadmium – a few other manufacturers are named.

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[111] Op. cit. Lucideon (2015a)

[112] Op. cit. Lucideon (2015a)

[113] Op. cit. Lucideon (2015b)

8.5 Critical Review

8.5.1 REACH Compliance - Relation to the REACH Regulation

Appendix A.1.0 of this report lists entry 23, 28 and entry 30 in Annex XVII of the REACH Regulation:

- Entry 23, stipulates that cadmium and its compounds shall not be used in mixtures and articles produced from a list of synthetic organic polymers (also referred to as plastic materials), in paints, in metallic plating of metal surfaces, in brazing filler or in jewellery.
- Entries 28 and 30 stipulate that various cadmium compounds and 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 view, entry 23 does not apply to the use of Cd in filter glasses or in reflectance standards, which do not fall under the scope of the specific derogations (i.e., filter glasses and reflectance standards are not manufactured from synthetic organic polymers, nor do they fall under the scope of the other applications mentioned). Nor do the consultants understand the restriction for substances under entry 28 and entry 30 of Annex XVII to apply to the use of cadmium and/or lead in filter glass applications or in reflectance standards. Pb and Cd used in these applications, in the consultants' point of view is not a supply of lead or cadmium and their compounds as substances, mixtures or constituents of other mixtures to the general public. The Pb and Cd in these applications are parts of an article and as such, entry 30 of Annex XVII of the REACH Regulation would not apply.

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

Spectaris further states that REACH includes obligations on cadmium in certain types of plastics, coatings and braze alloys, but that there are no restrictions on its use in glass. Though Spectaris explains several cadmium compounds to be SVHCs, none of these are present in optical glass filters.[114]

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

[114] Op. cit. Spectaris (2014)

8.5.2 Scientific and Technical Practicability of Substitution

Spectaris' main argumentation relates to the lack of substitutes for cadmium and lead in filter glasses used for optical applications. For each element it can be understood that the main property enabled by using Cd in various filter glasses or Pb in lead silicate green filter glass is the creation of a band pass filter which:

- enables very low transmission at wavelengths shorter than the cut-off wavelength (e.g, less than 1% for Cd based filter glasses); and
- enables very high transmission at longer wavelengths (e.g, over 95% in Cd based filter glasses); also
- enabling a "steep-edge" important for many applications as this prevents image distortion effects such as "flare" (stray light) and "ghosting" (a second feint image);

Though various substitution routes exist, which have also been successful for some applications, where the performance aspects detailed above are of less importance, substitutes do not provide sufficient cut-off performance for all applications. In the few cases where alternatives are said to supply sufficient performance in this respect, the materials used are too sensitive to environmental conditions of operation (such as heat or UV light) and thus do not provide a comparable reliability. In this sense, it can be followed that though alternatives have become available for some applications, for many diverse applications, such alternatives are still not suitable (see examples in Table 8-1 and in original exemption application). Though it can be followed that, in lack of suitable substitutes, an exemption may be justified, the current wording of the exemption is however, understood to be relatively wide. It is noted that alternatives have been applied for certain applications, thereby allowing the use of lead and cadmium to be avoided in these cases. A meeting was held with Spectaris on the 28 August 2015 to discuss the various aspects of the exemption that were still open. Spectaris was asked to explain if and how the exemption formulation could be adjusted to reflect relevant articles still on the market for which it is still needed. In this respect, Spectaris provided additional information with the aim of arriving at a formulation, which reflects the relevant scope of applications which is narrower than the scope of the current exemption.

Spectaris[115] explains that where Cd and Pb in filter glasses are concerned, two types of sub-applications can be named and associated with the two elements. "*Striking filter glasses provide uniquely steep slopes and an extremely high blocking effect, but due to their single edge only with a long pass characteristic. Band pass or band blocking filters require ion coloured glasses, which have two edges. However, these edges are smooth rendering only a moderate separation capability*":

- **Striking filter glasses** are explained to be filter glasses in which Cd is present. The name is derived from the production process of the glass in which "*about 1 % of cadmium compounds*" are added" *to molten glass. In the first stage*

[115] Spectaris (2015c), Answers to 3rd Round of Clarification Questions, submitted per email 15.9.2015

they are colourless clear glasses. By precisely controlled heat treatment (the so-called striking process) cadmium chalcogenide microcrystals are grown" [...].

- **Ion coloured optical filter glasses** make use of the light absorption of ions of special elements such as iron, manganese, chromium, vanadium, cobalt and copper. The special absorption characteristic of a given ion in a well-defined glass composition depends not only on the metal ion itself but also on its environment of other ions to which it is bonded in the glass matrix. The environment is given by the base glass composition in the first instance. Secondly, it varies considerably due to the amorphous character of glass, which contrary to crystals provides many different bonding distances and angles for the same type of ions. This variable environment causes absorption bands to broaden and hence leads to inferior filter properties with much less steep slopes. In order to obtain best filter characteristics the best environmental glass[116] and the optimum ion content has to be found. A further remaining optimization possibility is to use more than one colouring ion as e.g. in the green filter glass VG9, where Cu2+ and Cr3+ are used. This, however, puts even more stringent requirements on the base glass composition.

On this basis, Spectaris proposed the following formulation to better reflect filter glass applications in which lead and cadmium cannot be substituted:

"Lead in ion coloured optical filter glass types and cadmium in striking optical filter glass types"

8.5.3 Environmental Arguments

Spectaris[117] provides some information regarding environmental impacts related to the manufacture, use and end-of-life of "*cadmium and lead in filter glasses*". As the information does not compare the performance of lead and cadmium based filter glasses with possible alternatives, it would not allow concluding as to how such filter glasses compare to possible alternatives. In this respect the information does not allow concluding if the third criterion specified in Article 5(1)(a) of the Directive (see Section 7.5.5 below for detail) is fulfilled and is not further discussed here.

8.5.4 Stakeholder Contributions and the Scope of the Exemption

A few stakeholders have made contributions related to the scope of the exemption.

3M[118] have expressed their support in the application for renewal, detailing however, that "*it shares interest in the renewal of the exemption for quantum dot technologies*". In this respect 3M explains that quantum dots filter by colour,

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[116] The consultants understand the reference to environmental glass to mean the base glass composition, which enables the best environment in terms of other ions in the glass matrix and the bonding differences that result thereof.

[117] Op. cit. Spectaris (2014)

[118] Op. cit. 3M (2015)

converting all incident light into light of different wave lengths. Nanoco Technologies[119], however, are opposed to this observation, explaining that quantum dots are not incorporated in glass, and more importantly that this technology does not exhibit the sharp absorption filter cut-off or reflection cut-off performance that is the justification for 13(b). In contrast, they are said to absorb over a broad range of wavelengths and to re-emit light, which is explained to be different from the filter function relevant for glasses and glazes in Ex. 13b.

Spectaris[120] was asked to comment about these interpretations and explained "*We are not experts in quantum dots, but definitely the term and the technical idea behind it do not fit to the categories 'filter', or 'glass', or to the combination term 'filter glass'.*"

In general, the arguments raised by Nanoco and supported by Spectaris can be followed – quantum dots are understood to function in a different manner from the applications referred to in Ex. 13b. Though one may argue if the use of the word glass in the exemption relates to glass as a material or as an object (i.e., a plastic lens may also be referred to as a glass in some cases), the function of Cd is inherently different. The filtering function is explained to be needed to separate between desired wavelengths which pass through and between undesired ones that are blocked. The light in filter glasses either passes through or it is blocked, in contrast to quantum dots it is not converted.

