Adaptation to Scientific and Technical Progress under Directive 2002/95/EC – Evaluation of New Requests for Exemptions and/or Review of Existing Exemptions

Final report

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1 Background and Objectives

Article 4(1) of Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment ("RoHS Directive") provides "that from 1 July 2006, new electrical and electronic equipment put on the market does not contain lead, mercury, cadmium, hexavalent chromium, PBB or PBDE." The Annex to the Directive lists a limited number of applications of lead, mercury, cadmium and hexavalent chromium, which are exempted from the requirements of Article 4(1) and are subject to technical and scientific progress.

Article 5(1)(b) of the Directive provides that materials and components can be exempted from the substance restrictions contained in Article 4(1) if their elimination or substitution via design changes or materials and components which do not require any of the materials or substances referred to therein is technically or scientifically impracticable, or where the negative environmental, health and/or consumer safety impacts caused by substitution outweigh the environmental, health and/or consumer safety benefits thereof.

On the basis of this provision the Commission is receiving requests for applications to be exempted from the requirements of the Directive. These requests need to be evaluated in order to assess whether they fulfil the abovementioned requirements of Article 5(1)(b). Where the requirements are fulfilled the Commission can propose a draft decision amending the Annex to the RoHS Directive.

Furthermore, based on Article 5(1)(c), the Commission shall carry out a review of each exemption listed in the Annex at least every four years or four years after an item has been added to the list, i.e. the deletion of materials and components of electrical and electronic equipment from the existing Annex has to be considered if their elimination or substitution is possible with regard to the criteria listed in Article 5(1)(b) (see above). Hence, any request for the review of existing exemptions which may be received by the Commission will also need to be assessed.

Against this background the Commission has contracted Öko-Institut together with Fraunhofer IZM in view of technical assistance for both, the evaluation of requests for exemptions submitted according to Article 5(1)(b) and for the evaluation of existing exemptions according to Article 5(1)(c). Furthermore, the consultation with stakeholders on the review of the Annex according to Article 5(2) has been carried out and - where applicable - the suggestion for a final wording for the exemption is provided.

2 Scope

In the course of the project, four stakeholder consultations have been conducted; three existing RoHS exemptions have been reviewed and four new RoHS exemption requests have been evaluated. An overview on the covered exemptions and exemption requests is given in Table 1.

On 22 January 2010 a first stakeholder consultation was launched that ran until 29 March 2010 and covered the exemption request 1. A second stakeholder consultation ran from 23 April 2010 until 18 June 2010 covering the exemption request 2. A third stakeholder consultation covered the existing exemptions no. 30, 31 and 32 and ran from 20 September 2010 until 15 November 2010. The fourth and last consultation was launched on 6 December 2010 and ran until 14 February 2011. It covered two exemption requests 3 and 4.

A specific project website was set up in order to keep stakeholders informed on the progress of work: http://rohs.exemptions.oeko.info. The four consultations held during the project were carried out according to the principles and requirements of the Commission. Stakeholders who had registered at the website were informed by mailings about new steps within the project.

For each consultation, an own section on the project website provided a general guidance document, the applicant's documents in the case of exemption requests or results of former evaluations in the case of existing exemptions, a specific questionnaire and the link to the EU CIRCA website, where all non-confidential stakeholder comments submitted during the consultations were made available:
http://circa.europa.eu/Public/irc/env/rohs_2010_review/library.

The evaluation of the stakeholder contributions included inter alia getting back to stakeholders for further discussion, exchange in order to clarify remaining questions and cross-check with regard to technical correctness and confidentiality issues. Where necessary, stakeholder meetings were held.

3 Overview on the Evaluation Results

In the course of the project, three existing RoHS exemptions have been reviewed and four new RoHS exemption requests have been evaluated. The exemptions and exemption request covered in this project together with the involved stakeholders and the final recommendations and expiry date given are summarized in Table 1. Please refer to the corresponding chapters of this report for more details on the evaluation results. The final –

not legally binding - recommendations for exemption request no. 1 and 2 given to the EU Commission by Öko-Institut and Fraunhofer IZM have already been published at the EU CIRCA website on 23 November 2010. So far, the Commission has not adopted any revision of the Annex to Directive 2002/95/EC based on these recommendations.

Table 1 Overview on the recommendations and expiry date

Exemption requests				
No.	**Wording**	**Applicant**	**Recommendation**	**Expiry / review date**
1	"Cadmium in photoresistors for analogue optocouplers applied in professional audio equipment until 31 December 2013"	Meyer Sound Laboratories	Cadmium in photoresistors for analogue optocouplers applied in professional audio equipment up to 31 December 2013.	31 December 2013.
2	"Lead in PZT based dielectric ceramic materials for capacitors being part of integrated circuits or discrete semiconductors"	ESIA Ramtron	Lead in PZT based dielectric ceramic materials of capacitors being part of integrated circuits or discrete semiconductors.	
3	"Cadmium as a pigment for use in vitreous enamel"	Institute of Vitreous Enamellers	Grant only if certain conditions apply.	
4	"Restriction of exemption 1 to non-liquid mercury"	Neonlite Megaman	Not to be granted.	
Existing exemptions				
No.	**Wording**	**Stake-holders**	**Recommendation**	**Expiry / review date**
30	Cadmium alloys as electrical/ mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers with sound pressure levels of 100 dB (A) and more	None	Deletion of the exemption.	Expiry at least six months after official publication of this recommendation.
31	Lead in soldering materials in mercury-free flat fluorescent lamps (which e.g. are used for liquid crystal displays, design or industrial lighting)	OSRAM	Deletion of the exemption.	-
32	Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes	Coherent; JDS Uniphase	Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes	Review latest four years after official publication.

4 Exemption Request No. 1 "Cadmium in Photoresistors for Analogue Optocouplers Applied in Professional Audio Equipment until 31 December 2013"

Exemption request no.1 by Meyer Sound Laboratories is very similar to previous requests subitted by Marshall Amplification plc, Set 6, request no. 23 and Sound Devices, Set 7, request no. 4. Both exemptions were evaluated in the context of a former project in 2007 (see extract from corresponding report under http://rohs.exemptions.oeko.info/index.php?id=77).

The final recommendation led to the following wording that was included in the Annex to the RoHS Directive under entry no. 35: *Cadmium in photoresistors for optocouplers applied in professional audio equipment until 31.12.2009.*

Since the exemption has expired end of 2009, Meyer Sound Laboratories has requested a continuation of the exemption. This exemption request was subsequently subject to an online stakeholder consultation. Initial answers have been received from stakeholders[1] in the context of the online stakeholder consultation. Details and contributions can be found under http://rohs.exemptions.oeko.info/index.php?id=77.

Further questions have been sent to Meyer Sound Laboratories and BOSCH providing additional responses (Meyer Sound 2010) as well a conference call has been held with both stakeholders.

The outcome of this information gathering exercise and of the exchange with the above mentioned stakeholders is reflected in the following.

4.1 Properties and Terms for Cadmium-Based Photoresistors in Analogue Optocouplers

All audio systems are limited by inherent noise at low levels and by overload distortion at high levels. The usable region between these two extremes is the **dynamic range**[2] of the system. Otherwise defined as the range between the loudest and softest sounds a sound format or system can reproduce with noise or distortion (often expressed in dB).

Gain is "The power increase of a signal, usually expressed in dB." (Gensch et al. 2007)

Audio Limiter is a device that permits a high compression to be applied above a set threshold. It limits the output level from raising much above the set threshold. Vice versa, it

[1] Stakeholders include Meyer Sound Laboratories, BOSCH, Woodgate and Associates, Adam Hall, Hardy Kurandt. Within this chapter "stakeholders" is used as generic term referring to all mentioned organisations and / or individuals if not otherwise specified.

[2] Source: http://widescreenreview.com/eq_glossary.php?letter=D

facilitates the maximisation of an audio signal to the upper limits of the capabilities of the audio circuitry. Audio limiters prevent overload distortion, or “clipping” (cf. Figure 1).

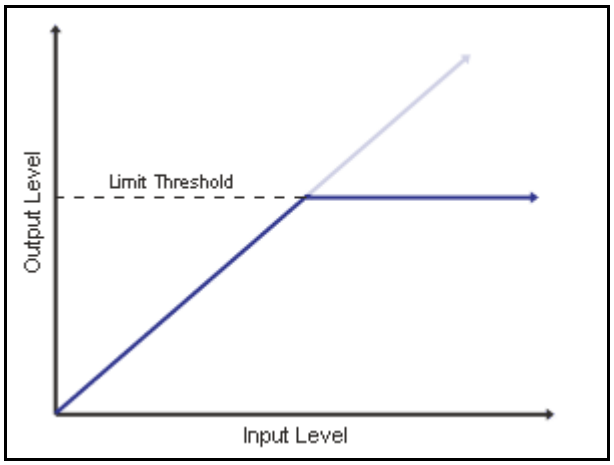

Figure 1 Input level vs. output level with limiting threshold[3]

Further on, it allows for maximisation of the audio level of the desirable audio signal relative to the audio noise in the floor of the audio signal, an inherent artefact to audio circuitry (Gensch et al. 2007).

Clipping is an audio signal distortion, which occurs through attempts to increase the voltage or current in an amplifier beyond its threshold of power (Gensch et al. 2007).

4.2 Description of the Requested Exemption

Analogue optocouplers are used in professional audio equipment as defined in EN 55103-1 for feedback control (control engineering), elements in automatic gain control circuits, audio limiting and compression, noiseless switching, and logic interfacing. They are also applied in portable professional digital audio recorders, where they limit the audio input AC voltage while recording audio signals, like for remote news gathering or major motion pictures (Meyer Sound 2009).

In addition, the exemption is needed for voice alarm systems (e.g. evacuation of buildings or ferries) and conference systems. The photoresistor components are used in microphone amplifier circuits to prevent clipping of the sound due to too high audio signals (Bosch 2010a).

An optocoupler or opto-isolator (see Figure 2) is a device which uses a beam of light to transmit analogue or digital signals between two isolated circuits. Its construction is typically a combination of two distinct packages: an LED (light-emitting diode) as the transmitter and an optical receiver such as a phototransistor or a photoresistor as in this exemption request. The

[3] Source: http://www.mediacollege.com/audio/processing/limiter/

use of light ensures that the sending and receiving circuits are electrically unconnected (i.e. galvanic isolation[4]).

