Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

IZM
Fraunhofer Institut Zuverlässigkeit und Mikrointegration

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Öko-Institut e.V.

Dipl.-Ing. Carl-Otto Gensch
Dipl.-Ing. Stéphani[illegible] Zangl
Dipl.-Geoök. [illegible]
Dipl.-Biol. Anna [illegible] Weber

Fraunhofer IZM

Dr.-Ing. Otmar Deubzer

Öko-Institut e.V.
Freiburg Head Office
P.O. Box 50 02 40
79028 Freiburg, Germany
Street Address
Merzhauser Str. 173
79100 Freiburg, Germany
Tel. +49 (0) 761 – 4 52 95-0
Fax +49 (0) 761 – 4 52 95-88

Darmstadt Office
Rheinstr. 95
64295 Darmstadt, Deutschland
Tel. +49 (0) 6151 – 81 91-0
Fax +49 (0) 6151 – 81 91-33

Berlin Office
Novalisstr. 10
10115 Berlin, Deutschland
Tel. +49 (0) 30 – 28 04 86-80
Fax +49 (0) 30 – 28 04 86-88

[8] JBCE stakeholder document “ROHS Exempted Application - Ceramic.doc”

[9] Stakeholder information via e-mail on 16 December 2008 and 9 January 2009 received from Lars Brückner, JBCE

[10] ZVEI stakeholder document “Concerns RoHS exemption 7c_01-2009_2.pdf” from January 2009

4.13 Exemption No. 8

“Cadmium and its compounds in electrical contacts and cadmium plating”

The complete wording of this exemption currently is:

Cadmium and its compounds in electrical contacts and cadmium plating except for applications banned under Directive 91/338/EEC amending Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances and preparations.

NEC/Schott [1] in the fourth stakeholder consultation in 2005 had submitted an exemption request to no longer allow the use of cadmium in “[…] applications of one-shot operation function such as thermal links […]”. NEC/Schott claimed to have cadmium-free solutions, and Öko-Institut recommended to remove the mechanical one-shot pellet type thermal cut-offs from the exemption in July 2007. The COM did not follow this recommendation, and exemption 8 is currently still in place without an expiry date.

In the current review process of the RoHS exemptions, several stakeholders ask for maintaining the exemption [2]-[10]. EACCM (European Association of Contact Material Manufacturers, [11]), KEMI Swedish Chemicals Agency [12], and a Chinese company [13] submitted stakeholder documents asking to restrict or to repeal exemption 8.

4.13.1 Description of exemption

Electrical contacts contain 10–12% of silver-cadmium-oxide (AgCdO). It prevents arcs when opening the contacts in case of high power / high current. Further on, it prevents the corrosion of electrical contacts which would reduce the durability and reliability. Corrosion can result in welding of the contacts, which would then destroy the functionality of the contact.

Cadmium-containing electrical contacts are used in manifold applications:

- switches, which again are used in many applications ranging from circuit breakers in information and telecommunication equipment, washing machines etc.;
- doorlocks in washing machines;
- thermal links for safety applications etc.

The stakeholders say they do not have information available on the absolute amounts of cadmium used under this exemption.

Thermal links

Thermal links are a specific application of cadmium under this exemption. Thermal links are non-resetting devices that function only once without refunctioning. They are used in thermal protection of equipment in which, under fault conditions, one or more parts may reach hazardous temperatures. [3] [16]

The following types of thermal links must be differentiated under the term “thermal links”:

1. One shot pellet type thermal cut-offs;
2. One shot alloy type thermal cut-offs.

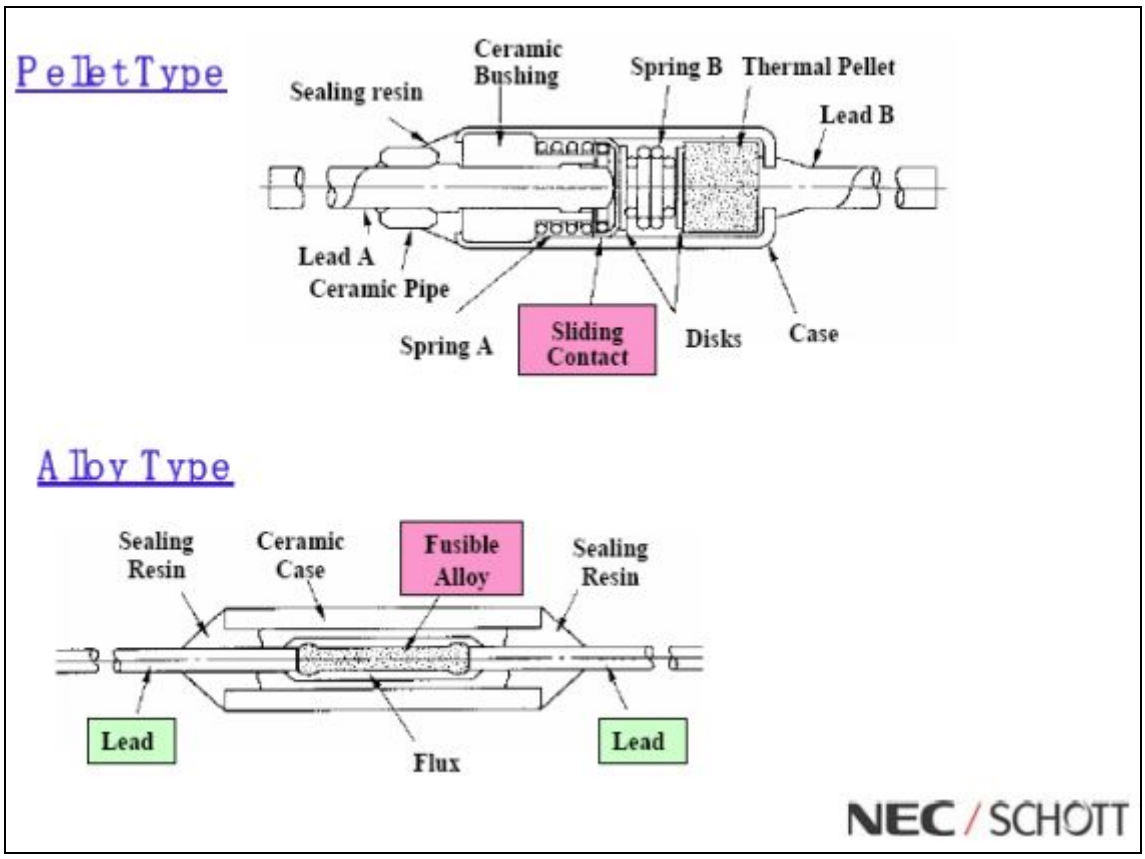

Figure 16 Types of thermal links: one shot pellet type thermal cut-off and one shot alloy type thermal cut-off

The one-shot pellet type thermal cut-off used to use cadmium on the sliding contact. Most alloy types contained lead, and some cadmium, too. Both types are available without cadmium and without lead.

NEC/Schott state that the “alloy type does not have an electrical contact“ and hence this manufacturer does not see the alloy type thermal links to be covered by exemption 8. [15]

As no other stakeholders plead to include the alloy type thermal links into the exemption, or to withdraw the exemption for these devices, they are not taken into consideration in the following.

4.13.2 Justification by stakeholders

Silver-cadmium oxide is an ideal combination of materials for switching where arcing occurs. The cadmium oxide has two main functions [3]:

1. Prevention of welding of the contacts
   The arc melts the silver and the solid cadmium oxide matrix prevents welding when contacts close
2. Prevention of silver loss from the contact
   Cadmium oxide slowly vaporises at the high arc temperatures and this prevents it from building up at the surface which would increase the electrical contact resistance. This would in turn result in a rise in temperature from resistance heating and an increase in the erosion rate.