Aside from this technical understanding of the different applications, from a procedural and a legal perspective, it also needs to be taken into consideration that there is an exemption listed in Annex III that is understood to apply to quantum dot technologies. The exemption was applied for by 3M in 2008, and dealt with in an evaluation that took place in 2008/2009[121], leading to the addition of exemption 39 to Annex III. In the consultants view, if 3M applied for the exemption despite the fact that Ex. 13 (which later evolved into Ex. 13a and 13b) was already available, this would mean that it did not interpret the quantum dot application to fall under the existing exemption.[122] The fact that the evaluators at the time recommended adding exemption 39, also supports that they did not view quantum dots to fall under the existing exemption 13, as in such a case a merge could have been proposed. Furthermore, from a legal perspective, including two exemptions in the annex that address the same application would not be consistent legislation as the revoke of one exemption would still leave a loop-hole for the use of such an application. It is

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[119] Op. cit. Nanoco (2015)

[120] Op. cit. Spectaris (2015b)

[121] See Excerpt of report under the following link: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_IX/Request_2013-2/Annex_02_OKO_report_2009_Excerpt.pdf

[122] In 2013, 3M also applied for the renewal of Ex. 39. Though the evaluation resulted in a recommendation to grant an exemption for use in display applications, the EU COMs proposal to grant the exemption was not supported by the EU Parliament, which required a revision of the request take place. This second evaluation is to take place in 2015-2016.

assumed that this was not the purpose of the evaluators, nor of the regulator. In this respect, it would be recommended to explicitly exclude quantum dot applications from Ex. 13b in the future to ensure that legislation is consistent and does not leave room for unconcise interpretations.

A further contribution, submitted by Lucideon, provides information related to reflectance standards, which are part of the original scope of the exemption. Though reflectance standards and filter glasses comprise of different applications, the function of Cd and Pb in these applications is similar. Lucideon explains the difficulty of finding suitable substitutes for the glazing in red and orange ceramic reflectance standards. Though these elements have been substituted in most reflectance standards, there remain two standards, for which substitution has not been successful. These two standards use a combination of lead glaze and cadmium pigment to produce colours, for which there is no suitable lead-free and cadmium-free alternative. Lucideon[123] explains that it is possible to produce red or orange coloured glass or plastic without Cd and Pb. However, in glass the steep reflectance slopes required cannot be achieved without these elements. Furthermore, alternatives often have complex reflectance curves, which make results from such standards hard to interpret in terms of instrument performance. In plastics the organic dyes used will produce steep reflectance curves but they are unstable and bleach (lose their colour) under the UV included in spectrophotometer light. As Cd and Pb are used in the functional part of the standards, which is a modified glass (glaze), Lucideon agreed in this respect that the term glaze could be used instead of glass. Here too, it can be followed that, although alternatives are available, they do not provide comparable performance or are inferior in terms of the reliability of performance over time.

In respect with the Lucideon contribution, it needs to be noted that according to Article 5 of the directive, an application for the renewal of an exemption needs to be submitted at least 18 months before the expiration date of the exemption. Lucideon did not apply for an exemption according to this timeline, but rather submitted their argumentation related to the exemption as part of the stakeholder contribution. In this sense, a question arises as to whether this form of justifying the scope of an exemption is perceived as legitimate. In this case, it seems that the original exemption request may relieve the difficulty of the decision. Spectaris requested the exemption renewal with the original formulation. Though they did not provide argumentation for reflectance standards, it was specified that they expected relevant manufacturers to provide such information.

Two additional contributions (Fraunhofer IOF and JBCE), support the requested renewal of exemption 13b in lack of sufficient substitutes. The contributions are partially detailed in Section 8.4 and as they do not raise further questions regarding the scope of the exemption they are not further discussed here.

[123] Op. cit. Lucideon (2015a)

8.5.5 Exemption Wording Formulation

From the information available, it can be understood that there are similarities in the function of Pb and Cd in both types of filter glasses and in reflectance standards. Against this background, an additional aspect was to understand if the exemption could be split in order to limit the use of the elements to the relevant application. This would result in a formulation based on the following:

Exemption 13b:

I - Lead in ion coloured optical filter glass types;

II - Cadmium in striking optical filter glass types;

III – Lead and cadmium in glazes used for reflectance standards;

Spectaris was asked about the possibility of splitting the exemption in light of the different relevance of substances (Cd and/or Pb) to each of the mentioned applications. Spectaris is not supportive of this change, given the additional administrative effort that would result and the subsequent costs that this would mean for the various actors in the supply chain. In this respect, costs were estimated to show the range of such impacts. Spectaris views this change as a pure administrative change, which would require supply chain actors (manufacturers, suppliers, OEMs) to re-categorize all products again, causing significant costs to supply chain companies. Spectaris thus believes that this change should be avoided, elaborating that "*Smaller companies try to avoid expensive software implementations to comply with RoHS, but work with spreadsheets or similar. The needed man-power per product group stays the same or is even higher in SMEs due to lack of smart software solutions*." To demonstrate the related burden of such a change, Spectaris provides the cost estimation example in Table 8-3 below.

Table 8-3: Costs of Corporate RoHS Administration

	Costs [in €]
RoHS: One-time implementation costs	
Compliance-Software SAP-CfP (software cost, software implementation in 2005 and companywide licence)	300.000
Project to implement RoHS-issue in company (2 years project 2005-2006: software, materials, substitution, training, RoHS compliant process development etc.)	700.000
Cost for Software-replacement due to business practise of SAP after 10 years from SAP-CfP to SAP-EHSM4.0 in 2014	300.000
RoHS: Yearly ongoing costs	
Annual Software-costs (licensing (50 k€) and renewal costs (30 k€))	80.000 / a
1 fulltime capacity equivalent in each business group producing RoHS-relevant devices (5 RoHS-relevant business groups; main affected functions: R&D, construction, supply chain, purchasing, production and assembly, quality assurance, quality management, testing, quality and environmental auditing), 140 k€/a	700.000 / a
1 fulltime capacity equivalent in total for central functions (IT, EH&S, chemistry/materials, central R&D, product data management), 140 k€/a	140.000 / a
RoHS: Costs due to changes in the wording of exemptions	
Adaption of compliance software due to changes, i.e. changes in scope, wording of exemptions etc. Necessary for every change.	25.000 – 50.000/sw-change
Extensive testing of every software change over approx. 250.000 part numbers (i.e. each part number is an individual RoHS compliance data set) within the compliance software (IT, EH&S, chemistry/materials, product data management, training of persons in business groups about changes etc.), ca. 0,25 fulltime equivalent capacity for each change before final release	40.000/sw-change

Source: Spectaris 2015c

It needs to be noted that additional costs per-se do not justify an exemption and would not suffice for this purpose. However, in article 5(1)(a) the directive lists some secondary criteria, including socio-economic aspects, that can also be considered. In this respect, the consultants assume that (as long as the regulated articles remain the same)splitting the exemption or listing the relevant applications so that overlaps are avoided, would both serve the same purpose of restricting the use of Cd and Pb. This would however avoid a situation in which a split creates additional administrative costs in light of changes in the exemption number. If the EU COM can follow this argumentation, it would be advisable to adapt the current wording as follows to reflect all relevant scope aspects:

"*Lead in ion coloured optical filter glass types, **or** cadmium in striking optical filter glass types **or** lead and cadmium in glazes used for reflectance standards - excluding applications falling under point 39 of this annex*".

8.5.6 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, based on the information provided by the applicant and other stakeholder, it can be followed that the elimination and the substitution of Cd and Pb in filter glasses and in the glaze of reflectance standards is currently not practical for the full range of applications. Though it is explained that where possible, alternatives have been developed and applied, it is understood that a large part of the potential for substitution has been realised and that the development of further alternatives, and their implementation as such, is likely to prove more challenging and more time-consuming. In this sense, the first criterion mentioned above is fulfilled, and would justify the renewal of an exemption where alternatives do not provide comparable performance in terms of separating between desired wavelengths and undesired ones in relation with the transmission of such light through the filter (or in terms of providing the reflectance standard performance related to red and orange hue calibration).

In some cases though performance may be comparable, it is understood that the alternatives are more sensitive to environmental conditions of operation (e.g., temperature, humidity, UV light, etc.) and would thus not provide comparable reliability.

As it could be understood that the exemption formulation was wider than the scope of applications for which it was needed, a few adaptations were discussed with the applicant and with Lucideon. The proposed formulations reflect these changes.

As for the requested duration of the exemption, it can be followed that where finding substitutes was relatively straightforward, this has occurred in the past and substitutes have already been implemented where possible. It can also be followed that finding alternatives for remaining applications shall be more complicated and more time-consuming in the future. On this basis, the requested duration of 5 years for the categories 1-7, 10 and 11 is perceived as justified.