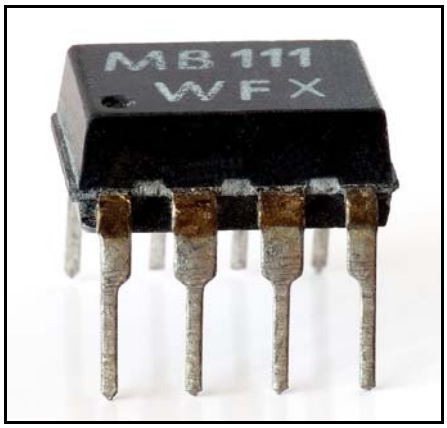

Figure 2 Optocoupler [5]

The analogue optocoupler devices include a cadmium-containing semiconductor in the photoresistors that may not be RoHS compliant. This cadmium sulphide semiconductor changes its resistance in proportion to the amount of light that hits it. The maximum rate of change in resistance of the cadmium sulphide has natural characteristics ideal for gain control in professional audio applications.

The photoresistors are thin film devices made by depositing a layer of a photoconductive cadmium sulphide material on a ceramic substrate. The photoconductive material is a compound of cadmium and sulphur oxide.

An important use of optocouplers is their application as optical isolators (electrical isolation / input-to output isolation)). The sending circuit operates with a low voltage direct current (5-24 V DC), the receiving circuit with a high voltage AC. The optocoupler enables the optical control of such high currents with a low drive current without an electrical contact between the two circuits.

Furthermore, analogue optocouplers are used in professional audio equipment to achieve the following functions (Meyer Sound 2009):

- No electrical power use when in a stand-by or idle operational state.
- Extremely low audible noise during operation.
- Extremely low audible distortion during operation.
- Bipolar characteristic ideal for audio alternating periodic current signals.

[4] http://en.wikipedia.org/wiki/Galvanic_isolation

[5] http://en.wikipedia.org/wiki/Opto-isolator

- Limiter circuits in audio amplifier can use audio signals fed directly into the light source input eliminating the need for other control circuitry.
- Slow response time results in “click”-free response to control transients

As a contributing stakeholder to the online consultation, Bosch provided the information that analogue photoresistors are also needed for microphone circuits in “voice alarm systems” and “conference systems”. For those systems set speech intelligibility requirements and audio quality, even under stressed conditions of the operator, are of important significance. In certain particularly sensitive situations some announcements (airports, railway stations) require voice signals up to 115 dB SPL (decibel sound pressure level). In these types of circumstances the audio limiting circuits will prevent audio signal clipping and result in a low noise up to 70 dB with low distortion[6] and keep up with an audible friendly speech intelligibility.

The analogue optocoupler cadmium content of Meyer Sound products is estimated at 2.000 µg per device. The annual analogue optocoupler sales of Meyer Sound amount to 3.000 units in the EU resulting in approximately 0,006 kg of cadmium put onto the EU market annually.

In comparison to the specifications of the former exemption request of Sound Device (cf. Gensch et al. 2007) the amount of cadmium used in an optocoupler was stated to be around 100 µg. Sound Devices’ annual sales to the EU were said to be 12.000 optocouplers, resulting in the lower cadmium amount of 0,0012 kg cadmium.

Total figures for all producers using such devices in professional audio equipment are not available. Meyer Sound did not provide any sales and cadmium content figures. However, they indicated the current amount (in absolute number and in percentage by weight) of cadmium in the photoresistor, of an average analogue optocoupler using a photosensitive layer in RoHS relevant applications (cf. Table 2).

Table 2 Overview amount of cadmium used in RoHS application by Meyer Sound

Device	Cadmium weight in µg	Cadmium concentration weight in %
analog optocoupler	1.973	0.15%
photoresistor		0.54%
photosensitive layer		75.31%

[6] Compliant to IEC 60914 i.e. a maximum audio distortion of 1% over a 30 dB limiter range is in line with the requirements for conference systems applications.

The applicant requests a continuation of exemption 35 with the following wording:

"Cadmium in photoresistors for analogue optocouplers applied in professional audio equipment until 31 December 2013".

4.3 Justification for Exemption

The following section summarises the information from Meyer Sound and the other involved stakeholders as well from the previous evaluation in 2007 (Gensch et al. 2007).

Meyer Sound Laboratories considers that there are no known technically and scientifically feasible RoHS compliant substitutes and alternate processes at the moment. Nevertheless they state to being continuously investigating new state of the art solutions to replace this component but however fail to provide any substantiated evidence on these activities.

According to Meyer Sound, the elimination of the analogue optocoupler cadmium sulphide in the current applications would result in non functional equipment, for example in removing the control circuit which keeps the equipment electrically safe from the risk of fire and electric shock. The use of cadmium-containing analogue optocoupler allows exact high input-to-output isolation and matching the true resistance element output. Furthermore, other stakeholders say that the usage of an analogue photoresistor benefits from a low complexity (notably digital technologies), low audio noise, low distortion, high dynamic range and audible compressing and limiting behaviour. Stakeholders underline that all of these required properties and considerations are of high importance for professional audio equipment (especially loudspeakers) (Woodgate 2010).

Further technical advantages of analogue optocouplers as stated by stakeholders is that they use no electrical power when in a stand-by or idle operational states and that no other proposed solution can meet this high energy usage standard. Professional audio products are designed for high performance and long product life. Production quantities are thus limited and the owners tend to repair the products rather than dispose of them. Therefore, stakeholders argue that keeping a high quality standard of the product is necessary in order to ensure these characteristics.

According to stakeholders, professional audio equipment will be installed and replaced by professionals thus ensuring take-back to professional waste treatment installations (Bosch 2010a).

4.3.1 Cadmium-Free Photoresistors or Substitutes

The applicant argues that there are no technically and scientifically available substitutes known for cadmium and that there is no direct replacement for the analogue optocoupler that does not contain trace amounts of cadmium. According to Meyer Sound, any replacement would require a complete redesign of the audio amplifier circuits from analogue design to a RoHS-compliant or to a based on silicon-technology digital signal processing (DSP) type.

More detailed explanation about digital signals and their distinction from analogue signals can be derived from previous evaluation results (Gensch et al. 2007).

The applicant has also investigated in other alternative technologies like the use of a Junction Field Effect Transistor (JFET) or a voltage controlled amplifier (VCA). Both alternates would not give the desired characteristics and due to its extra complexity they incur significant extra component costs (Meyer Sound 2009).

Meyer Sound Laboratories is pursuing a further path towards the replacement of cadmium-free photoresistors or alternative technologies in the next years. They aimed at a broad support through the join with the AVNU Alliance[7], an industry forum dedicated to the advancement of professional audio and video technology by promoting the adoption of the IEEE 802.1 Audio Video Bridging (AVB)[8] standards. The AVB standards represent a shift in the manner in which audio will be used in professional applications, whereby digital audio signals will soon or later replace analogue signals because of AVB's enhanced bit rates and network bandwidth (Meyer Sound 2010).

In recent years Bosch developed some DSP-based amplifier circuit to emulate the function of analogue optocouplers currently used. These digital formats are increasingly used for non professional applications such as for music compact discs or recording. However, that digital technology does not reproduce music and sound perfectly, particularly at high and low frequencies. For professional use, new DSP-based technology has been released only in first pilot applications (for example in very small loudspeakers, which lack the dynamic range and the sound quality). In order to make them comparable with analogue signals they utilise an external electronic control unit whose design is based on analogue optocouplers used to limit and control the amplifier power delivered to the loudspeaker. In current activities towards the replacement of cadmium photoresistors by DSP, BOSCH has completed several additional DSP-based amplifier designs. The results of changing to a digital solution were not satisfying. Meyer Sound and BOSCH state that especially the dynamic range requirement does not match the performance of the existing analogue design. Furthermore the DSP processing would require too much power consumption (environmental impacts) and more space and technical complexity for the components.

Nevertheless, while DSP and alternative technologies advance, the stakeholders spend time and efforts in developing and testing alternatives to achieve the performance of the current analogue optocoupler with a RoHS compliant solution up to 2013.

4.3.2 Analogue Signals versus RoHS-Compliant Appliances

As stated before, the current exemption request is very similar to the previous request by Marshall Amplification plc and Sound Devices. Both have submitted several test reports

[7] http://www.avnu.org/

[8] http://www.ieee802.org/1/pages/avbridges.html

(RWTT Laboratory 2006a and RWTT Laboratory 2006b) supporting the RoHS compliance of an alternative device by Macron (also analogue signal). Other stakeholders provided test reports documenting that those optocouplers are not RoHS-compliant (ERA Laboratory 2007).

Meyer Sound have examined Macron components and found they do not have the same basic functionality as the current analogue cadmium-containing component. Particularly, the Macron components above said have a lower difference in minimum and maximum resistance in the specified working range and to make the essential limiter range impossible.

According to Meyer Sound while for some applications it is possible to adjust the circuit gain for the Macron component, the on/off times would not be possible to align. This would cause that the loudspeaker drivers are overdriven with voltage signals, resulting in failures. The figure below illustrates acceptable voltage levels for the analogue component in grey, and the voltage levels from the Macron component in yellow (Meyer Sound 2010).

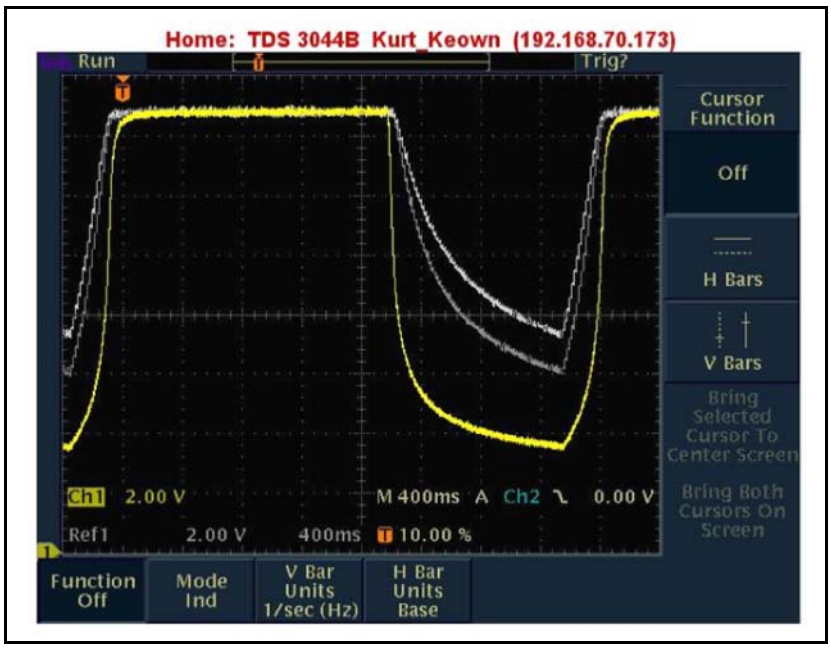

Figure 3 Level of voltage signals in overdriven loudspeakers (Meyer Sound 2010)

Notwithstanding these results, Meyer Sound Laboratories intends to acquire production quantities of the Macron component and to perform tests using measurement methods recommended by the U.K. National Measurement Office, which include:

- ICP-OES, inductively coupled plasma optical emission spectrometry,
- ICP-MS, inductively coupled plasma mass spectroscopy,
- Atomic absorption spectroscopy (AAS).