Some lower current contacts have been produced with silver-nickel. It is easier to use than silver tin oxide and does not increase in contact resistance. Silver nickel is not suitable for higher current switching. In fluorescent lighting equipment, contacts with silver nickel that switched higher currents failed by welding after only 18 months. [3]

The main alternatives to cadmium oxide in higher current switching are based on tin oxide and on zinc oxide, often with additional elements added, principally to modify the oxide particle size and shape. Both tin and zinc oxides have higher melting and boiling temperatures than cadmium oxide. They vaporize slower than cadmium oxide and so tend to build up on contact surfaces causing a gradual increase in contact resistance, as silver erodes. This increases the contact temperature which again may increase the wear rate and risk of welding. Many users of tin oxide and zinc oxide contacts complain that these materials are unsatisfactory substitutes for AgCdO because they wear faster and so have shorter lifes. Some manufacturers have found that silver tin oxide lasts for only half the time of silver cadmium oxide. [3]

Many, but far from all, off-the-shelf components now include cadmium-free contacts. However, they cannot be used as drop-in replacements. Design changes are required. It is necessary to make the contacts larger to compensate for the increased wear rate, and make other changes to switch and relay design. Thus, while silver cadmium oxide is suitable for a wide range of conditions, silver-tin oxide requires a more specific design, which then is suitable for a limited range of use conditions. [3]

4.13.2.1 Specific conditions in automotive electric contacts

The ban of cadmium in the ELV Directive forced the substitution of cadmium in contact surfaces. In automotive, silver tin oxide showed to be a suitable substitute. Lower current relays use silver nickel. Vehicles, however, use 12 or 24 volt DC (direct current) which gives very different arc behaviour to mains (240V) AC (alternate current) switching. Good performance in vehicles thus does not guarantee good performance for AC switching. [3]

Switching DC is different to AC. When a DC arc strikes on opening contacts, it will continue until the contact gap is sufficiently large for the plasma to be diluted by air and cooled. When AC contacts open, the arc will stop when the voltage reaches the null point (zero volts) as long as the gap is large enough to prevent it re-starting. AC voltage is a sign-wave where the voltage oscillates between positive and negative through zero. [3]

Automotive switching is also different to many electronic applications because many vehicle circuits have high inrush currents due to inductive loads. These result in brief high current surges that cause contact material vaporisation so that material transfers from one contact to the other. Silver tin oxide is particularly resistant to this as it is a material with high melting and boiling point, while at the same time the high inrush current vaporises sufficient material to prevent it from building up at the contact surface. Such a build-up would increase the contact resistance and spur the loss of silver and contact erosion as well as welding, as described before. The higher melting and vaporization point in this case is advantageous to maintain low contact resistance. [3]

Most applications in the scope of the RoHS directive and also in medical devices and monitoring and control instruments are AC applications without large inrush currents where silver tin-oxide is not universally suitable as a drop-in substitute unlike in automotive applications. [3]

4.13.2.2 Research, supply chain and qualification issues

The development of cadmium-free contact materials is by far more than simply changing the material only, but has to deal with many parameters, which even my vary depending on the application [3]:

- the gap between contacts when open;
- contact size (diameter and thickness);
- opening and closing speed;
- actuator design to minimise contact bounce; and also
- the choice of contact material composition and fabrication method.

The research and developments take a considerable amount of time.

One additional issue is that although silver cadmium oxide contacts from all suppliers behave similarly, the performance and behaviour of silver tin oxide depends on the essential minor

additives that are used. Every supplier's product is significantly different in behaviour and performance. Testing of one type from one supplier may give good results whereas others will be found to perform badly. This is a significant disadvantage because if a suitable contact type is identified, this will have only one manufacturer and so there is a potential risk to supply if the manufacturer has production difficulties (e.g. a factory fire) or ceases trading. [3]

Most equipment manufacturers, except for the largest multinationals, do not carry out research into electric contact materials or switch and relay design and are only users of these products. The technical issues for choosing a suitable switch or relay design are complicated and are not understood by most equipment manufacturers who inevitably have to rely on their component suppliers for guidance. [3]

Research into substitutes and their qualification is being carried out at three levels [3]:

1. Manufacturers of the contacts are developing new materials which they test under simulated conditions although these may not represent all of those used by their customers.
2. Manufacturers of switches, relays etc. are also carrying out research to evaluate the new contacts, but are also having to re-design their components to achieve acceptably long reliable lives. Each type of switch or relay may be used in a wide range of conditions – with or without inrush current, switching frequency etc. and any contacts chosen must perform well under all conditions. This is possible with silver-cadmium oxide but more difficult with silver-tin oxide.
3. Finally, when the new switch and relay designs are available these have to be tested by equipment manufacturers using their own conditions for reliability assessment. Manufacturers need to obtain samples of a possible alternative, build equipment and carry out lengthy tests taking upwards of 6 months. The cost of these tests is at least several thousand Euros for each type of contact material and for each application. Frequently the first material evaluated is found to be unsuitable and so several types of contact need to be tested simultaneously which significantly increases the cost. This is particularly a problem for small and medium size manufacturers who cannot afford to do this. In addition medical equipment manufacturers will need to generate data for obtaining approvals under the medical devices directives which are required before the new components can be used. Some large multinationals have been investigating alternatives for several years, so far without success and so are still using silver-cadmium oxide in large quantities for at least some of their products.

Cadmium-free switches and relays are on the market for switching medium to moderately high currents, and they have been used. However, due to the above reasons, there are also many others that contain silver-cadmium oxide contacts and these are used by many European manufacturers. [3]

The removal of this exemption would particularly affect small and medium size manufacturers who do not have the resources to carry out the lengthy tests that are required. It appears that technically, substitutes should be available for all applications but some manufacturers have yet to identify suitable substitutes. In all cases, this will involve product re-design and lengthy and costly trials with no guarantee of success as simple drop-in replacements do not exist. [3]

For safety and durability/reliability reasons, AgCdO can not be replaced in most types of electrical switches and circuit breakers. [2] Despite of numerous tests over years, it has not been possible so far to replace all cadmium-containing electrical contacts [10].

Several other stakeholders support the continuation of exemption 8 in general or for specific applications [8, 9, 10, 11, 12, 13, 14, 15]. In principle, they put forward similar arguments like those described above.

Other stakeholders oppose the continuation of the exemption. The European Association of Contact Material Manufacturers claims that cadmium-free contact materials are available at this stage for all applications. It might, in certain cases, just need adaptations in the design of the electrical contact [16]. There are further stakeholder submissions claiming that alternatives are available for specific applications:

- for one-shot pellet-type thermal cut-offs [1] [15];
- for use in air conditioners [17];
- for electrical contacts, switches and relays [15].

4.13.2.3 Inclusion of cat. 8 and 9 equipment into the scope of the RoHS Directive

Documents were submitted pointing out the specific importance of exemption 8 for category 8 and 9 equipment (medical devices, monitoring and control instruments). They ask to extend exemption 8 [3], [13]. ERA states that any significant changes to medical equipment must be approved by a Notified Body as a requirement under the Medical Device Directives, which will require up to two years to complete including time for testing. When the new switch and relay designs are available to the medical equipment manufacturers, these have to be tested by equipment manufacturers using their own conditions for reliability assessment. In addition, medical equipment manufacturers will need to generate data for obtaining approvals under the medical devices directives which are required before the new components can be used. [3]

ERA says that category 8 and 9 manufacturers are now busy developing lead-free soldering technology and most, especially small and medium producers would have difficulty finding resources to also work on silver-cadmium oxide substitution due to a lack of suitably skilled manpower. [3]

4.13.3 Critical review

Cadmium platings

No supporting evidence was submitted during the stakeholder consultation that the further use of cadmium in platings, the second part of the current exemption 8, is required further on. During the stakeholder workshop in Brussels in June, there was no support for this part of the exemption either, but it was stated that the exemption probably is no longer needed for the products in the scope of the RoHS Directive. Further investigations at Amphenol in UK, a manufacturer using cadmium platings, confirmed that cadmium platings are no longer used for products in the scope of the RoHS Directive, but mostly for military and avionic applications.

In line with the requirements of Art. 5 (1) (b), the cadmium plating part of the exemption therefore can be revoked without any transition time.

One-shot pellet type thermal cut-offs (OPCOs)

NEC/Schott [1] in the fourth stakeholder consultation in 2005 had submitted an exemption request to no longer allow the use of cadmium in "[…] applications of one-shot operation function such as thermal links […]". NEC/Schott claimed to have cadmium-free solutions relying on AgCuO as contact material. Another manufacturer of one-shot pellet type thermal cut-offs states that "For pellet-type one shot thermal cut-offs, long-term reliability data can be reviewed and if acceptable, can entertain removal of the Exemption by 2010."[4]

For one-shot pellet type thermal links (=one-shot pellet type thermal cut-offs), meanwhile cadmium-free alternatives are available from more than one manufacturer. At least some manufacturers of end products already apply them or currently introduce them into their products. [14, 1, 15]

The substitution of cadmium in OPCOs thus is no longer technically impracticable, and the OPCOs must hence be removed from exemption 8 following the requirements of Art. 5 (1) (b). The OPCOs are, however, a safety-relevant component. Their proper function in products is indispensable and should not be put at risk. Failures may cause fire and other hazards. A proper expiry date for the OPCOs under exemption 8 therefore is crucial.