At present, EEE falling under categories 8 and 9 has only started to come into scope. According to Article 5(2) it can be understood that the duration of exemptions listed in Annexes III and IV, for these categories, only begins once the categories come into scope, subsequently valid for 7 years, as long as substitutes cannot be determined that could be applied, making the exemption obsolete. In the consultants' perspective, a distinction could currently not be made between applications falling under these categories and applications falling under categories 8 and 9 in terms of properties enabled through the use of Cd and/or Pb and in terms of the applicability of substitutes. In this sense it would be recommended in the future to perform joint evaluations of the exemption for all categories, and where applicable to arrive at mutual recommendations regarding exemption wording and duration. As in this case, it can be understood that the state of substitution would not allow for changing the exemption scope (excluding certain product groups), the consultants currently do not see a need to discuss possible change to the exemption duration for these categories other than those prescribed in Article 5(2) of the Directive. It is worth noting, however, that in future reviews consideration should be given to the possibility of aligning exemption durations of all categories with time, to allow the evaluation process to be more efficient and to be carried out less often.

8.6 Recommendation

As explained, the consultants can follow that in light of the lack of sufficient alternatives to allow for substitution or elimination of the need for cadmium and/or lead in filter glasses and in the glaze of reflectance standards for the full product range, an exemption would be justified in line with the Article 5(1)(a) criteria. The consultants thus recommend granting a renewal of exemption 13b as follows:

Exemption	Duration*
Lead in ion coloured optical filter glass types, **or** cadmium in striking optical filter glass types **or** lead and cadmium in glazes used for reflectance standards – excluding applications falling under point 39 of this annex	For Cat. 1-7 & 10 : to expire 21 July 2021
Cadmium and lead in filter glasses and glasses used for reflectance standards	For Cat. 8 and Cat. 9: to expire 21 July 2021
	For Sub-Cat. 8 in-vitro: to expire 21 July 2023
	For Sub-Cat. 9 industrial: to expire 21 July 2024

*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.

If the EU COM does not agree that the administrative burden related to a split of the exemption is significant enough to justify maintaining the exemption in the merged form, the following formulation would be recommended instead:

Exemption 13b	Duration*
I - Lead in ion coloured optical filter glass types; *II - Cadmium in striking optical filter glass types; excluding applications falling under Ex. 39 of Annex III of Directive 2011/65/EU* *III – Lead and cadmium in glazes used for reflectance standards;*	For Cat. 1-7 & 10 : to expire 21 July 2021
IV - Cadmium and lead in filter glasses and glasses used for reflectance standards	For Cat. 8 and Cat. 9: to expire 21 July 2021
	For Sub-Cat. 8 in-vitro: to expire 21 July 2023
	For Sub-Cat. 9 industrial: to expire 21 July 2024

8.7 References Exemption Request 13b

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Spectaris (2015b)	Der Deutsche Verband der Hightech Industrie, Answers to 2nd Round of Clarification Questions, submitted on 24.8.2015
Spectaris (2015c)	Der Deutsche Verband der Hightech Industrie Answers to 3rd Round of Clarification Questions, submitted per email 15.9.2015
Spectaris (2015 d)	Der Deutsche Verband der Hightech Industrie Answers to 3rd Round of Clarification Questions, submitted per email 14.10.2015.

Appendices

A.1.0 Appendix A.1.0: Links between the REACH Regulation and the RoHS Directive

Relevant annexes and processes related to the REACH Regulation have been cross-checked to clarify:

- In what cases granting an exemption could "*weaken the environmental and health protection afforded by Regulation (EC) No 1907/2006*" (Article 5(1)(a), pg.1)
- Where processes related to the REACH regulation should be followed to understand where such cases may become relevant in the future;

Compiled information in this respect has been included, with short clarifications where relevant, in the following tables:

Table A.1.0-1 lists those substances appearing in Annex XIV, subject to Authorisation, which are relevant to the RoHS substances dealt with in the requests evaluated in this project. As can be seen, at present, exemptions have not been granted for the use of these substances.

Table A.1.0-1: Relevant Entries from Annex XIV: The List of Substances Subject to Authorization

Designation of the substance, of the group of substances, or of the mixture	Transitional arrangements		Exempted (categories of)uses
	Latest application date (1)	Sunset date (2)	
10. **Lead chromate** EC No: 231-846-0 CAS No: 7758-97-6	21 Nov 2013	21 May 2015	-
11. **Lead sulfochromate yellow** (C.I. Pigment Yellow 34) EC No: 215-693-7 CAS No: 1344-37-2	21 Nov 2013	21 May 2015	-
12. **Lead chromate molybdate sulphate red** (C.I. Pigment Red 104) EC No: 235-759-9 CAS No: 12656-85-8	21 Nov 2013	21 May 2015	-
16. **Chromium trioxide** EC No: 215-607-8 CAS No: 1333-82-0	21 Mar 2016	21 Sep 2017	-

Designation of the substance, of the group of substances, or of the mixture	Transitional arrangements		Exempted (categories of)uses
	Latest application date (1)	Sunset date (2)	
17. **Acids generated from chromium trioxide and their oligomers** Group containing: **Chromic acid** EC No: 231-801-5 CAS No: 7738-94-5 **Dichromic acid** EC No: 236-881-5 CAS No: 13530-68-2 **Oligomers of chromic acid and dichromic acid** EC No: not yet assigned CAS No: not yet assigned	21 Mar 2016	21 Sep 2017	-
18. **Sodium dichromate** EC No: 234-190-3 CAS No: 7789-12-0 10588-01-9	21 Mar 2016	21 Sep 2017	-
19. **Potassium dichromate** EC No: 231-906-6 CAS No: 7778-50-9	21 Mar 2016	21 Sep 2017	-
20. **Ammonium dichromate** EC No: 232-143-1 CAS No: 7789-09-5	21 Mar 2016	21 Sep 2017	-
21. **Potassium chromate** EC No: 232-140-5 CAS No: 7789-00-6	21 Mar 2016	21 Sep 2017	
22. **Sodium chromate** EC No: 231-889-5 CAS No: 7775-11-3	21 Mar 2016	21 Sep 2017	
28. **Dichromium tris(-chromate)** EC No: 246-356-2 CAS No: 24613-89-6	22. July 2017	22 January 2019	
29. **Strontium chromate** EC No: 232-142-6 CAS No: 7789-06-2	22 July 2017	22 January 2019	
30. **Potassium hydroxyoctaoxodizincatedichromate** EC No: 234-329-8 CAS No: 11103-86-9	22 July 2017	22 January 2019	
31. **Pentazinc chromate octahydroxide** EC No: 256-418-0 CAS No: 49663-84-5	22 July 2017	22 January 2019	

For the substances currently restricted according to RoHS Annex II: cadmium, hexavalent chromium, lead, mercury, polybrominated biphenyls and polybrominated diphenyl ethers and their compounds, we have found that some relevant entries are listed in Annex XVII of the REACH Regulation. The conditions of restriction are presented in Table A.1.0-2 below. Additionally, some amendments have been decided upon, and are still to be included in the concise version. These can be seen in Table A.1.0-3.