Results, however, are not yet available in order to be taken into consideration for this evaluation.

4.4 Critical Review

A critical review of the documents made available by the applicant and an evaluation of the stakeholder's contribution led to the following observations. It seems that the applicant is not aware of any currently available technical and scientific substitutes. However, since the original exemption application was handed in by Meyer Sound the development of two RoHS-compliant applications on the basis of DSP technology has been completed. Other stakeholders also use DSP signal-based technology, whereas only for particular solutions and resulting in quality disadvantages, higher component count, higher space requirements and higher power consumption.

This shows that the applicant and other stakeholders are not fully in agreement on the question where DSP or other possible alternatives might already be used today and where not. Motivating the professional audio industry to accelerate the use of substitutes would lead to technical (more complex electronics components) and environmental (increased energy consumption) impacts, which the stakeholders cannot manage at this stage.

However the negative environmental impact through the increased power consumption could be evaluated against the reduced use of cadmium. As described in section 4.1 the total annual cadmium output on the EU market by Meyer Sound applications is 6 g. The applicant as well Sound Device did not provide total figures on the EU market for cadmium analogue optocouplers. Even if the annual output were increased to more than 7 g by Sound Device it is estimated that this amount would have a minor impact on the environment.

To determine whether a component is RoHS compliant, it is necessary to determine whether there are any homogeneous materials present that contain RoHS substances at concentrations greater than the permitted maximum concentration values. The maximum concentration value for cadmium is 0.01% by weight in "homogeneous materials".[9]

The contradicting RoHS-compliance tests (ERA Laboratory 2007; RWTT Laboratory 2006a and RWTT Laboratory 2006b) did not allow assessing whether the Macron cadmium-based photoresistors contain cadmium below the allowed threshold level of 0.01%. Therefore it could not be established whether they are RoHS-compliant or not. To some extent, these two results diverge due to different interpretation of the term "homogeneous material" (Gensch et al. 2007).

As described above, the technical properties of the Macron components with regard to their RoHS compliance and thus their feasibility as a substitute for non-RoHS-compliant photoresistors are not yet juridically and technically sufficiently assessed. Therefore, the contractor cannot take a position on this topic. In this case, the exemption request can only be evaluated on the basis that if the applicant does not consider the Macron devices to be RoHS compliant, the necessity for an exemption will be assessed under this precondition.

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[9] Source: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:037:0019:0023:EN:PDF

In this respect, the technical necessity for analogue optocouplers was well justified for both types of applications: professional audio equipment and voice alarm and conference systems.

4.5 Recommendation

Considering all available information (i.e. in addition to information provided during the current evaluation also the previous requests submitted by Marshall Amplification plc, Set 6, request No. 23 and Sound Devices, Set 7, request No. 4 as well the evaluation from Gensch et al. 2007) a justification for an exemption according to the requirements of Article 5(1) (b) seems to be given even if for some applications, RoHS-compliant alternatives like DSP might be a solution.

But in this case, the exemption would need to be limited to specific applications (e.g. voice alarm systems or conference systems), which would however require further investigation and information gathering to assess which products are suitable for technically viable RoHS-compliant alternatives. It is very unclear what level of technical equivalence must be achieved by substitutes to the analogue optocoupler.

Meyer Sound and Bosch have the same opinion about the future possibilities to substitute cadmium in analogue technologies. The applicant and Bosch continue to spend time and effort in developing and testing alternatives as was well presented in a roadmap suggesting that a RoHS-compliant solution is possible within the next years hence proposing an exemption limited to three additional years.

Concluding on the available information and technical justification, it is recommended to grant this exemption until 31 December 2013. This period of time should allow the stakeholders to carry out the necessary development to gather new amplifier solutions to replace the use of cadmium-based analogue optocouplers.

The recommended wording for the exemption is:

“Cadmium in photoresistors for analogue optocouplers applied in professional audio equipment until 31 December 2013”.

4.6 References

Hall 2010 — Stakeholder document submitted by Adam Hall on 29 March 2010 within the consultation; http://circa.europa.eu/Public/irc/env/rohs_2010_review/library?l=/consultation_1/stakeholder_input&vm=detailed&sb=Title

BOSCH 2010a — Stakeholder document submitted by Bosch on 29 March 2010 within the consultation; http://circa.europa.eu/Public/irc/env/rohs_2010_review/library?l=/consultation_1/stakeholder_input&vm=detailed&sb=Title

BOSCH 2010b — Attachment to the Stakeholder document submitted by Bosch on 29 March 2010

Kurandt Musician 2010 — Stakeholder document submitted by Kurandt, Musician Sound Design on 4 March 2010 within the consultation; http://circa.europa.eu/Public/irc/env/rohs_2010_review/library?l=/consultation_1/stakeholder_input&vm=detailed&sb=Title

Meyer Sound 2009 — Applicant exemption request document, checklist for requests, submitted 13 October 2009; http://rohs.exemptions.oeko.info/index.php?id=77

Meyer Sound 2010 — Document submitted by Meyer Sound during the evaluation.

Gensch et al. 2007 — Gensch, C.-O.; Zangl, S.; Deubzer, O.; Adaptation to Scientific and Technical Progress under Directive 2002/95/EC Contract N°07010401/2006/445990/ATA/G4. Final Report, 22 October 2007; http://rohs.exemptions.oeko.info/fileadmin/user_upload/rohs_final_report_Oeko_Institut__22-Oct-2007_01.pdf

Woodgate 2010 — Stakeholder document submitted by Woodgate, Electronics Design, Standards and Marketing Consultants on 12 March 2010 within the consultation; http://circa.europa.eu/Public/irc/env/rohs_2010_review/library?l=/consultation_1/stakeholder_input&vm=detailed&sb=Title

The following documents are stakeholder documents submitted in the previous 6th and 7th stakeholder consultation rounds:

ERA Laboratory 2007	Stakeholder document submitted by Silonex (Testing laboratory by ERA) in 2007.
RWTT Laboratory 2006a	Stakeholder document submitted by Macron Electronics (Testing laboratory by RoHS and WEEE Test Technology – RWTT) in 2006.
RWTT Laboratory 2006b	Stakeholder document submitted by Macron Electronics (Testing laboratory by RoHS and WEEE Test Technology – RWTT) in 2006.

5 Exemption Request No. 2 "Lead in PZT Based Dielectric Ceramic Materials for Capacitors Being Part of Integrated Circuits or Discrete Semiconductors"

The applicant ESIA / RAMTRON requests an amendment of exemption 7c as it was recommended during the previous RoHS Annex review.

5.1 Background

Exemption 7c was reviewed during the last adaptation of the Annex to the scientific and technical progress in 2008/2009. The consultants recommended rewording and restricting the exemption (Gensch et al. 2009). In its draft proposal for the new Annex, the Commission has adopted this recommendation with the following wording (European Commission 2009):

7(c)-I Electrical and electronic components containing lead in a glass or ceramic other than dielectric ceramic in capacitors, e.g. piezoelectronic devices, or in a glass or ceramic matrix compound

7(c)-II Lead in dielectric ceramic in capacitors for a rated voltage of 125 V AC or 250 V DC or higher

7(c)-III Lead in dielectric ceramic in capacitors for a rated voltage of less than 125 V AC or 250 V DC until 1 January 2013, and after that date may be used in spare parts for EEE placed on the market before 1 January 2013.

In case the above wording is published in the Official Journal (expected for beginning of September 2010), lead hence could no longer be used in dielectric ceramic materials of low voltage capacitors after 31 December 2012.

Exemption 10 in Annex II of the ELV Directive exempted the use of lead in ceramics and glass as well. The background of this exemption technically is the same as exemption 7c in

the RoHS Directive. Exemption 10 of the ELV Directive was reviewed in 2009/2010 and it was recommended to restrict the use of lead in dielectric ceramic materials of capacitors following the example in the RoHS Directive (Zangl et al. 2010).

During the review of exemption 10 ELV Directive, stakeholders informed the consultants that ceramic capacitors being part of integrated circuits or discrete semiconductors use dielectric ceramic materials based on PZT ceramics. These ceramics require the use of lead. As these capacitors are conceived for rated voltages of less than 125 V DC or 250 V AC, the use of lead in these components would no longer be allowed after December 2012.

The stakeholders claimed that the PZT ceramics cannot be replaced in these capacitors and that the use of lead in these integrated capacitors hence is indispensable at the current state of science and technology. Based on the available information and in the absence of contrary information, the contractors recommended granting an exemption in the ELV Directive with the following wording as exemption 10 (a) (iv) (Zangl et al. 2010):

"Lead in PZT based dielectric ceramic materials of capacitors being part of integrated circuits or discrete semiconductors."

The stakeholders submitted an identical exemption request during this review process (DIGITALEUROPE 2010; ESIA et al. 2010). The submitted information supports the facts and findings of the review of Annex II of the ELV Directive finalised in July 2010 (Zangl et al. 2010). The reviewers hence recommend granting the exemption with the identical wording recommended for Annex II of the ELV Directive:

"Lead in PZT based dielectric ceramic materials for capacitors being part of integrated circuits or discrete semiconductors."

5.2 Recommendation

In view of aligning the exemption wordings of the ELV and the RoHS Directive and following the argumentation line taken in the review process of exemption 10 ELV Directive, as well as based on the available information, the use of lead in integrated capacitors with PZT based dielectric ceramics is unavoidable. In accordance with Article 5(1) (b), it is therefore recommended to grant an additional exemption under exemption 7c in the Annex of the RoHS Directive with the following wording:

"Lead in PZT based dielectric ceramic materials of capacitors being part of integrated circuits or discrete semiconductors."

5.3 References

DIGITALEUROPE 2010 — Stakeholder document submitted by DIGITALEUROPE on 16 June 2010 within the consultation; http://circa.europa.eu/Public/irc/env/rohs_2010_review/library?l=/consultation_request/stakeholder_input&vm=detailed&sb=Title

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6 Exemption Request No. 3 “Cadmium as a Pigment for Use in Vitreous Enamel”

6.1 Description of Requested Exemption

The applicant, “The Institute of Vitreous Enamellers” (IVE), asks for an exemption for “Cadmium as a pigment for the use in vitreous enamels” (IVE 2010).

Vitreous enamel or porcelain enamels (USA) are based on borosilicate glass that is fused to metal substrates at 800°C. The applicant describes that the vitreous enamels are used as coatings on cast iron and sheet steel for the fronts, doors and utensils of domestic appliances. Enamels are the best surfaces for cooking products, as these have specific

requirements for high temperature performance additionally to scratch resistance (IVE 2010; IVE 2011).