Viable cadmium-free OPCOs are available in the supply chain. Besides the supplier point of view, the users perspective, however, is important as well. A manufacturer of white goods [14] states that AgCuO is not a well known and well investigated contact-material in Europe. The introduction requires extensive investigation and testing. This manufacturer has started introducing cadmium-free OPCOs into its products. The required lifetime is 10 Years or 2000 washing or drying cycles. [14] For qualification, especially a lifetime-test in the machine, a thermal-shock-test and an electrical-overstress-test have to be carried out. In addition, the

abnormal-operation-test for every type of application has to be repeated. The whole procedure takes about 1 year for each type of fuse. The white good manufacturer states that in the end it is the field experience that brings the final proof that the cadmium-free OPCOs are a viable alternative [14].

Further on, a simple drop-in exchange of the current cadmium-containing OPCOs by cadmium-free ones often is not possible. Different cut-off times and OPCO geometries, for example, can require different geometries of the OPCO environment in the equipment [14]. A simple and quick exchange thus is not possible, but needs a sound design or redesign of the equipment.

An appropriate transition time is therefore recommended allowing sufficient time for testing and evaluating the OPCOs and to adapt the design of the equipment to the cadmium-free OPCOs. Manufacturers should then be able to find the best cadmium-free option for their products.

Assuming the official amendment of the RoHS Annex by the end of 2009, it is recommended to set the expiry date for the OPCOs at 31 December 2011. This gives manufacturers 2 years time after the amendment of the Annex to select the most appropriate cadmium-free OPCOs and to adapt their products without compromising the safety of their customers.

In case category 8 and 9 equipment will be included into the scope of the RoHS Directive, the time line until end of 2011 is still long enough to apply for further specific exemptions accommodating the special conditions of these types of equipment.

Cadmium in other electrical contact materials

Cadmium-free materials like for electrical contacts have been available on the market for a while, as several stakeholders confirm [1, 2, 3, 11, 12]. Despite of some e-mail exchange, no further information could be obtained on the stakeholder comment from China [13] claiming that cadmium-free relays are available for use in air conditioners.

The main substitutes, which the suppliers offer are silver-nickel materials for lower current contacts and tin and zinc oxides for higher currents. They are used in electrical contacts already, in particular in lower current applications [3, 4].

However, the stakeholders' explain technically plausible that cadmium-free materials are not a drop-in replacement for the cadmium-containing contacts. On the equipment manufacturer side, it requires comprehensive testing and evaluation of the cadmium-free contacts and geometrical adaptations in the contacts and in the equipment to decide on a case-by-case base whether they are appropriate for the intended application. It is not clear, whether for every application appropriate cadmium-free materials are available. On request for more detailed information on cadmium-free alternatives for cadmium in electrical contacts, no further inputs were received from stakeholders that had pointed out to either have cadmium-free alternatives available or to know companies who offer them.

Cadmium-free contact materials are already used in electrical contacts, mainly in automotive application and in the lower voltage application range [3]. The stakeholders plausibly explain why the use of cadmium-free contact materials in automotive applications is technically different from other uses. This application thus is not a proof for the general viability of cadmium-free contact materials in other applications outside the automotive ones.

A limitation of exemption 8 to higher current applications is impossible or complicated. The stakeholders explain that for lower current applications, the different conditions in the specific application may not allow the use of cadmium-free contact materials in any case.

It might be possible to exclude a few specific cadmium contact applications from exemption 8. It would require defining the specific application conditions with possibly several parameters like current, inrush current, frequency of switching, life time, alternate or direct current, minimum available space in the product, operating temperature etc. This would not be manageable: it would require a complicated exemption wording, which would create confusion and insecurity in industry on the one hand. On the other hand, it would make monitoring difficult or even impossible for the authorities.