Table A.1.0-2: Conditions of Restriction in REACH Annex XVII for RoHS Substances and Compounds

Designation of the substance, of the group of substances or of the mixture	Conditions of restriction
8. **Polybromobiphenyls; Polybrominatedbiphenyls (PBB)** CAS No 59536-65-1	1. Shall not be used in textile articles, such as garments, undergarments and linen, intended to come into contact with the skin. 2. Articles not complying with paragraph 1 shall not be placed on the market.
16. **Lead carbonates:** (a) Neutral anhydrous carbonate ($PbCO_3$) CAS No 598-63-0 EC No 209-943-4 (b) Trilead-bis(carbonate)-dihydroxide $2PbCO_3$-$Pb(OH)_2$ CAS No 1319-46-6 EC No 215-290-6	Shall not be placed on the market, or used, as substances or in mixtures, where the substance or mixture is intended for use as paint. However, Member States may, in accordance with the provisions of International Labour Organization (ILO) Convention 13, permit the use on their territory of the substance or mixture for the restoration and maintenance of works of art and historic buildings and their interiors, as well as the placing on the market for such use. Where a Member State makes use of this derogation, it shall inform the Commission thereof.
17. **Lead sulphates:** (a) $PbSO_4$ CAS No 7446-14-2 EC No 231-198-9 (b) Pb_xSO_4 CAS No 15739-80-7 EC No 239-831-0	Shall not be placed on the market, or used, as substances or in mixtures, where the substance or mixture is intended for use as paint. However, Member States may, in accordance with the provisions of International Labour Organization (ILO) Convention 13, permit the use on their territory of the substance or mixture for the restoration and maintenance of works of art and historic buildings and their interiors, as well as the placing on the market for such use. Where a Member State makes use of this derogation, it shall inform the Commission thereof.
18. **Mercury compounds**	Shall not be placed on the market, or used, as substances or in mixtures where the substance or mixture is intended for use: (a) to prevent the fouling by micro-organisms, plants or animals of: — the hulls of boats, — cages, floats, nets and any other appliances or equipment used for fish or shellfish farming, — any totally or partly submerged appliances or equipment; (b) in the preservation of wood; (c) in the impregnation of heavy-duty industrial textiles and yarn intended for their manufacture; (d) in the treatment of industrial waters, irrespective of their use.
18a. **Mercury** CAS No 7439-97-6 EC No 231-106-7	1. Shall not be placed on the market: (a) in fever thermometers; (b) in other measuring devices intended for sale to the general public (such as manometers, barometers, sphygmomanometers, thermometers other than fever thermometers).

Designation of the substance, of the group of substances or of the mixture	Conditions of restriction
	2. The restriction in paragraph 1 shall not apply to measuring devices that were in use in the Community before 3 April 2009. However, Member States may restrict or prohibit the placing on the market of such measuring devices. 3. The restriction in paragraph 1(b) shall not apply to: (a) measuring devices more than 50 years old on 3 October 2007; (b) barometers (except barometers within point (a)) until 3 October 2009. 5. The following mercury-containing measuring devices intended for industrial and professional uses shall not be placed on the market after 10 April 2014: (a) barometers; (b) hygrometers; (c) manometers; (d) sphygmomanometers; (e) strain gauges to be used with plethysmographs; (f) tensiometers; (g) thermometers and other non-electrical thermometric applications. The restriction shall also apply to measuring devices under points (a) to (g) which are placed on the market empty if intended to be filled with mercury. 6. The restriction in paragraph 5 shall not apply to: (a) sphygmomanometers to be used: (i) in epidemiological studies which are ongoing on 10 October 2012; (ii) as reference standards in clinical validation studies of mercury-free sphygmomanometers; (b) thermometers exclusively intended to perform tests according to standards that require the use of mercury thermometers until 10 October 2017; (c) mercury triple point cells which are used for the calibration of platinum resistance thermometers. 7. The following mercury-using measuring devices intended for professional and industrial uses shall not be placed on the market after 10 April 2014: (a) mercury pycnometers; (b) mercury metering devices for determination of the softening point. 8. The restrictions in paragraphs 5 and 7 shall not apply to: (a) measuring devices more than 50 years old on 3 October 2007; (b) measuring devices which are to be displayed in public exhibitions for cultural and historical purposes.
23. **Cadmium** and its compounds CAS No 7440-43-9 EC No 231-152-8	For the purpose of this entry, the codes and chapters indicated in square brackets are the codes and chapters of the tariff and statistical nomenclature of Common Customs Tariff as established by Council Regulation (EEC) No 2658/87 (1). 1. Shall not be used in mixtures and articles produced from the

Designation of the substance, of the group of substances or of the mixture	Conditions of restriction
	following synthetic organic polymers (hereafter referred to as plastic material): — polymers or copolymers of vinyl chloride (PVC) [3904 10] [3904 21] — polyurethane (PUR) [3909 50] — low-density polyethylene (LDPE), with the exception of low-density polyethylene used for the production of coloured masterbatch [3901 10] — cellulose acetate (CA) [3912 11] — cellulose acetate butyrate (CAB) [3912 11] — epoxy resins [3907 30] — melamine-formaldehyde (MF) resins [3909 20] — urea-formaldehyde (UF) resins [3909 10] — unsaturated polyesters (UP) [3907 91] — polyethylene terephthalate (PET) [3907 60] — polybutylene terephthalate (PBT) — transparent/general-purpose polystyrene [3903 11] — acrylonitrile methylmethacrylate (AMMA) — cross-linked polyethylene (VPE) — high-impact polystyrene — polypropylene (PP) [3902 10] Mixtures and articles produced from plastic material as listed above shall not be placed on the market if the concentration of cadmium (expressed as Cd metal) is equal to or greater than 0,01 % by weight of the plastic material. By way of derogation, the second subparagraph shall not apply to articles placed on the market before 10 December 2011. The first and second subparagraphs apply without prejudice to Council Directive 94/62/EC (13) and acts adopted on its basis. By 19 November 2012, in accordance with Article 69, the Commission shall ask the European Chemicals Agency to prepare a dossier conforming to the requirements of Annex XV in order to assess whether the use of cadmium and its compounds in plastic material, other than that listed in subparagraph 1, should be restricted. 2. Shall not be used in paints [3208] [3209]. For paints with a zinc content exceeding 10 % by weight of the paint, the concentration of cadmium (expressed as Cd metal) shall not be equal to or greater than 0,1 % by weight. Painted articles shall not be placed on the market if the concentration of cadmium (expressed as Cd metal) is equal to or greater than 0,1 % by weight of the paint on the painted article. 3. By way of derogation, paragraphs 1 and 2 shall not apply to articles coloured with mixtures containing cadmium for safety reasons. 4. By way of derogation, paragraph 1, second subparagraph shall not apply to: — mixtures produced from PVC waste, hereinafter referred to as ‘recovered PVC’, — mixtures and articles containing recovered PVC if their

Designation of the substance, of the group of substances or of the mixture	Conditions of restriction
	concentration of cadmium (expressed as Cd metal) does not exceed 0,1 % by weight of the plastic material in the following rigid PVC applications: — (a) profiles and rigid sheets for building applications; (b) doors, windows, shutters, walls, blinds, fences, and roof gutters; (c) decks and terraces; (d) cable ducts; (e) pipes for non-drinking water if the recovered PVC is used in the middle layer of a multilayer pipe and is entirely covered with a layer of newly produced PVC in compliance with paragraph 1 above. Suppliers shall ensure, before the placing on the market of mixtures and articles containing recovered PVC for the first time, that these are visibly, legibly and indelibly marked as follows: '*Contains recovered PVC*' or with the following pictogram:  In accordance with Article 69 of this Regulation, the derogation granted in paragraph 4 will be reviewed, in particular with a view to reducing the limit value for cadmium and to reassess the derogation for the applications listed in points (a) to (e), by 31 December 2017. 5. For the purpose of this entry, 'cadmium plating' means any deposit or coating of metallic cadmium on a metallic surface. Shall not be used for cadmium plating metallic articles or components of the articles used in the following sectors/applications: (a) equipment and machinery for: — food production [8210] [8417 20] [8419 81] [8421 11] [8421 22] [8422] [8435] [8437] [8438] [8476 11] — agriculture [8419 31] [8424 81] [8432] [8433] [8434] [8436] — cooling and freezing [8418] — printing and book-binding [8440] [8442] [8443] (b) equipment and machinery for the production of: — household goods [7321] [8421 12] [8450] [8509] [8516] — furniture [8465] [8466] [9401] [9402] [9403] [9404] — sanitary ware [7324] — central heating and air conditioning plant [7322] [8403] [8404] [8415] In any case, whatever their use or intended final purpose, the placing on the market of cadmium-plated articles or components of such articles used in the sectors/applications listed in points (a) and (b) above and of articles manufactured in the sectors listed in point (b) above is prohibited.