Cadmium (Cd) is used in pigments in coloured enamels, in particular yellow and red ones. The pigments must withstand the processing temperatures of at least 800°C without loss of performance and product quality. They must also meet touch temperature requirements for cooking products (IVE 2010), meaning that the outside temperature of the cooking device must remain below a certain temperature even though the device is under operation and therefore hot.

The yellow and red pigments used in enamels are based on Cd-sulphoselenide. The Cd-content in enamel layers are one to two percentages by weight, depending on the ratio of sulphur and selenium (IVE 2010). IVE indicates the amount of Cd used in the specific application with around 6 kg per annum (IVE 2010). This figure is based on sales in 2005, before the withdrawal of the red-coloured products, in EU 27 and Norway.

IVE (2010) explains that Cd-free yellow pigments are available. They give a reduced but broadly acceptable range of yellow colours and therefore have replaced the Cd-based yellow pigments. Cd-free alternatives for red pigment in vitreous enamels are based on tin. IVE (2010) claims that they lack the lustre and vibrancy of Cd-pigments and can only give brown-reds, but not deep vivid reds. The cadmium in cooking appliances enamelled with red pigments was hence not substituted. These red cooking devices were no longer put on the market from 2006 on as RoHS compliance could not be achieved (IVE 2011).

IVE (2010) claims that the energy efficiency of electric products could be increased which was not possible for gas or solid fuel appliances. According to IVE, this made the electric appliances more attractive for customers concerned with energy efficiency in order to reduce the greenhouse effect. Further on, manufacturers want to improve the fuel efficiency of their products. IVE (2010) says that therefore it is now more important than in 2006 to be able to offer all colour options in electric versions and hence asks for this exemption.

6.2 Justification for Exemption

6.2.1 Substitutes from a Technical Point of View

Technically, the substitution of cadmium can be achieved in two ways. The cadmium-containing, red pigments used in vitreous enamels could be replaced by other cadmium-free pigments as one option. Another technical option is applying other coatings than enamels, which do not depend on cadmium-containing pigments to create red colours.

Cadmium-free pigments for enamels

IVE (2010) explains that the following compounds will produce pigments for enamels with red colourations:

- iron III oxide: reddish browns,
- tin chrome: reddish browns,
- lead chromate: not RoHS-compliant because of lead and chrome VI,
- gold oxide: pink
- cadmium sulphide and cadmium selenide: only pigments for true reds.

IVE (2010) claims that the cadmium-free red pigments lack the lustre and vibrancy of Cd-pigments and can only give brown-reds, but not deep vivid reds. Based on the internationally recognized CieLAB system, “redness” can be expressed as a positive A value. For the above cadmium-free pigments, the A value has an upper limit of +25, while true red colours achieve A values of +35 and upwards, typically +45.

Additionally, the tin-based alternatives reduce the yield in manufacturing. Chemical reactions of tin during the process may result in white specks and gas defects.

According to IVE (2010), the Max Planck Institute was looking for alternatives to Cadmium red using perovskites, which, however, have not become commercially available. Organic pigments as another alternative cannot withstand the temperatures of 800°C required for vitreous enamel processing, limiting possible alternative pigments for enamels to inorganic ones.

Alternative coatings

For sheet steel and cast iron the most suitable substitution is epoxy polyester powder paint. They give the best mix of properties regarding coverage, scratch resistance and temperature resistance that can be expected from paint (IVE 2010).

Hardness and manufacturability

IVE (2011) explains that vitreous enamels form a much harder wearing surface than paint. Enamel takes a 9H pencil hardness test whereas paint achieves a maximum of 2H. Vitreous enamels therefore are required in areas where there may be excessive cleaning or potential for scratching. Areas on a cooker fitting this requirement would be top plates and some control panels. Domestic appliances, especially those at the high end of the market, are expected to last for a number of years and this is not possible with paint in all applications. Use of paints or powder coatings would therefore lead to products having a reduced working life. Earlier replacement would be necessary, with the associated resource, as well as possible safety and environmental costs.

In manufacturing, paints are especially difficult for use on cast iron because of gas defects from pores in the iron. There are some possibilities to using paint for sheet steel parts.

Touch temperature requirements

The Applicant (2011) explains that according to standard EN60335, surfaces of cookers must not exceed certain temperatures, when they are in operation. The touch temperature limits are ambient +45 degrees for paint or uncoated surfaces, and +50 degrees for enamel. Enamel surfaces are allowed higher temperatures because vitreous enamel being glass is less thermally conductive than either uncoated or painted surfaces so that it takes more time to give a skin burn. IVE (2010 and 2011) claims that it is not always possible to achieve the lower temperature limit for paint without extensive design change. For a cast iron part this is less possible as there is no easy method to insert insulation or heat sinks into the door, where these touch temperature requirements are in particular critical.

6.2.2 Environmental Considerations – Safety of Vitreous Enamels

Low risk related to vitreous enamels

IVE (2010) claims that the cadmium in enamels does not pose any risk to environment, health and safety, whereas there are health and consumer safety concerns with various other “substitute coatings” that might be considered as replacements.

The pigments used are cadmium sulphoselenide-based. These undergo calcinations during processing, followed by acid washing. For this reason they have very low levels of soluble cadmium (e.g. < 0.01%, and usually < 0.001%) using the test method in Council of Europe Resolution AP (89) 1. The pigments thus remain well below the safe recommended leaching levels applicable for use in food-contact plastics. This is before they are further contained within the enamel. Cadmium pigments hence are highly stable, being both insoluble and resisting very high temperatures. This greatly reduces the potential for exposure (IVE 2010).

In manufacturing, the process of red enamel spraying is segregated from the rest of production to ensure that no discharge is made to the atmosphere or water. Over spray enamel is collected and fused at the glass transition temperature into its glass state to ensure it is highly stable for disposal This method, known as glass vitrification, is a proven method to contain hazardous substances and is used for various applications including high-risk radioactive materials.

At the end of their life, the component parts of domestic equipment have a high value for recycling as they are made from metals. For cast iron products it is in the manufacturer’s interest to get back the product at the end of life in order to re-use it as a raw material to make more cast iron. Most companies operate buy back and trade in schemes to ensure that this is maximized and work with renovators to maintain the longevity of the product. This greatly limits the amount of cadmium going into landfill.

During metal recycling, vitreous enamel will form a slag containing the inorganic cadmium compounds within a vitrified structure. The cadmium compounds remain stable during this high temperature processing and do not burn. The cadmium compounds present are insoluble making them difficult to become dispersed into the environment. The resultant slag can find use as a building aggregate, so does not need to be land filled (IVE 2010).

Vitreous enamels in the REACh ordinance and other regulations

IVE (2010) claims that the REACh ordinance underpins that cadmium containing enamels are safe. The use of cadmium pigments in vitreous enamel is not restricted in REACH Annex XVII. Glass and ceramic frits comprising vitreous enamel further on is exempt from REACH registration in Annex V due to its recognized safety except where they meet criteria for classification as dangerous according to Directive 67/548/EEC. In the case of cadmium containing enamels the enamel is exempt but the pigment requires registration.

Cadmium pigments are the only cadmium compounds not to have designated supply hazard requirements under Directive 67/548/EEC (Hazardous Substances 1967) (IVE 2010) resp. Regulation 1272/2008 (CLP).

IVE (2010) states that vitreous enamel is exempt from UK IPPC sector guidance note S403 relating to the release of certain metals. It is considered that vitreous enamel effectively encapsulates these metals. Vitrification using borosilicate glass (vitreous enamel) is a recognized method to contain the release of hazardous substances.

Cadmium pigments have been through two reviews under the “existing chemicals” Directive and, in both cases, it was concluded that they offer no significant hazard to human health or to the environment (IVE 2010).

6.2.3 Environmental Concerns Related to Alternative Coatings and their Pigments

Alternative coatings would be plastic resins that will burn giving CO, CO_2 and other possible toxic decomposition products during recycling. Many plastic resins, among them the main alternative coating epoxy polyester resins sometimes with Nylon added, contain isocyanate cross linkers (polyesters, urethane) which will burn to give toxic hydrogen cyanide as a product of decomposition (IVE 2010; IVE 2011).

The epoxy polyester powder paints coatings are based on epoxy resins made from bisphenole A, which is subject to a number of safety concerns as a reproduction hazard being an estrogen mimic. Bisphenole A may also be subject to future RoHS or REACH restrictions. It is included in the Evans report as a suggested candidate for future RoHS restrictions (IVE 2010).

Organic red pigments used for plastic resins are based on organic complex carbon ring structures. The most common in use are azo-pigments. These are made from absorbing azo-dye compounds that are in the main carcinogenic onto a carrier. Azo-pigments are normally

regarded as non-toxic although some have been found to be mutagenic and there are studies linking azo-pigments with basal cell carcinoma. Some organic azo-pigments also contain halogen groups, e.g. Red PR254 (Chlorinated), Red PR216 (Brominated), the formation of dioxins or furans are therefore possible decomposition products during any high temperature recycling of the base substrate. Other possible decomposition products of organic pigments are carcinogenic aromatic amines because of the presence of Nitrogen and aromatic ring structures (IVE 2010).

The use of paints or powder coatings will reduce domestic appliances' working life. Earlier replacement would be necessary, with the associated resource, as well as possible safety and environmental impacts (IVE 2010).

Applicant's Conclusion

The applicant concludes that it is possible to further speculate on negative health and environmental impacts of alternatives, as none of them have been studied to the same extent as cadmium pigments or vitreous enamel. These pigments and vitreous enamel have a high level of safety because of the highly stable nature of both (IVE 2010).

6.2.4 Economic Impacts

IVE (2010) points out that a number of producers already had to withdraw products from the market as there was no suitable alternative to the use of cadmium-based pigments. Withdrawal of product implies losses in sales. Red colour is very popular in the cooking appliance industry. This has meant that customers have gone elsewhere to obtain red products. At the high end of the cooking appliance market there is also an active refurbishment market. Customers have gone to this market to obtain red products, either by refurbishment of products or by re-enamelling of parts into red. This refurbishment market has less control over the use of Cadmium pigments and also means that red colour can become placed onto electrical products produced after 2006 without the knowledge of the original manufacturer (IVE 2010; IVE 2011).

The manufacturers of electric cookers hence ask for the exemption as the lost sales have not been recouped with other choices of colour. The domestic appliance sector is a significant large scale user of vitreous enamel throughout Europe. Removal of the ability to use cadmium as a pigment will have a negative economic impact on this important contributor to the European economy (IVE 2010).

Alternative pigments based on tin are more expensive. Tin-based pigments are added typically at five times the amount of cadmium pigments. They have an advantage that, different from cadmium pigments, they do not need separate processing in manufacturing. They do not offer the same range of colour so they have limited use. Enamel coating companies have already made use of these where possible.