In order to nevertheless appraise and further promote the scientific and technical progress in this field, and to suffice the requirements of Art. 5 (1) (b), the exemption for cadmium in electrical contacts is proposed to expire on 31 July 2014. Assuming that the RoHS Annex is officially amended end of 2009, this expiry date accommodates four conditions:

1. As many electrical contacts are used in safety-critical applications, the transition to cadmium-free contacts must not compromise the safety of consumers. The testing and qualification procedures are comprehensive and lengthy, and additional design adaptations in products may be necessary. In particular in small and medium size enterprises, the manpower is limited, and it cannot be easily enhanced. Excessive pressure to replace cadmium-containing contacts might thus result in overhasty and not careful enough testing and qualification of the alternative solutions. This might endanger consumer safety. The expiry date in 2014 gives equipment manufacturers – including those of category 8 and 9 in case they are included into the RoHS Directive – enough time to carefully test and evaluate whether and how available or upcoming cadmium-free materials on the market are appropriate for their products.
2. Given the long and comprehensive qualification procedures, this expiry date should be early enough to spur manufacturers' efforts to implement cadmium-free contact materials in their products. This expiry date thus also appraises the fact that cadmium-free materials are available, should reward the suppliers offering such materials, and promote further research into cadmium-free alternatives.
3. As it is not clear whether cadmium can be replaced in each electrical contact application by the currently available contact materials, the expiry date must be far enough in

the future to allow industry applying for specific exemptions to maintain their products' safety. It must be made sure that such exemptions are in place before exemption 8 expires.

An earlier expiry date than 2014 might result in industry having to apply for many exemptions with unclear definitions and complex wordings similar to the situation now. Until 2014, there may be sufficient progress to avoid this situation. If industry can prove that the situation is technically as complex as it is now, the next general review for 2014 may accommodate this fact shifting the expiry date further into the future and maintaining the general exemption, or limit or completely cancel it otherwise.

4. In case category 8 and 9 equipment will be included into the scope of the RoHS Directive, the time line until July of 2014 is still long enough to apply for further specific exemptions accommodating the special conditions of these types of equipment.

4.13.4 Recommendation

Cadmium-free alternatives are available, although not always applicable. Maintaining exemption 8 in its broad and general character as it is now would not be in line with the requirements of Art. 5 (1) (b).

It is recommended to revoke the exemption for cadmium platings, as they are no longer used for equipment under the scope of the RoHS Directive.

The use of cadmium for electrical contacts in one-shot pellet type thermal cut-offs should be excluded from exemption 8 from 1 January 2011 on. Cadmium-free alternatives are available, but need time to be properly implemented in products, as such cut-offs are safety critical components.

Finally, the expiry date 31 July 2014 should be added to the use of cadmium in electrical contacts. Even though it is not clear whether they can be used in each application, cadmium-free alternative materials are available. A limitation of the cadmium use in electrical contacts to specific applications fails. The technical situation is complex, and a categorization of applications, in which the use of cadmium is allowed, would result in a complicated and unclear exemption wording. Additionally, end product manufacturers need time to test and evaluate whether and how the available or upcoming cadmium-free contact materials are appropriate for their products. Many contact materials are used in safety-critical applications, a careful transition hence is necessary not to compromise consumer safety. At the same time it must be made sure that equipment manufacturers can apply for specific exemptions in case cadmium-free alternatives do not work in some applications.

The proposed expiry date 31 July 2014 thus is a compromise between industrial feasibility, safety requirements and the requirements of Art. 5 (1) (b).

For a better understanding, exemption 8 is proposed to be split into two parts. The new wording of exemption 8 would thus be:

(8a) Cadmium and its compounds in one shot pellet type thermal cut-offs until 31 December 2011 and in one shot pellet type thermal cut-offs used as spare parts for the reuse and repair of equipment put on the market before 1 January 2012.
(8b) Cadmium and its compounds in electrical contacts until 31 July 2014[32], and in electrical contacts in spare parts used for the repair and reuse of equipment put on the market before 1 August 2014.