Designation of the substance, of the group of substances or of the mixture	Conditions of restriction
	6. The provisions referred to in paragraph 5 shall also be applicable to cadmium-plated articles or components of such articles when used in the sectors/applications listed in points (a) and (b) below and to articles manufactured in the sectors listed in (b) below: (a) equipment and machinery for the production of: — paper and board [8419 32] [8439] [8441] textiles and clothing [8444] [8445] [8447] [8448] [8449] [8451] [8452] (b) equipment and machinery for the production of: — industrial handling equipment and machinery [8425] [8426] [8427] [8428] [8429] [8430] [8431] — road and agricultural vehicles [chapter 87] — rolling stock [chapter 86] — vessels [chapter 89] 7. However, the restrictions in paragraphs 5 and 6 shall not apply to: — articles and components of the articles used in the aeronautical, aerospace, mining, offshore and nuclear sectors whose applications require high safety standards and in safety devices in road and agricultural vehicles, rolling stock and vessels, — electrical contacts in any sector of use, where that is necessary to ensure the reliability required of the apparatus on which they are installed. 8. Shall not be used in brazing fillers in concentration equal to or greater than 0,01 % by weight. Brazing fillers shall not be placed on the market if the concentration of cadmium (expressed as Cd metal) is equal to or greater than 0,01 % by weight. For the purpose of this paragraph brazing shall mean a joining technique using alloys and undertaken at temperatures above 450 °C. 9. By way of derogation, paragraph 8 shall not apply to brazing fillers used in defence and aerospace applications and to brazing fillers used for safety reasons. 10. Shall not be used or placed on the market if the concentration is equal to or greater than 0,01 % by weight of the metal in: (i) metal beads and other metal components for jewellery making; (ii) metal parts of jewellery and imitation jewellery articles and hair accessories, including: — bracelets, necklaces and rings, — piercing jewellery, — wrist-watches and wrist-wear, — brooches and cufflinks. 11. By way of derogation, paragraph 10 shall not apply to articles placed on the market before 10 December 2011 and jewellery more than 50 years old on 10 December 2011.

Designation of the substance, of the group of substances or of the mixture	Conditions of restriction
28. Carcinogen category 1A or 1B or carcinogen category 1 or 2 According to Appendices 1 and 2: **Cadmium oxide** **Cadmium chloride** **Cadmium fluoride** **Cadmium Sulphate** **Cadmium sulphide** **Cadmium (pyrophoric)** **Chromium (VI) trioxide** **Zinc chromates including zinc potassium chromate** **Nickel Chromate** **Nickel dichromate** **Potassium dichromate** **Ammonium dichromate** **Sodium dichromate** **Chromyl dichloride; chromic oxychloride** **Potassium chromate** **Calcium chromate** **Strontium chromate** **Chromium III chromate; chromic chromate** **Sodium chromate** **Lead Chromate** **Lead hydrogen arsenate** **Lead Nickel Salt** **Lead sulfochromate yellow; C.I. Pigment Yellow 34;** **Lead chromate molybdate sulfate red; C.I. Pigment Red 104;**	Without prejudice to the other parts of this Annex the following shall apply to entries 28 to 30: 1. Shall not be placed on the market, or used, — as substances, — as constituents of other substances, or, — in mixtures, for supply to the general public when the individual concentration in the substance or mixture is equal to or greater than: — either the relevant specific concentration limit specified in Part 3 of Annex VI to Regulation (EC) No 1272/2008, or, — the relevant concentration specified in Directive 1999/45/EC where no specific concentration limit is set out in Part 3 of Annex VI to Regulation (EC) No 1272/2008. Without prejudice to the implementation of other Community provisions relating to the classification, packaging and labelling of substances and mixtures, suppliers shall ensure before the placing on the market that the packaging of such substances and mixtures is marked visibly, legibly and indelibly as follows: 'Restricted to professional users'. 2. By way of derogation, paragraph 1 shall not apply to: (a) medicinal or veterinary products as defined by Directive 2001/82/EC and Directive 2001/83/EC; (b) cosmetic products as defined by Directive 76/768/EEC; (c) the following fuels and oil products: — motor fuels which are covered by Directive 98/70/EC, — mineral oil products intended for use as fuel in mobile or fixed combustion plants, — fuels sold in closed systems (e.g. liquid gas bottles); (d) artists' paints covered by Directive 1999/45/EC; (e) the substances listed in Appendix 11, column 1, for the applications or uses listed in Appendix 11, column 2. Where a date is specified in column 2 of Appendix 11, the derogation shall apply until the said date.
29. Mutagens: category 1B or category 2 According to Appendices 3 and 4: **Cadmium chloride** **Cadmium fluoride** **Cadmium Sulphate** **Chromium (VI) trioxide** **Potassium dichromate** **Ammonium dichromate** **Sodium dichromate** **Chromyl dichloride; chromic**	

Designation of the substance, of the group of substances or of the mixture	Conditions of restriction
oxychloride Potassium chromate Sodium chromate	
30. Toxic to reproduction: category 1A or 1B or toxic to reproduction category 1 or 2 According to Appendices 5 and 6: Cadmium chloride Cadmium fluoride Cadmium Sulphate Potassium dichromate Ammonium dichromate Sodium dichromate Sodium chromate Nickel dichromate Lead compounds with the exception of those specified elsewhere in this Annex Lead Arsenate Lead acetate Lead alkyls Lead azide Lead Chromate Lead di(acetate) Lead hydrogen arsenate Lead 2,4,6-trinitroresorcinoxide, lead styphnate Lead(II) methane- sulphonate Trilead bis- (orthophosphate) Lead hexa-fluorosilicate Mercury Silicic acid, lead nickel salt	
47. **Chromium VI** compounds	1. Cement and cement-containing mixtures shall not be placed on the market, or used, if they contain, when hydrated, more than 2 mg/kg (0,0002 %) soluble chromium VI of the total dry weight of the cement. 2. If reducing agents are used, then without prejudice to the application of other Community provisions on the classification, packaging and labelling of substances and mixtures, suppliers shall ensure before the placing on the market that the packaging of cement or cement-containing mixtures is visibly, legibly and indelibly marked with information on the packing date, as well as on the storage conditions and the storage period appropriate to maintaining the activity of the reducing agent and to keeping the content of soluble chromium VI below the limit indicated in paragraph 1. 3. By way of derogation, paragraphs 1 and 2 shall not apply to the placing on the market for, and use in, controlled closed and totally automated processes in which cement and cement-containing

Designation of the substance, of the group of substances or of the mixture	Conditions of restriction
	mixtures are handled solely by machines and in which there is no possibility of contact with the skin. 4. The standard adopted by the European Committee for Standardization (CEN) for testing the water-soluble chromium (VI) content of cement and cement-containing mixtures shall be used as the test method for demonstrating conformity with paragraph 1. 5. Leather articles coming into contact with the skin shall not be placed on the market where they contain chromium VI in concentrations equal to or greater than 3 mg/kg (0,0003 % by weight) of the total dry weight of the leather. 6. Articles containing leather parts coming into contact with the skin shall not be placed on the market where any of those leather parts contains chromium VI in concentrations equal to or greater than 3 mg/kg (0,0003 % by weight) of the total dry weight of that leather part. 7. Paragraphs 5 and 6 shall not apply to the placing on the market of second-hand articles which were in end-use in the Union before 1 May 2015.
63. **Lead** and its compounds CAS No 7439-92-1 EC No 231-100-4	1. Shall not be placed on the market or used in any individual part of jewellery articles if the concentration of lead (expressed as metal) in such a part is equal to or greater than 0,05 % by weight. 2. For the purposes of paragraph 1: (i) 'jewellery articles' shall include jewellery and imitation jewellery articles and hair accessories, including: (a) bracelets, necklaces and rings; (b) piercing jewellery; (c) wrist watches and wrist-wear; (d) brooches and cufflinks; (ii) 'any individual part' shall include the materials from which the jewellery is made, as well as the individual components of the jewellery articles. 3. Paragraph 1 shall also apply to individual parts when placed on the market or used for jewellery-making. 4. By way of derogation, paragraph 1 shall not apply to: (a) crystal glass as defined in Annex I (categories 1, 2, 3 and 4) to Council Directive 69/493/EEC (*); (b) internal components of watch timepieces inaccessible to consumers; (c) non-synthetic or reconstructed precious and semiprecious stones (CN code 7103, as established by Regulation (EEC) No 2658/87), unless they have been treated with lead or its compounds or mixtures containing these substances; (d) enamels, defined as vitrifiable mixtures resulting from the fusion, vitrification or sintering of minerals melted at a temperature of at least 500 °C. 5. By way of derogation, paragraph 1 shall not apply to jewellery articles placed on the market for the first time before 9 October 2013 and jewellery articles produced before 10 December 1961. 6. By 9 October 2017, the Commission shall re-evaluate paragraphs 1 to 5 of this entry in the light of new scientific information, including the availability of alternatives and the migration of lead