Substitution to paint would require massive investment. Any company undertaking this change requires a new process and the resultant product would be less durable than vitreous enamel and have an expected lower life time. Benefits are lower cost per unit, but manufacturing with paints requires initial investments, which can only be recovered for large volume productions. This is not an option for some applications.

6.2.5 Reference to Other RoHS Exemptions and Applicant's Conclusion

IVE (2010) claims that the use of cadmium-pigments in enamels is similar to the exemption 29 for lead in crystal glass. The glass is binding the RoHS restricted substance into a safer form and is both decorative and functional. Chemically, the requested exemption is almost identical to the exemption for cadmium and lead in printing inks for enamel onto borosilicate glass (exemption 21), which is from the same family of substances (vitreous enamel).

The applicant concludes that neither alternative pigments for enamels nor alternative coatings to enamels are available. The cadmium-free pigments for enamels cannot provide bright red colours. Cadmium-free coating materials equivalent to the cadmium-enamels are not available either. These materials cannot provide the combination of reliability in manufacturing, heat and abrasion resistance, chemical resistance, and colour stability.

6.3 Critical Review

6.3.1 Non-Availability of Cadmium-Free Deep-Red Pigments for Enamels

The applicant claims that commercially available cadmium-free pigments for enamels cannot achieve A values higher than +25 in the CIELab system. Jansen (2000) had demonstrated that cadmium-free pigments based on solid solutions of perovskites are well-performing substitutes achieving higher redness values. IVE (2010) claimed that these have not become commercially available since then. This information was confirmed with the author of the article (Jansen 2011).

No information could be found contradicting the applicant's arguments that no cadmium-free pigments are commercially available for enamels with CIELab A values higher than +25.

6.3.2 Non-Availability of Substitutes for Vitreous Enamel Coatings

Paints as alternative coatings

The applicant states in IVE 2010 and IVE 2011 that, for steel and cast iron, epoxy polyester powder paints give the best mix of properties regarding coverage, scratch resistance and temperature resistance that can be expected from paint. The paints cannot match, however, the touch temperature requirements for some parts like e.g. the doors of cookers. The Applicant (2011) said that vitreous enamels are without alternative on cast iron in general,

and on sheet iron where alternative design cannot rule out coatings other than vitreous enamel. For a cooking appliance, enamel hence must be used on all internal parts and parts that come close to burners such as cooker tops. Facia/control panels can sit proud of the cooker top and then come close to the burners or hot pan supports, in which case these require enamel, too. Facia often are the same colour as the doors. On sheet iron doors heat sinks and insulation may enable the use of paint still meeting the temperature requirements. For cast iron being solid and therefore without a cavity this does not apply.

Additionally, paints reduce the yield in manufacturing if applied on iron cast sheets due to the more porous cast iron surface compared to steel sheets.

Altogether, the applicant could plausibly explain that alternative coatings in bright red colours are not appropriate substitutes on cast-iron because of its porous surface, and because design changes cannot guarantee that such surfaces suffice the touch temperature requirements. For steel sheets, the Applicant (2011) said that the use of enamels is a lesser requirement. The applicant agreed that for steel sheet cookers it is difficult to make a case strong enough for exemption and that the exemption's scope thus should be limited to cast iron cookers.

Use of steel cookers instead of cast iron cookers

If steel cookers do not depend on cadmium to achieve red products, they can be considered as a mean to eliminate the restricted substance cadmium.

The applicant stated that cast iron ranges are a very traditional product and for this reason have a unique place in the market. The look and shape of the product is also traditional and this shape can only be cast. It is impossible to work steel into the angles and contours that are synomynous with the product (Applicant 2011).

The applicant further on puts forward that cast iron ranges give a unique cooking experience. The way they heat up is different to a normal steel cooker. The cast iron absorbs and retains heat in a more even way than a normal cooker and attracts customers that want to cook in this special way. Cast iron gives unrivalled results for slow cooking, roasting and simmering. This type of cooking could not be reproduced using steel (Applicant 2011).

Lower hardness of paint coatings as factor limiting life time

(IVE 2010; IVE 2011) is also concerned about the lower hardness of paints compared to enamels (2H versus 9H pencil hardness). The applicant was asked whether the hardness would actually be the factor limiting the equipments' life times. The Applicant (2011) put forward that the average life time of a range cooker has been reported as 18 years, and that 10 years is not unusual. At the higher end of the market where products can cost 10.000 Euros upward, the life expectancy is high. Cast iron cookers meet these higher expectations in most cases. For some customers, a high end cooking appliance is an aspirational product and a once in a lifetime purchase. That there is active market in re-enamelling cast iron

cookers is proof of the expectation for longevity with the coating as an important limiting factor for the life time (Applicant 2011).

Cooker design does not change as quickly as for other electrical appliances where technology moves much faster. Apart from safety functions, energy use and efficiency legislation that is driving some technical changes, cookers' basic designs can last for many years (Applicant 2011).

Actually, if a re-enamelling market exists, it is plausible to conclude that the durability of the coating plays a role in the overall lifetime expectancy. Vitreous enamel is required where there may be excessive cleaning or potential for scratching on areas such as the top plates and some control panels.

6.3.3 Environmental and Cost Considerations

According to IVE (2010), producers have not offered domestic products in red colours that would have required the use of cadmium-pigmented enamels. Following the applicant's arguments, more energy efficient electric cookers cause customers shift away from gas and solid fuel cookers towards these higher energy efficient electric cookers. According to IVE (2010), the producers want to promote energy efficiency and hence be able to offer the whole range of electric products including bright red ones.

This motivation may be economically plausible. From the environmental point of view, shifting from non-electric to electrical cookers considerably reduces the overall energy efficiency. Generating heat from gas is ecologically preferable to the use of electricity for this purpose. While gas cookers make use of almost 60% of primary energy input, electrical cookers just achieve around 30% (EcoTopTen). The applicant's justification to reintroduce bright red electric cookers into the market hence may be economically plausible, but it cannot be justified from the energy efficiency point of view.

In the further argumentation, IVE 2010 states that the use of cadmium in pigments is environmentally safe, and that the risk is even reduced further if such pigments are enclosed in enamel. The applicant quotes several studies to underpin his statement.

A risk assessment showing the low risk related to the use of a substance banned in the RoHS Directive, however, cannot be base for an exemption, as the case of Deca-BDE shows (Court of Justice). Art. 5(1)(b) only allows an exemption if substitution or elimination of the restricted substance are scientifically and practically impossible, or if the substitution of the restricted substance probably produces effects that are likely to outweigh the benefits of substitution for the environment, health and safety. The applicant's environmental information shows that epoxy polyester powder and other paints as a substitute may have adverse environmental, health and safety impacts. The applicant did, however, not submit any evidence that the negative environmental, health and/or consumer safety impacts of substitution or elimination would outweigh the environmental, health and safety benefits of substitution. The argument that the use of cadmium in this application is environmentally safe hence

cannot justify an exemption in line with Art. 5(1)(b). The same applies to the applicant's cost arguments.

6.3.4 Esthetical Aspects and Analogies to Existing Exemptions

According to IVE (2010), the producers had not put bright red coloured electric cookers on the EU market after June 2006. Technically, red coloured electric cookers are not necessary. In so far, the exemption request cannot be justified technically. On the other hand, the applicant claims that the use of cadmium-pigments in enamels is similar to exemption 29, which reads "Lead bound in crystal glass as defined in Annex I (Categories 1, 2, 3 and 4) of Council Directive 69/493/EEC". IVE (2010) says that the glass is binding the RoHS restricted substance into a safer form and is both decorative and functional.

The applicant behind exemption 29 had claimed that lead-free crystal glass lacks the brilliancy and some other properties of lead-glass, and described the use of leaded glass: "In the range of electric and electronic equipment this form of glass is used in pure (colourless) or coloured form for decorative and/or functional purposes, e.g. lamps, chandeliers, decoration of mobile covers, watches" (Swarovski 2006). The applicant had argued at that time that functionality is not limited to the purely technical function, but includes esthetical aspects (Gensch et al. 2006).Purely decorative uses were not excluded from the scope of exemption 29, which allows the use of lead in crystal glass. In analogy, it would be justifiable to say that the colour of an electrical cooker is a decorative element as well, which, even though not part of the technical functionality, forms part of the overall functionality of a product. Where alternative coatings to enamels are not available, the use of cadmium-containing pigments for red-coloured enamels would then be in line with Art. 5(1)(b).

IVE (2010) also maintains that the requested exemption would be chemically comparable to the current exemption 21 exempting lead and cadmium in printing inks for the application of enamels on glasses, such as borosilicate and soda lime glasses. This exemption, however, was based on the specific requirements related to this specific application. Even though chemically both exemptions relate to enamels, the justifications are different.

6.3.5 Relevance of the Exemption for the Domestic Appliances Market

Domestic appliances producers supporting the exemption request

The applicant, the Institute of Vitreous Enamellers, seems to be an association of material suppliers. As no manufacturer of domestic appliances supported the exemption request in the online stakeholder consultation, the applicant was asked to prove that such an exemption would actually be needed. Applicant (2011) explained that the IVE represented both suppliers and also end users of enamel. The main company requesting the exemption is AGA[10]

[10] AGA, http://www.aga-ranges.com/; last accessed 10 May 2011.

in the United Kingdom (UK) that specialises in traditional style cast iron range products and had to stop putting red products on the market after 30 June 2006. Applicant (2011) states that there is also some interest from other manufacturers of sheet steel range products who because of design limitations cannot offer painted products for certain designs. According to the Applicant (2011), this is, however, a lesser requirement.

Such products are popular in the UK and French markets as the main EU outlets. Applicant (2011) stated that in the main volume cooker market there is not such need for exemption, as most are producing in black, white or stainless steel in large volumes for the general consumer at the right price. Companies specializing in range cookers tend to be smaller companies in a niche market and offer a wider aesthetic range than the larger volume manufacturers.

Opinion of other domestic appliances manufacturers

Bosch-Siemens Hausgeräte (BSH), a big manufacturer of domestic appliances, was interviewed on the exemption request to find out whether and how far other producers would support the exemption request, or may have a solution for the red enamels.

The manufacturer stated that “Exemptions from these bans [of cadmium, the author] in our opinion should only be granted if a certain technical function requires its use, in case the function cannot be achieved otherwise. Design requirements in our opinion do not justify an exemption. The types of enamels used by BSH meet all technical and mechanical requirements of electric stoves and cookers used in households without the use of cadmium.” (BSH 2011, translated from German).

BSH, as a big European producer, does not see the need to offer red electric ranges on the market, and it would not accept the use of cadmium in such an application for its products. A cadmium-free enamel solution for such red electric ranges actually is not available, and enamels were confirmed to be the best choice as coatings.