4.13.5 References

[1] NEC/Schott Stakeholder consultation no. 4, http://circa.europa.eu/Public/irc/env/rohs_4/library?l=/requests_exemption/compounds_electrical&vm=detailed&sb=Title; last access July 2008

[2] EICTA et al. on ex. 8, Stakeholder consultation document "Exemption_8_EICTA_and- others_1_April_2008.pdf"

[3] ERA on ex. 8, Document "RoHS exemption 8 technical information final.pdf", submitted to Öko-Institut by Dr. Paul Goodman, ERA, in July 2008

[4] Stakeholder consultation documents "T-O-D RoHS Exempt 8 Response.pdf", "T-O-D Exemption 8 Input.pdf" and "ECTTOD Responses to stakeholders questions (0 1).pdf" from Emerson/Thermodisc

[5] Stakeholder consultation documents "Exemption-8_ITW-Metalflex_Specific-questions_31_March_2008I.pdf" and "Exemption-8_ITW-Metalflex_31_March_2008.pdf"

[6] Stakeholder consultation document "Exemption-8_Marquardt_31_March_2008.pdf"

[7] Stakeholder consultation document "Exemption 8-Ekowicki-Feb-08.pdf"

[8] Stakeholder consultation document "Exemption_8_Emerson_all_20_March_2008.pdf"

[9] Stakeholder consultation document "Exemption-8_Test-Measurement-Coalition_31_March_2008.pdf"

[10] Stakeholder consultation document "Exemption-8_Bleckmann_1_April_2008.pdf"

[11] Online stakeholder document „Exemption-8_EACMM_31_March_2008.pdf" from the European Association of Contact Materials Manufacturers

[32] The following addition was cancelled assuming that it referred to cadmium platings only, which were deleted from exemption 8: "except for applications banned under Directive 91/338/EEC amending Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances and preparations". In case the above addition is also necessary for the further specification of the exemption as it is worded here, it would have to be added again. This is subject to further clarification.

[12] Stakeholder consultation document "Exemption_1-2-3-4-6-8-9a-9b-25-29_Sweden_1_April_2008.pdf"

[13] E-mail from Mr. Echo Zheng, Xiamen Hualian Electronics Co. Ltd., China, to Öko-Institut on 23 April 2008

[14] e-mail communication between Mr. Bernt Peters, Bosch-Siemens Hausgeräte, and Otmar Deubzer, 11 August 2008

[15] NEC/Schott via e-mail, e-mail communication from Mr. Harald Schäfer and Mr. M. Gomi, NEC/Schott, with Otmar Deubzer, 10 August 2008

[16] IEC 691, International standard publication 691

[17] ERA-Report 2004, Dr. Paul Goodman et al.: Technical adaptation under Directive 2002/95/EC (RoHS) – Investigation of exemptions; final report Dec. 2004; Document "ERA Report 2004-0603.pdf"

4.14 Exemption No. 9

"Hexavalent chromium as anti-corrosion of the carbon steel cooling system in absorption refrigerators"

4.14.1 Description of exemption

Chromate is currently used as a corrosion inhibitor in absorption refrigerators. These kinds of refrigerators are inter alia used in hospitals, hotels and small apartments (RoHS scope) as well as in caravans and motor homes (ELV scope). Absorption refrigerators are used in these areas of application due to the fact that they can work independently from electricity with a heat-driven technology using gas (propane / butane) or kerosene as energy source [1]. Furthermore, they have the advantage that they have no moving parts and are thus completely silent, making them further attractive for the above described uses. They mostly belong to category 1 "large household appliances" of the WEEE Directive. Some appliances like e.g. medical refrigerators and refrigerators for laboratory use belong to category 8&9 equipment [1].

Dometic – formerly Electrolux – states to be one of the main producers of absorption refrigerators in Europe[33]. Its absorption cooling units are constructed in carbon steel because of its strength as well as its good welding and cold-working properties. The refrigerant is an ammonia-water solution. The absorption cooling system is a completely closed system, which is pressurised with hydrogen gas. In order to prevent corrosion of the carbon steel cooling system sodium chromate is added to the refrigerant. This allows Dometic to produce absorption

[33] However, Dometic has less than 50% of the market of RoHS relevant applications. Several small actors from Italy, Turkey and China are present on the market.