Designation of the substance, of the group of substances or of the mixture	Conditions of restriction
	from the articles referred to in paragraph 1 and, if appropriate, modify this entry accordingly. 7. 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. That limit shall not apply where it can be demonstrated that the rate of lead release from such an article or any such accessible part of an article, whether coated or uncoated, does not exceed 0,05 μg/cm 2 per hour (equivalent to 0,05 μg/g/h), and, for coated articles, that the coating is sufficient to ensure that this release rate is not exceeded for a period of at least two years of normal or reasonably foreseeable conditions of use of the article. For the purposes of this paragraph, it is considered that an article or accessible part of an article may be placed in the mouth by children if it is smaller than 5 cm in one dimension or has a detachable or protruding part of that size. 8. By way of derogation, paragraph 7 shall not apply to: (a) jewellery articles covered by paragraph 1; (b) crystal glass as defined in Annex I (categories 1, 2, 3 and 4) to Directive 69/493/ EEC; (c) non-synthetic or reconstructed precious and semi-precious stones (CN code 7103 as established by Regulation (EEC) No 2658/ 87) unless they have been treated with lead or its compounds or mixtures containing these substances; (d) enamels, defined as vitrifiable mixtures resulting from the fusion, vitrification or sintering of mineral melted at a temperature of at least 500 ° C; (e) keys and locks, including padlocks; (f) musical instruments; (g) articles and parts of articles comprising brass alloys, if the concentration of lead (expressed as metal) in the brass alloy does not exceed 0,5 % by weight; (h) the tips of writing instruments (i) religious articles; (j) portable zinc-carbon batteries and button cell batteries; (k) articles within the scope of: (i) Directive 94/62/EC; (ii) Regulation (EC) No 1935/2004; (iii) Directive 2009/48/EC of the European Parliament and of the Council (**); (iv) Directive 2011/65/EU of the European Parliament and of the Council (***) 9. By 1 July 2019, the Commission shall re-evaluate paragraphs 7 and 8(e), (f), (i) and (j) of this entry in the light of new scientific information, including the availability of alternatives and the migration of lead from the articles referred to in paragraph 7, including the requirement on coating integrity, and, if appropriate, modify this entry accordingly. 10. By way of derogation, paragraph 7 shall not apply to articles placed on the market for the first time before 1 June 2016. (*) OJ L 326, 29.12.1969, p. 36.

Designation of the substance, of the group of substances or of the mixture	Conditions of restriction
	(**) Directive 2009/48/EC of the European Parliament and of the Council of 18 June 2009 on the safety of toys (OJ L 170, 30.6.2009, p. 1). (***) Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (OJ L 174, 1.7.2011, p. 88).

Table A.1.0-3: Summary of Relevant Amendments to Annexes Not Updated in the Last Concise Version of the REACH Regulation

Designation of the substance, of the group of substances, or of the mixture	Conditions of restriction	Amended Annex	Amendment date
Addition of **Entry 62** concerning: (a) **Phenylmercury acetate** EC No: 200-532-5 CAS No: 62-38-4 (b) **Phenylmercury propionate** EC No: 203-094-3 CAS No: 103-27-5 (c) **Phenylmercury 2-ethylhexanoate** EC No: 236-326-7 CAS No: 13302-00-6 (d) **Phenylmercury octanoate** EC No: - CAS No: 13864-38-5 (e) **Phenylmercury neodecanoate** EC No: 247-783-7 CAS No: 26545-49-3	1. Shall not be manufactured, placed on the market or used as substances or in mixtures after 10 October 2017 if the concentration of mercury in the mixtures is equal to or greater than 0,01% by weight. 2. Articles or any parts thereof containing one or more of these substances shall not be placed on the market after 10 October 2017 if the concentration of mercury in the articles or any part thereof is equal to or greater than 0,01% by weight.'	Annex XVII, entry 62	20 Sep 2012

As of 28 September 2015, the REACH Regulation Candidate list includes those substances relevant for RoHS listed in Table A.1.0-4 (i.e., proceedings concerning the addition of these substances to the Authorisation list (Annex XIV) have begun, and shall be followed by the consultants to determine possible discrepancies with future requests of exemption from RoHS (new exemptions, renewals and revokals))[124]:

Table A.1.0-4: Summary of Relevant Substances Currently on the REACH Candidate List

Substance Name	EC No.	CAS No.	Date of Inclusion	Reason for inclusion
Cadmium fluoride	232-222-0	7790-79-6	17 December 2014	Carcinogenic (Article 57 a); Mutagenic (Article 57 b); Toxic for reproduction (Article 57 c); Equivalent level of concern having probable serious effects to human health (Article 57 f)
Cadmium sulphate	233-331-6	10124-36-4 31119-53-6	17 December 2014	Carcinogenic (Article 57 a); Mutagenic (Article 57 b); Toxic for reproduction (Article 57 c); Equivalent level of concern having probable serious effects to human health (Article 57 f)
Cadmium chloride	233-296-7	10108-64-2	16 June 2014	Carcinogenic (Article 57a);
Cadmium sulphide	215-147-8	1306-23-6	16 Dec 2013	Carcinogenic (Article 57a); Equivalent level of concern having probable serious effects to human health (Article 57 f)
Lead di(acetate)	206-104-4	301-04-2	16 Dec 2013	Toxic for reproduction (Article 57 c);
Cadmium	231-152-8	7440-43-9	20 Jun 2013	Carcinogenic (Article 57a); Equivalent level of concern having probable serious effects to human health (Article 57 f)
Cadmium oxide	215-146-2	1306-19-0	20 Jun 2013	Carcinogenic (Article 57a); Equivalent level of concern having probable serious effects to human health (Article 57 f)
Pyrochlore, antimony lead yellow	232-382-1	8012-00-8	19 Dec 2012	Toxic for reproduction (Article 57 c)
Lead bis(tetrafluoroborate)	237-486-0	13814-96-5	19 Dec 2012	Toxic for reproduction (Article 57 c)

[124] Updated according to http://echa.europa.eu/web/guest/candidate-list-table

Substance Name	EC No.	CAS No.	Date of Inclusion	Reason for inclusion
Lead dinitrate	233-245-9	10099-74-8	19 Dec 2012	Toxic for reproduction (Article 57 c)
Silicic acid, lead salt	234-363-3	11120-22-2	19 Dec 2012	Toxic for reproduction (Article 57 c)
Lead titanium zirconium oxide	235-727-4	12626-81-2	19 Dec 2012	Toxic for reproduction (Article 57 c)
Lead monoxide (lead oxide)	215-267-0	1317-36-8	19 Dec 2012	Toxic for reproduction (Article 57 c)
Silicic acid ($H_2Si_2O_5$), barium salt (1:1), lead-doped *[with lead (Pb) content above the applicable generic concentration limit for 'toxicity for reproduction' Repr. 1A (CLP) or category 1 (DSD); the substance is a member of the group entry of lead compounds, with index number 082-001-00-6 in Regulation (EC) No 1272/2008]*	272-271-5	68784-75-8	19 Dec 2012	Toxic for reproduction (Article 57 c)
Trilead bis(carbonate)dihydroxide	215-290-6	1319-46-6	19 Dec 2012	Toxic for reproduction (Article 57 c)
Lead oxide sulfate	234-853-7	12036-76-9	19 Dec 2012	Toxic for reproduction (Article 57 c)
Lead titanium trioxide	235-038-9	12060-00-3	19 Dec 2012	Toxic for reproduction (Article 57 c)
Acetic acid, lead salt, basic	257-175-3	51404-69-4	19 Dec 2012	Toxic for reproduction (Article 57 c)
[Phthalato(2-)]dioxotrilead	273-688-5	69011-06-9	19 Dec 2012	Toxic for reproduction (Article 57 c)
Tetralead trioxide sulphate	235-380-9	12202-17-4	19 Dec 2012	Toxic for reproduction (Article 57 c)
Dioxobis(stearato)trilead	235-702-8	12578-12-0	19 Dec 2012	Toxic for reproduction (Article 57 c)
Tetraethyllead	201-075-4	78-00-2	19 Dec 2012	Toxic for reproduction (Article 57 c)
Pentalead tetraoxide sulphate	235-067-7	12065-90-6	19 Dec 2012	Toxic for reproduction (Article 57 c)
Trilead dioxide phosphonate	235-252-2	12141-20-7	19 Dec 2012	Toxic for reproduction (Article 57 c)
Orange lead (lead tetroxide)	215-235-6	1314-41-6	19 Dec 2012	Toxic for reproduction (Article 57 c)
Sulfurous acid, lead salt, dibasic	263-467-1	62229-08-7	19 Dec 2012	Toxic for reproduction (Article 57 c)
Lead cyanamidate	244-073-9	20837-86-9	19 Dec 2012	Toxic for reproduction (Article 57 c)
Lead(II) bis(methanesulfonate)	401-750-5	17570-76-2	18 Jun 2012	Toxic for reproduction (Article 57 c)
Lead diazide, Lead azide	236-542-1	13424-46-9	19 Dec 2011	Toxic for reproduction (article 57 c),
Lead dipicrate	229-335-2	6477-64-1	19 Dec 2011	Toxic for reproduction (article 57 c)