The exemption is thus only relevant to extend the offer of products in a niche market, and to possibly strengthen the market position of producers like AGA in such niche markets.

6.3.6 Conclusions

Provided that the conditions of Art. 5(1)(b) applied, the market share of a product so far has not been of relevance in the previous reviews of exemption requests. The pivotal criterion was that the substitution of a restricted substance is scientifically and technically unpractical.

The applicant could show that enamels at least on cast iron cookers cannot be replaced by alternative coatings, and red enamels with CIELab A values beyond +25 cannot be produced without the use of cadmium. The applicant further on explained that the look of traditional cookers and the specific cast iron cooking style cannot be produced using steel instead of cast iron, and that cooking with cast iron cookers may produce unique cooking results.

In case esthetical design aspects like “red colour” in combination with “traditional design” and specific ways of cooking are considered part of the product function, granting an exemption would be in line with Art. 5(1)(b), as these functions cannot be produced without cadmium-pigments. An appropriate wording of the exemption in this case is recommended as:

Cadmium in red pigments for borosilicate glass vitreous enamels exceeding CieLab A values of +25 for use on electrical cast iron cookers

As commercially available substitutes are not foreseeable, no expiry date would be recommended for such an exemption prior to the maximum validity period.

6.4 Final Recommendation

The applicant could plausibly explain that at least for cast iron cookers, alternatives to enamel coatings are not a viable option. Viable substitutes for cadmium-containing red pigments for enamels exceeding the CieLAB value of +25 are not available.

Beyond these technical aspects, the exemption request raises principal questions around esthetical aspects. Only red cast iron electric cookers cannot be produced with cadmium-fee enamels. Steel iron cookers as alternatives to cast iron cookers cannot be manufactured into cookers with traditional shapes and specific cooking properties. The pure technical functionalities and requirements of electric cookers do not depend on their colour.

The consultants therefore recommend granting this exemption if the above properties are considered as part of a product’s functionality beyond the pure technical functions (see section “Esthetical Aspects and Analogies to Existing Exemptions” on page 25). In the consultants’ opinions, answering this question goes beyond their mandate of conducting a technical assessment of the exemption request.

6.5 References

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7 Exemption Request No. 4 “Restriction of Exemption 1 to Non-Liquid Mercury”

Currently the RoHS Annex includes exemption 1 with the following wording:

Table 3 Overview on the current exemption 1 in the Annex to Directive 2002/95/EC

Exemption		Scope and dates of applicability
1	Mercury in single capped (compact) fluorescent lamps not exceeding (per burner)	
1(a)	For general lighting purposes < 30 W: 5 mg	Expires on 31 December 2011; 3,5 mg may be used per burner after 31 December 2011 until 31 December 2012; 2,5 mg shall be used per burner after 31 December 2012
1(b)	For general lighting purposes ≥ 30 W and < 50 W: 5 mg	Expires on 31 December 2011; 3,5 mg may be used per burner after 31 December 2011
1(c)	For general lighting purposes ≥ 50 W and ≤ 150 W: 5 mg	
1(d)	For general lighting purposes ≥ 150 W: 15 mg	
1(e)	For general lighting purposes with circular or square structural shape and tube diameter < 17 mm	No limitation of use until 31 December 2011; 7 mg may be used per burner after 31 December 2011
1(f)	For special purposes: 5 mg	

The company Neonlite Ltd requests to amend exemption 1 and to restrict it to single capped (compact) fluorescent lamps without liquid mercury. Neonlite claims that its non-liquid mercury lamps offer environmental, health and safety benefits compared to other dosing technologies (Neonlite Ltd 2010).

The original request did not include a clear wording proposal for an amended exemption 1 but stated that it should be restricted to non-liquid mercury lamps. In the course of the evaluation, via exchange of further questions in writing and further discussions over the phone, it was clarified with the applicant that the request refers to steering amalgam as mercury dosing technology in the sense that this dosing technology would be considered as “non-liquid”. During the discussion at the stakeholder meeting (see below), Neonlite first agreed that there was no differentiation needed between steering amalgam and other amalgam dosing technologies and that its request would cover all amalgam dosing technologies. However, written input was provided after the meeting pointing out that Neonlite wanted to get back to their original statement, i.e. that its request should cover only steering amalgam lamps (Neonlite Ltd 2010; Neonlite Ltd 2011).

In the context of the online stakeholder consultation, the European Lamp Companies Federation (ELC) provided input that challenged the claimed advantages of amalgam lamps as stated by the applicant (ELC 2011a).

All relevant documents of the consultation can be found at http://rohs.exemptions.oeko.info/index.php?id=90.

Both parties were contacted with further questions and provided additional input (ELC 2011b; Neonlite Ltd 2011). As it appeared that most of the questions could not be clarified and that many contradictory statements were issued, it was proposed to organise a stakeholder meeting with a view to reach a common agreement on how to further proceed. This meeting was held on 27 April 2011. The outcome is summarised in the following.

7.1 Main Arguments of Stakeholders

In the course of document review and exchange with stakeholders prior to the meeting it became clear that there was a need of clarification with regard to the applicant's intention in respect to the scope of the request and with respect to the terminology used in the discussion. Also, many documents including test results were provided by both parties mainly focussing on the release of mercury in case of lamp breakage. The discussion at the meeting mainly focussed on these aspects. But also other lifecycle aspects of Compact Fluorescent Lamps (CFLs) using different dosing technologies were briefly touched.

7.1.1 Scope and Definition

Steering amalgam had been defined as a "non-liquid mercury" dosing technology by Neonlite prior to the meeting (see above). However, as mercury has different physical properties depending inter alia on the temperature, it was agreed that rather than referring to non-liquid and liquid mercury the discussion should use the names of the dosing technologies.

Even though amalgam itself can be sub-divided in many different sub-categories, stakeholders agreed that as much Neonlite as ELC manufacturers use different types of amalgam (with different properties) and that no further differentiation was needed in respect to the issue discussed. However, Neonlite has provided additional input after the meeting that in contrary to their statement at the meeting, their intention was to discuss the differences between steering amalgam lamps and lamps with other dosing technologies (Neonlite Ltd 2011).

Concluding on this clarification, the further discussion intended to exchange views on the advantages of amalgam lamps as claimed by the applicant in comparison with other mercury dosing technologies. However, all participants agreed that these other dosing technologies included only state-of-the art dosing technologies and not the manual needle injection with liquid mercury as this was an outdated technology that did not allow for meeting current and future RoHS mercury limit values.

Also, it was pointed out that nevertheless the RoHS Directive could not support one technology over the other through the restriction of exemption 1 and that in any case an amended wording would need to be technology-independent.

Neonlite thus proposed during the meeting to amend its request and re-formulate it in a way that a maximum limit could be set within exemption 1 for mercury release in case of lamp breakage. As such, no technology would be excluded and only those lamps that could meet the limit would be allowed to use mercury. It provided further details on this new proposal after the meeting (Neonlite Ltd 2011):

"From Megaman test data the proposal is to leave current dosing limits as defined in RoHS and have an additional limit that no more than 20% of this dose be released when a warm lamp breaks. An additional column could simply be added line by line defined as mg of Mercury. By defining it this way it allows for future reductions in absolute dosing levels – the overall goal being zero."

In this respect ELC pointed out that such a restriction would only focus on one aspect of a lamp's lifecycle and that it thus did not consider this approach to be justified in the context of the RoHS Directive.

In the context of the evaluation of Neonlite's request, this new proposal has been noted down and commented. However, no formal evaluation of this new proposal is possible as further steps would be needed beforehand as described in section 7.2. Also, Neonlite has been informed after the meeting that it would need to forward a new exemption request formally to the European Commission should it want this new proposal to be evaluated formally.

7.1.2 Lamp Breakage

Possible health hazards related to the release of mercury in case of lamp breakage have recently been present in the public opinion quite a lot. Concern of consumers is high and hence many public authorities have looked at the question with the help of scientific analysis and expert opinions (Fraunhofer WKI 2010; Gorbacheva 2010; SCHER 2010). However, the general concern is not subject to the evaluation of exemption request 1 but merely the question whether (steering) amalgam lamps behave differently than other lamps in this respect as claimed by the applicant.

Neonlite has supported its claim that steering amalgam lamps have an environmental, health and safety benefit through the provision of in-house test results on the amount of mercury released in the case of lamp breakage for steering amalgam lamps in comparison with other dosing technologies (Neonlite Ltd 2010; Neonlite Ltd 2011). As the tests have not been done by an independent third-party institution and since there is no commonly agreed test method with respect to measurement of mercury release and resulting exposure, the provided test results could not be evaluated. Other tests on lamp breakage referred to by stakeholders all use different test methods and mostly have not looked at the different behaviour of amalgam lamps versus other dosing technologies (ELC 2011b). Only a master thesis referred to by ELC and carried out at the Technical University of Munich (Gorbacheva 2010) came to the conclusion that amalgam lamps may release less mercury if broken when turned off and little burning hours. However, when broken at higher operating temperatures and with more

burning hours amalgam lamps would release as much mercury as other lamps. But as this result also refers to a non-standardised test method, no commonly agreed conclusion can be derived from it.

As a conclusion from the discussion on this aspect, stakeholders agreed that different CFLs using different dosing technologies do behave differently in many aspects – possibly including mercury release in case of lamp breakage – but that due to many parameters influencing the test results such as temperature, test set up, condition of the lamp when broken and due to the fact that no standardised test method was available no conclusion could be drawn from available test results with respect to the differences between the CFLs based on different dosing technologies.

Even though Neonlite claims that their test results give sufficient hints that amalgam lamps have advantages in case of lamp breakage, they also agreed that further independent and standardised testing would be needed to allow a generally agreed conclusion (Neonlite Ltd 2011). In this respect it referred to its proposal to restrict exemption 1 to lamps that meet a certain maximum mercury release limit in case of lamp breakage but agreed that in this case an agreement on a test method would be needed as much as on a maximum limit that could be founded on scientific evidence. In this respect the following was proposed by Neonlite after the meeting: “The test method can be developed using the Ecolabel criteria as a basis (2002/747/EC) alternatively if the new IEC standard is developed in time then this should be used (IEC working groups expect a new standard defined by end 2011).”

ELC challenged this statement as it considers that no such limit is needed as it has been scientifically confirmed that no health hazard was given in case of lamp breakage. Setting such a limit would give the wrong signal to the general public as it would suggest that some CFLs might not be safe products hence harming the technology as such while it would currently rather need support in view of the upcoming phasing-out of the 60 W incandescent lamp by 1 September 2011. Furthermore, in the opinion of the ELC the measurement standards Neonlite refers to are not suitable to measure the mercury content after lamp breakage and that no standard exists for measuring mercury release in case of lamp breakage.

7.1.3 Other Lifecycle Aspects

Even though lamp breakage was the focus of the discussion other lifecycle aspects were also looked at since the evaluation of the request needs to analyse whether restricting exemption 1 to (steering) amalgam lamps or to lamps meeting a maximum release limit would lead to an overall benefit or whether negative impacts could outweigh the potential benefits.

Neonlite claimed that amalgam lamps are also produced with very low environmental and health impacts and that also waste handling and disposal have lower environmental and occupational health impacts than with other lamps. For the advantages in waste handling

they refer to the reduced release in case of breakage. For the advantages in waste disposal they refer to leaching tests that have been done showing less emission for amalgam lamps.

ELC challenges both arguments as the issue of lamp breakage can currently not be proven and also stating that the total amount of mercury will enter the environment anyway – whether through the air compartment or as mercury residue in the phosphor of the lamp or as residue in any other remaining parts of the lamp. Also it claims that some ELC manufacturers have also done leaching test that led to different results and that such test would need to be carried out with the whole lamp and not only the amalgam. ELC has furthermore claimed that other dosing technologies can also be produced and waste-handled in a safe way and that they could not see an advantage of amalgam lamps in this respect.

In addition aspects such as safety and consumer satisfaction with regard to amalgam lamps and their comparable long run-up time were briefly touched but not in detail as it already became clear that no commonly agreed conclusion could be reached with respect to the applicant's request. Furthermore, the information provided on these aspects was not complete and would have needed further detailed assessment.

7.2 Critical Review

In order to reach an agreement on a recommendation resulting from the evaluation it has to be kept in mind that the intention of the RoHS Directive is to limit / restrict mercury in applications falling under its scope. An exemption was granted to the use of mercury in CFLs as it is proven that even though mercury is used an overall reduction of mercury emissions occurs (the benefits of energy saving and thus the reduction of mercury emissions connected to the electricity generation outweighs the emissions generated through the use of mercury in CFLs). However, the goal of the RoHS Directive should be to restrict the amount of mercury used in the lamps as much as possible. This is currently the case as the allowed maximum limit is decreased gradually.

In this respect, further environmental advantages within the different CFLs would need to be analysed carefully and compared to the possible negative impacts with regard to the environment, consumer safety and health. Here it has to be stated that LCA analysis has so far confirmed that the main environmental impacts of CFLs are associated with their energy need during use.

Due to the lack of comparable and verifiable data, it can currently not be concluded whether steering amalgam lamps could have a potential overall benefit compared to other dosing technologies. Rather, the discussions lead to the conclusion that each CFL type has its own advantages and disadvantages that cannot be assessed in the context of the RoHS Directive. Further full lifecycle analyses would have to be carried out for all types of CFLs in order to reach a conclusion in this respect.

Even though it has currently been concluded that CFLs do not pose a risk when broken (SCHER 2010), public authorities could see the need for precautionary and preventive measures and investigate whether a maximum exposure limit could be useful. However, the contractor's opinion is that it is rather a matter of product safety than it is for heavy metal ban regulation. But it is left to public authorities to assess whether this is a matter of concern and what measures they would intend to take.

Furthermore, the proposed eco-label or IEC standard refers to a measurement on the mercury content and not to the measurement of mercury indoor concentrations / exposure.

7.3 Recommendation

Considering the above, it is recommended not to grant the exemption request as currently no sufficient justification is given with regard to Article 5(1)(b). Nevertheless, should the Commission consider that the issue of potential risks associated with CFL lamp breakage is a concern, it is recommended to assess whether the development of a commonly agreed test method could be supported as well as an agreement on which maximum release values would be appropriate. Also, the best regulatory context for such a measure would need to be assessed.

7.4 References

ELC 2011a — Stakeholder document submitted by European Lamp Companies Federation (ELC), 14 February 2011; http://circa.europa.eu/Public/irc/env/rohs_2010_review/library?l=/consultation_request_1&vm=detailed&sb=Title

ELC 2011b — Additional information document "Answers to Ökoinstitut's questions and comments" submitted during the evaluation, 21 April 2011.

Neonlite Ltd 2010 — Applicant exemption request documents submitted 29 October 2010; http://rohs.exemptions.oeko.info/index.php?id=90

Neonlite Ltd 2011 — Additional information "Discussion document" submitted during the evaluation, 3 May 2011.

7.4.1 Additional References from Neonlite

Aucott et al. 2004 — Aucott, M.; McLinden, M.; Winka, M.; Release of Mercury from Broken Fluorescent Bulbs. Environmental Assessment and Risk Analysis Element; Research Project Summary; February 2004

Megaman n.d. — Face the Facts: compact Fluorescent Lamps (cFL) contain mercury. Accessible at http://www.neonlite.eu.com/docs/Megaman_Mercury_2.pdf, last accessed 25 May 2011.

7.4.2 Additional References from ELC

Aucott et al. 2004 — Aucott A.; McLinden M.; Winka M.; Release of Mercury from Broken Fluorescent Bulbs; New Jersey Department Environment Protection, Environmental Assessment and Risk Analysis Element, Research Project Summary; February 2004; http://www.state.nj.us/dep/dsr/research/mercury-bulbs.pdf

Fraunhofer WKI 2010 — Fraunhofer WKI; Bestimmung des Quecksilbergehaltes in der Raumluft nach der Zerstörung von Energiesparlampen. Untersuchungsbericht Nr. MAIC-2010-1899 im Auftrag des Umweltbundesamtes; Berlin 2010

Gorbacheva 2010 — Gorbacheva, M.; Ermittlung geeigneter Reinigungsmaßnahmen beim Bruch quecksilberhaltiger Kompaktleuchtstofflampen; Masterarbeit; Technische Universität München, Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt; Freising – Weihenstephan; 28. Oktober 2010

Link 1999 — Link, B.; Richtwerte für die Innenraumluft: Quecksilber; Bundesgesundheitsblatt 1999, 42, 68-174

Navigant Consulting 2009 — Navigant Consulting (Europe) Limited; Life Cycle Assessment of Ultra-Efficient Lamps. SPMT08_069. Final Report to the Department for Environment, Food and Rural Affairs; 5 May 2009

Phillips 2011 — TCLP testing of CFLni – effect of dosing method on leachable mercury; Pieter Stobbelaar, GBU fluorescent, 30 March 2011

SCHER 2010 — Scientific Committee on Health and Environmental Risks, SCHER; Opinion on Mercury in Certain Energy-saving Light Bulbs. Opinion adopted 18 May 2010; http://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_124.pdf

Schierl et al. 2011 — Schierl, R.; Boehlandt, A.; Nowak, D.; Quecksilber-Biomonitoring nach Bruch von Energiesparlampen? Deutsche Medizinische Wochenschrift, 06 April 2011.

Süring 2010 — Süring, K.; Gesundheitliche Gefahr durch Quecksilber in Energiesparlampen? UMID, 2010, 1, 7-11 http://www.umweltbundesamt.de/umid/archiv/umid0110.pdf

TNO 2008 — TNO Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek / Netherlands Organisation for Applied Scientific Research; Short risk analysis for compact fluorescent lightbulb collection; October 2008.

8 Review of Exemption No. 30 "Cadmium Alloys as Electrical/ Mechanical Solder Joints to Electrical Conductors Located Directly on the Voice Coil in Transducers Used in High-Powered Loudspeakers with Sound Pressure Levels of 100 dB (A) and More"

8.1 Background

The current wording of exemption no. 30 is

"Cadmium alloys as electrical/mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers with sound pressure levels of 100 dB (A) and more."

The Commission had adopted this exemption in January 2008 and it has now become due for review. An online stakeholder consultation had been started for exemptions 30, 31 and 32 on 20 September 2010. The consultation ended on 15 November 2010. On 2 November 2010, the stakeholders were sent a reminder informing them about the approaching end of the online consultation and asking them to submit information, as at that time no information had been received an thus not been uploaded to the consultation website yet.

Unlike for exemptions 31 and 32, no answers were received to the consultants' questions on exemption 30 during the consultation process. Other information was not handed in either.

The consultants thus must assume that there is no further need for this exemption and that this exemption hence can be repealed.

8.2 Recommendation

The consultants recommend repealing exemption 30. No stakeholder information had been received during the online consultation process. It must hence be assumed that there is no further need for this exemption.

As a matter of precaution and to give stakeholders time for adaptation, the Commission should grant a transition period of at least 6 months after publication of this decision before the exemption expires.

The wording of the exemption is recommended as

"Cadmium alloys as electrical/mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers with sound pressure levels of 100 dB (A) and more until [at least six months after official publication of this exemption]".

9 Review of Exemption no. 31 "Lead in Soldering Materials in Mercury-Free Flat Fluorescent Lamps (which e.g. Are Used for Liquid Crystal Displays, Design or Industrial Lighting)"

9.1 Background

OSRAM and the European Lamp Companies Federation (ELCF) had applied for this exemption in 2006 (OSRAM et al. 2006).

Öko-Institut e.V together with Fraunhofer IZM had recommended granting the exemption (Gensch et al. 2006). The exemption was then approved during the decision-making process and came into force in January 2008 without an expiry date with the following wording:

"Lead in soldering materials in mercury-free flat fluorescent lamps (which e.g. are used for liquid crystal displays, design or industrial lighting)."

Following Article 5(1)(b) of the RoHS Directive (2002/95/EC), exemptions have to be reviewed at least every four years. Exemption 31 was therefore open to an online stakeholder consultation with a view to adapt it to scientific and technical progress.

Only one stakeholder[11] has submitted documentation in the context of the online stakeholder consultation. Details can be found under http://rohs.exemptions.oeko.info/index.php?id=88.

OSRAM as the former applicant for the exemption 31 submitted that no further exemption is requested.

9.2 Justification for the Termination of the Existing Exemption

OSRAM has decided to stop the production of mercury-free flat panels, where lead was required in glass soldering materials. This is why the existing exemption is no longer needed (OSRAM 2010).

9.3 Recommendation

During the previous evaluation it was stated that the development of lead-free flat panel lamps could possibly be phased out within a 2-year time frame (Gensch et al. 2006). Nearly 3 years after the exemption 31 came into force OSRAM has pronounced that leaded mercury-free flat panels are no longer manufactured.

Other producers of mercury-free flat panels have not responded to the consultation.

Against this background it is recommended to delete the exemption from the RoHS Annex without transition period.

[11] Contribution submitted by Osram, 15 November 2010.