Substance Name	EC No.	CAS No.	Date of Inclusion	Reason for inclusion
Dichromium tris(chromate)	246-356-2	24613-89-6	19 Dec 2011	Carcinogenic (article 57 a)
Pentazinc chromate octahydroxide	256-418-0	49663-84-5	19 Dec 2011	Carcinogenic (article 57 a)
Potassium hydroxyoctaoxo-dizincatedichromate	234-329-8	11103-86-9	19 Dec 2011	Carcinogenic (article 57 a)
Lead styphnate	239-290-0	15245-44-0	19 Dec 2011	Toxic for reproduction (article 57 c)
Trilead diarsenate	222-979-5	3687-31-8	19 Dec 2011	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Strontium chromate	232-142-6	7789-06-2	20 Jun 2011	Carcinogenic (article 57a)
Acids generated from chromium trioxide and their oligomers. Names of the acids and their oligomers: Chromic acid, Dichromic acid, Oligomers of chromic acid and dichromic acid.	231-801-5, 236-881-5	7738-94-5, 13530-68-2	15 Dec 2010	Carcinogenic (article 57a)
Chromium trioxide	215-607-8	1333-82-0	15 Dec 2010	Carcinogenic and mutagenic (articles 57 a and 57 b)
Potassium dichromate	231-906-6	7778-50-9	18 Jun 2010	Carcinogenic, mutagenic and toxic for reproduction (articles 57 a, 57 b and 57 c)
Ammonium dichromate	232-143-1	7789-09-5	18 Jun 2010	Carcinogenic, mutagenic and toxic for reproduce-tion (articles 57 a, 57 b and 57 c)
Sodium chromate	231-889-5	7775-11-3	18 Jun 2010	Carcinogenic, mutagenic and toxic for reproduction (articles 57 a, 57 b and 57 c)
Potassium chromate	232-140-5	7789-00-6	18 Jun 2010	Carcinogenic and mutagenic (articles 57 a and 57 b).
Lead sulfochromate yellow (C.I. Pigment Yellow 34)	215-693-7	1344-37-2	13 Jan 2010	Carcinogenic and toxic for reproduction (articles 57 a and 57 c))
Lead chromate molybdate sulphate red (C.I. Pigment Red 104)	235-759-9	12656-85-8	13 Jan 2010	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Lead chromate	231-846-0	7758-97-6	13 Jan 2010	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Lead hydrogen arsenate	232-064-2	7784-40-9	28 Oct 2008	Carcinogenic and toxic for reproduction (articles 57 a and 57 c)
Sodium dichromate	234-190-3	7789-12-0, 10588-01-9	28 Oct 2008	Carcinogenic, mutagenic and toxic for reproduction (articles 57a, 57b and 57c)

Additionally, Member States can register intentions to propose restrictions or to classify substances as SVHC. The first step is to announce such an intention. Once the respective dossier has been submitted, it will be reviewed and decided whether the restriction or authorisation process should be further pursued or whether the intention should be withdrawn.

As at the time of writing (Fall 2015), it cannot yet be foreseen how these procedures will conclude. It is thus not yet possible to determine if the protection afforded by REACH Regulation would in these cases consequently be weakened by approving the exemption requests dealt with in this report. For this reason, the implications of these decisions have not been considered in the review of the exemption requests dealt with in this report. However, for the sake of future reviews, the latest authorisation or restriction process results shall be followed and carefully considered where relevant.[125]

As for registries of intentions to identify substances as SVHC, as of 28 September 2015, Sweden has submitted intentions regarding the classification of cadmium fluoride and cadmium sulphate as CMR, intending to submit dossiers in August 2014.None of the current registries of intentions to propose restrictions apply to RoHS regulated substances.[126]

As for prior registrations of intention, dossiers have been submitted for the substances listed in Table A.1.0-5.

Table A.1.0-5: Summary of Substances for which a Dossier has been submitted, following the initial registration of intention

Restriction / SVHC Classification	Substance Name	Submission Date	Submitted by	Comments
Restriction	Cadmium and its compounds	17 Jan 2014	Sweden	Artist paints
	Cadmium and its compounds	17 Oct 2013	ECHA	Amendment of the current restriction (entry 23) on use of paints with TARIC codes [3208] & [3209] containing cadmium and cadmium compounds to include placing on the market of such paints and a concentration limit.

125 European Chemicals Agency (ECHA), Registry of intentions to propose restrictions: http://echa.europa.eu/registry-of-current-restriction-proposal-intentions/-/substance/1402/search/+/term (28.09.2015)

126 ECHA website, accessed 28.09.2015: http://echa.europa.eu/web/guest/addressing-chemicals-of-concern/registry-of-intentions

Restriction / SVHC Classification	Substance Name	Submission Date	Submitted by	Comments
	Lead and lead compounds	18 Jan 2013	Sweden	Placing on the market of consumer articles containing Lead and its compounds
	Chromium VI	20 Jan 2012	Denmark	Placing on the market of leather articles containing Chromium VI
	Phenylmercuric octanoate; Phenylmercury propionate; Phenylmercury 2-ethylhexa-noate; Phenylmercury acetate; Phenylmercury	15 Jun 2010	Norway	Mercury compounds
	Mercury in measuring devices	15 Jun 2010	ECHA	Mercury compounds
	Lead and its compounds in jewellery	15 Apr 2010	France	Substances containing lead
SVHC Classification	Cadmium chloride	03 Feb 2014	Sweden	CMR; other;
	Cadmium sulphide	05 Aug 2013	Sweden	CMR; other;
	Lead di(acetate)	05 Aug 2013	Netherlands	CMR
	Cadmium	04 Feb 2013	Sweden	CMR; other; Substances containing Cd
	Cadmium oxide	04 Feb 2013	Sweden	CMR; other; Substances Containing Cd
	Trilead dioxide Phosphonate; Lead Monoxide (Lead Oxide); Trilead bis(carbonate)di-hydroxide; Lead Dinitrate; Lead Oxide Sulphate; Acetic acid, lead salt, basic; Dioxobis(stearato)trilead; Lead bis(tetrafluoroborate); Tetraethyllead; Pentalead tetraoxide sulphate; Lead cyanamidate; Lead titanium trioxide; Silicic acid ($H_2Si_2O_5$), barium salt (1:1), lead-doped; Silicic acid, lead salt; Sulfurous acid, lead salt, dibasic; Tetralead trioxide sulphate; [Phthalato(2-)]dioxotrilead; Orange lead (lead tetroxide); Fatty acids, C16-18, lead salts; Lead titanium zirconium oxide	30 Aug 2012	ECHA	CMR; substances Containing Lead

Restriction / SVHC Classification	Substance Name	Submission Date	Submitted by	Comments
	Lead(II) bis(methanesulfonate)	30 Jan 2012	Netherlands	CMR; Amides
	Lead styphnate; Lead diazide; Lead azide; Lead dipicrate	01 Aug 2011	ECHA	CMR; Substances containing lead
	Trilead diarsenate			CMR; Arsenic compounds
	Strontium Chromate	24 Jan 2011	France	CMR; Substances containing chromate
	Acids generated from chromium trioxide and their oligomers: Chromic acid; Dichromic acid; Oligomers of chromic acid and dichromic acid	27 Aug 2010	Germany	CMR; Substances containing chromate
	Chromium Trioxide	02 Aug 2010	Germany	CMR; Substances containing chromate
	Sodium chromate; Potassium chromate; Potassium Dichromate	10 Feb 2010	France	CMR; Substances containing chromate
	Lead chromate molybdate sulfate red (C.I. Pigment Red 104); Lead sulfochromate yellow (C.I. Pigment Yellow 34)	03 Aug 2009	France	CMR; substances Containing Lead
	Lead Chromate	03 Aug 2009	France	CMR; Substances containing chromate
	Lead hydrogen arsenate	27 Jun 2008	Norway	CMR; Arsenic compounds
	Sodium dichromate	26 Jun 2008	France	CMR; Substances containing chromate

Concerning the above-mentioned processes, as at present, it cannot be foreseen if, or when, new restrictions or identification as SVHC might be implemented as a result of this proposal; its implications have not been considered in the review of the exemption requests dealt with in this report. In future reviews, however, on-going research into restriction and identification as SVHC processes and the results of on-going proceedings shall be followed and carefully considered where relevant.

A.2.0 Appendix A.2.0: Answers to Request for information concerning RoHS Exemption 9b

Danfoss Answers, sent per email, 25.9.2015 after being specifically approached and requested to comment on the exemption request and its relevance to Danfoss activities：

Stakeholder Consultation Questions

1. Do you agree with the proposed exemption wording and its requested duration of three years? If not, please provide an alternative wording.

2. Please provide information concerning substitutes for lead in the above-mentioned application. In your answers please clarify for which types of bushings and bearings suggested substitutes could be of relevance (e.g., journal bearings, linear bearings, etc.), as well as the applicability of such alternatives for refrigerant-containing compressors, with a stated electrical power input of only 9 kW or lower.

3. Do you share the applicant's arguments, or are you opposed to the requested exemption? Please explain your answer in detail, in particular if you oppose the requested exemption. Please also explain if you have additional arguments to support the request.

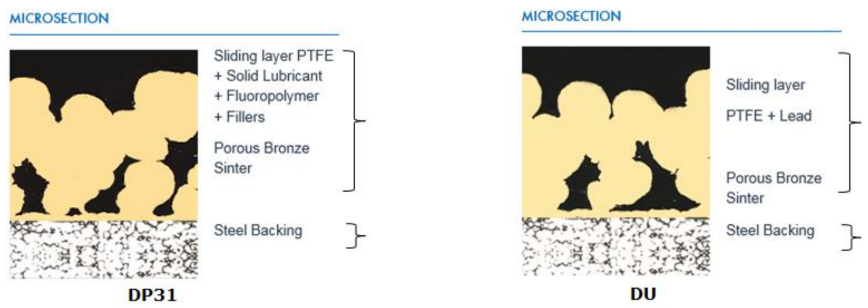
4. There are other manufacturers delivering refrigerant compressors within the EU market, e.g. Bitzer and Tecumseh. It is yet to be established whether some or all of these other manufacturers support the exemption request. Please provide information as to why these manufacturers do not need the requested exemption, or alternatively, to clarify why granting the requested exemption is justified for the applicants refrigerant-containing compressors, with a stated electrical power input of 9 kW or lower, despite their being other such devices on the market that do not need the exemption?

5. Are there any other aspects you deem to be of importance for the requested exemption?

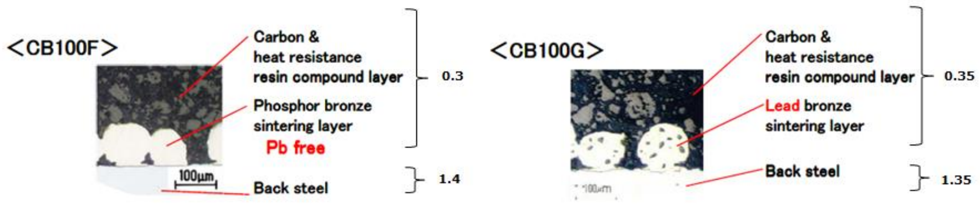
Answers:

1. Yes, we agree with the proposed exemption wording and the duration time.
2. For the compressors with a stated electrical power input of only 9kW or lower, in Danfoss we have two proposes currently.

   - One is that we try to use DP31 bushing (which is free lead) to replace the DU bushing, from the microsection we can see the details. The oil lubricated properties DP31 bushing is better than DU bushing theoretically, and costs will increase



- The other is that we try to use CB100G bushing (which is free lead) to replace the CB100F bushing; from the microsection we can see the details. The difference of CB100G and CB100F is the inner material; we think the exchange will not influence the compressor performance, but the costs will increase.



- However, the two material is not used before, we don't know the actual influence on our compressor, we have to do the more test to prove the two materials, and it will need a long time.

3. Yes, we agree with the applicant's argument.

   - Because lead is a key element in the bushing for reliability, currently bushing construction and material we used is decided by the special construction of hermetical scroll compressor and lubrication system. It will take a long time for us to switch to a new material. There are many technical challenges.

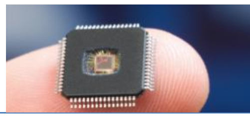
4. We will answer the question "why granting the requested exemption is justified for the applicants refrigerant-containing compressor, with a stated electrical power input of 9kW or lower, despite their being other such devices on the market that do not need the exemption".

   - The answer is similar with question3, because of the special construction of compressors and in order to meet the functional requirements. We will switch the material as soon as possible, but it will take a long time, because it need constantly pilot test to meet the functional requirements.

5. No more advice.

A.3.0 Appendix A.3.0: Devices and their Usage by Professional and Non-professional Customers

Figure 1: Selected Devices and their Use.

Device	Professional customer	Non-professional customer	Typical Application
Stereo Microscope	X	X	Botanic / Zoology[1] 
Laserscanning Microscope	X		Medicine / Cytology[2] 
Photographic Lenses	X	X	Architecture[3] 
Binoculars and Telescopes	X	X	Ornithology[4] 
Lithographic Lenses	X		Photolithography[5] 
Projectors	X	X	Presentations / Movies[6] 

There is a broad spectrum of optical devices for commercial and professional usage. In most cases, lead-free glass types are used. In some cases, the properties of lead-containing glass are necessary to enable certain applications and unique features. There are two reasons why a differentiation between professional and nonprofessional devices is not productive:

1) Beside the professional market are engaged non-professional users who are buying and using professional equipment, like Stereo-Microscopes or high

performance photographic lenses. It is their personal interest of to work with such devices.

2) There are still some consumer products which need properties of lead-containing glass types, for example projection systems which become very hot during use. The special thermal behaviour of some lead-containing glasses is needed.

Conclusion:
We would not propose to differentiate between professional devices and consumer devices within the exemption.

References

[1]*http://www.zeiss.de/microscopy/de_de/produkte/stereo-zoom-microscopes/stemi-508.html (Königsfarn – Sori und Sporangien, Spot K LED, schräges Auflicht, Zoom 0,63x und Frontoptik 0,63x)*

[2]*http://www.zeiss.de/microscopy/de_de/produkte/confocal-microscopes/lsm-700-for-biology.html (Drosophila-Embryo, immungefärbt für Tropomyosin, Pax 3/7 und Anti-HRP. Alle Nuklei sind grau dargestellt (DAPI). Mit freundlicher Genehmigung des Marine Biological Laboratory, Woods Hole, MA)*

[3]*http://www.zeiss.de/camera-lenses/de_de/camera_lenses/slr-lenses/distagont2815.html*

(Potsdamer Platz, by http://christian.dandyk.de)

[4]*http://www.zeiss.de/sports-optics/de_de/natur/erleben/aktuelles.html*

[5]*http://www.zeiss.de/semiconductor-manufacturing-technology/de_de/maerkte-partner.html*

[6]*http://www.sanfranciscosentinel.com/?p=171514*