9.4 References

Gensch et al. 2006 — Gensch, C.; Zangl, S.; Möller, M.; Lohse, J.; Müller, J.; Schischke, K.; Deubzer, O.; Adaptation to Scientific and Technical Progress under Directive 2002/95/EC, Final Report, Freiburg, July 2006, pp 127 ff; http://ec.europa.eu/environment/waste/weee/pdf/rohs_report.pdf

OSRAM 2010 — Stakeholder document submitted by OSRAM within the consultation, 15 November 2010 http://circa.europa.eu/Public/irc/env/rohs_2010_review/library?l=/consultation_exemption/stakeholder_exemption_1&vm=detailed&sb=Title

OSRAM et al. 2006 — Stakeholder document submitted by OSRAM within the online stakeholder consultation on Adaptation to scientific and technical progress under Directive 2002/95/EC for the purpose of a possible amendment of the annex; http://circa.europa.eu/Public/irc/env/dir_2002_95/library?l=/requests_exempions/15_mercury_panel&vm=detailed&sb=Title

10 Review of Exemption No. 32 "Lead Oxide in Seal Frit Used for Making Window Assemblies for Argon and Krypton Laser Tubes"

10.1 Background

In 2006, Coherent had applied for this exemption (Coherent 2006). Öko-Institut e.V. together with Fraunhofer IZM had recommended granting the exemption (Gensch et al. 2006). The exemption was then approved during the decision-making process and, in January 2008, came into force without, however, specifying the expiry date, with the following wording :

"Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes."

Following Article 5(1)(b) of the RoHS Directive (2002/95/EC), exemptions have to be reviewed at least every four years. Exemption 32 was therefore open to an online stakeholder consultation with a view to adapt it to scientific and technical progress.

Two stakeholders[12] have submitted feedback in the context of the online stakeholder consultation. They support the continuation of the existing exemption with the following wording:

"Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes."

[12] Coherent Inc. and JDS Uniphase (JDSU)

Details and contributions can be found under http://rohs.exemptions.oeko.info/index.php?id=87.

Further questions have been discussed with Coherent in several conference calls.

The outcome of this information gathering exercise and of the exchange with the above-mentioned stakeholders is reflected in the following paragraph.

10.2 Description of Application

As the majority of the ion lasers are components of large-scale stationary industrial tools, they are not subject to RoHS restrictions. Only in a small number of appliances, lead oxide is used in the seal frit as a vacuum seal in the manufacture of argon and krypton laser tube. The stakeholders request to maintain the exemption for the RoHS-relevant applications such as laser products, since such stable, coherent light sources find multiple uses in scientific applications (such as bioinstrumentation), in semiconductor industry (JDSU 2010), in light commercial applications (such as spectroscopy, microscopy, holography) as well as in the entertainment industry (Coherent 2010).

Frit sealing is a special technique used in high vacuum applications to bond the front and the rear glass. The glass (window) is the critical optical interface, where optical absorption and distortion eventually determine the performance of the laser. Special types of glass such as crystalline quartz are used because of their resistance to darkening caused by sub-200 nm deep ultraviolet (DUV), emanating from the electric arc discharge operating in the laser tube. Part geometries are adjusted within the particular constraints of the device in order to minimize the demands placed on the seal (Coherent 2010). These windows referred to as Brewster windows, need, for example, an acute angle at which the reflection losses for polarized light are at a minimum.

The typical quantity of lead per laser tube is about 10 to 20 mg (Gensch et al. 2006), while the current total annual amount of lead put on the EU-27 market by Coherent which is relevant for this exemption is less than 0,5 g (Coherent 2010).

10.3 Justification for Exemption

The stakeholder arguments to justify the continuation of the request can be summarised as follows:

- Lead oxide used in the seal frit is required for technical reasons:
  - the application requires a hermetic, thermo-mechanically stable, vacuum-tight seal (extremely low porosity) that will tolerate vacuum bake-out temperatures, however, lead oxide has a liquidus-solidus temperature that will not result in unacceptable mechanical strain at the operating temperature. The lead oxide in the seal frit is located in an optomechanical assembly that provides the mentioned vacuum-tight

seal and that is optically transparent to the laser radiation. Figure 4 below shows the location of the seal frit in the laser tube assembly.

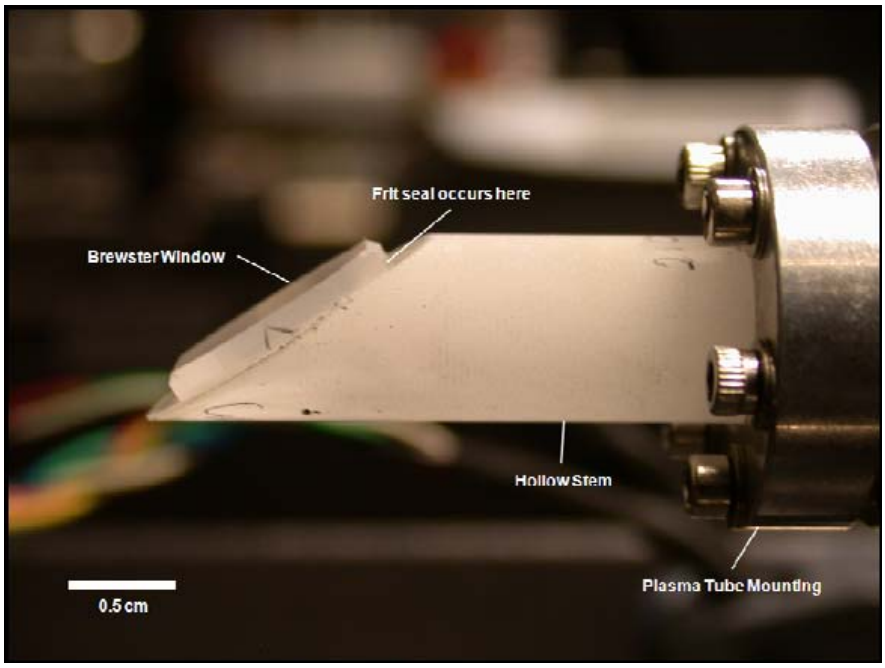

Figure 4 Lead oxide located in the seal frits *(Source: Coherent 2010)*

– The lead lowers the melting point of the seal frit which is necessary for the vital coefficient of thermal expansion. At approximately 420°C, the window temperature does not promote damage to fragile components (JDSU 2010). Other materials with lead-free fritted windows require a higher melting point. The higher temperature (up to 120°C) results in major optical losses (absorption problems) and a degradation of the transverse emission mode between 20-25%. This decreased reliability of the seal will cause the lasers to fail and thus result in an unacceptable risk to the end users. In addition, the higher melting point and the ensuing cooling down phase contribute to the fact that the window does not come to the correct angle (Coherent 2010).
– In contrast to the flat panel industry, the requirements for the window assemblies for krypton and argon tubes are very high. The windows play a role in determining the transverse mode quality and the divergence of the laser beams. These qualities ensure that the laser beam can be delivered and focused to an extremely small spot, thus determining its usefulness as a radiation source.
– The yield related to these laser tubes adds to more than 90%, and could only be achieved through the use of lead frits.

- Lead oxide in the seal frit currently cannot be substituted:
  - Despite years of ongoing development on the use of substitutes such as bismuth-based or phosphorus-based frits, the stakeholders to date have no technically viable substitute for the use of lead oxide in such laser tubes (JDSU 2010). Lead-free substitutes result in a poor yield, significantly higher melting temperatures. Moreover, they have different coefficients of thermal expansions than the present frit.
  - Other technologies such as thermal combination or optical contacting rely on the atomic forces which come into play when atoms in the quartz can be brought close enough as to hold them together[13]. This could only be achieved by the use of components that are enormously thin. Otherwise, a weak attraction of these components and a leakage could result. Moreover, the highly specialized requirements for flatness increased the process costs, resulted in a lower yield (it was not possible to achieve a yield of more than 50%) and uncertain lifetime (Coherent).
- Both stakeholders also argued that there were significantly smaller environmental, health and safety impacts in the case of continuation of the exemption than with the use of other sealing technologies and substitutes. The elimination of lead, for example, would require more frequent replacements and would cause increased waste streams.

10.4 Critical Review

The stakeholders provided comprehensive data and well-structured responses to the consultation questions, especially on the issue of substitutes and other technologies for sealing the argon and krypton laser tubes. Therefore, a critical review of the documents that was made available and an evaluation of the stakeholders' contribution led to the following observations:

Since the original exemption application was handed in by Coherent, additional testing has been completed using lead-free materials. Recently, for example, lead oxide, which had been used in glass frit as a sealing process, has been eliminated for some devices such as flat panel displays. However, it seems that the stakeholders are not aware of any currently available technical and scientific substitutes for their purpose-built appliances. The requirements for glass in a flat panel display are different from those applicable to the window assembly for the argon and krypton laser tubes. According to the stakeholders, lead-free frit materials and other technologies are no alternative for these special window assemblies, as they fail to meet the higher requirements set for this product group, such as the transverse mode quality, the impermeable vacuum seal and divergence of the laser beam.

[13] Because of Van der Waal´s forces.

Furthermore, Coherent argues that other technologies (e.g. optical contacting) are technically and scientifically impracticable as it was not possible to achieve sufficient yield results. This statement was already indicated in the previous evaluation (Gensch et al. 2006).

10.5 Recommendation

Concluding on the basis of all available information and technical justification, it is unavoidable to use lead oxide in seal frit used for making window assemblies for argon and krypton laser tubes. In accordance with the requirements of Article 5(1)(b) and with regard to the abovementioned arguments, it is recommended to grant a continuation of this exemption. From the consultant's point of view, the present wording seems to be appropriate for the time being:

„*Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes*."

10.6 References

Coherent 2006 — Stakeholder document submitted by Coherent within the online stakeholder consultation on Adaptation to scientific and technical progress under Directive 2002/95/EC for the purpose of a possible amendment of the annex; http://circa.europa.eu/Public/irc/env/dir_2002_95/library?l=/requests_exempions/electrical_transducers&vm=detailed&sb=Title

Coherent 2010 — Stakeholder document submitted by Coherent within the online stakeholder consultation on Adaptation to scientific and technical progress under Directive 2002/95/EC for the purpose of a possible amendment of the annex; http://circa.europa.eu/Public/irc/env/rohs_2010_review/library?l=/consultation_exemption/stakeholder_exemption&vm=detailed&sb=Title

Gensch et al. 2006 — Gensch, C.; Zangl, S.; Möller, M.; Lohse, J.; Müller, J.; Schischke, K.; Deubzer, O. Adaptation to Scientific and Technical Progress under Directive 2002/95/EC, Final Report; Freiburg, July 2006, pp 137 ff; http://ec.europa.eu/environment/waste/weee/pdf/rohs_report.pdf

JDSU 2010 — Stakeholder document submitted by JDS Uniphase within the online stakeholder consultation on Adaptation to scientific and technical progress under Directive 2002/95/EC for the purpose of a possible amendment of the annex; http://circa.europa.eu/Public/irc/env/rohs_2010_review/library?l=/consultation_exemption/stakeholder_exemption&vm=detailed&sb=Title