Questionnaire No. 13

"Lead and cadmium in metallic bonds creating superconducting magnetic circuits"

Background

The Öko-Institut together with Fraunhofer IZM has been appointed for the technical assistance in reviewing the requests for exemptions from the requirements of the RoHS Directive 2011/85/EU (RoHS II) by the European Commission. You have submitted the above mentioned request for exemption which has been subject to a first completeness and understandability check.

As a result we have identified that there is some information missing and a few questions to clarify before we can proceed with the online consultation on your request. Therefore we kindly ask you to reformulate your request taking the following points into consideration.

Questions

The application you request an exemption for is already covered by Annex IV exemption 12 "Lead and cadmium in metallic bonds to superconducting materials MRI and SQUID".

1. Please explain why you consider category 9 equipment not to fall under the scope of this existing exemption. The phrasing of exemption 11 does not restrict it to category 8 equipment.

The phrasing of exemption 11 does not extend the use of the same technologies to applications other than MRI and SQUID. The exemption has identified correctly that lead and cadmium is critical to create metallic bonds between superconducting materials. These bonds are connecting superconducting wires together forming a superconducting electromagnet to create a magnetic field. This magnetic field generated by the superconducting magnet is not limited to use in MRI applications. One major additional application to MRI is NMR. MRI is actually a branch of NMR used specifically for imaging. Agilent Technologies manufactures superconducting magnets which the field generated can used for MRI, NMR, FT-ICR. The technology is essentially the same as the core item is a superconducting magnet. The main difference is that MRI magnets are horizontally mounted whereas NMR products such as FT mass spectrometers in category 9 are normally mounted vertically.

Unfortunately the lack of differences were missed by ERA in their report. During the co-decision of the RoHS recast Agilent attempted political correction of this error but it was not considered part of the political process and had to be considered as a new request after category 9 officially came into scope with publication of Directive 2011/85/EU

Fundamentally superconducting magnets have this exemption for MRI use but not for NMR use. The purpose of this request is to have a new or amended exemption for NMR use in category 9 products using superconducting magnets.

Understanding differences between NMR and MRI is as follows. **Nuclear magnetic resonance** is the study of molecular structure by means of the interaction of radio-frequency (RF) electromagnetic radiation with a collection of nuclei immersed in a magnetic field. **Magnetic resonance imaging** is a branch of NMR that uses manipulations of the magnetic field to encode spatial information into the NMR signal. This enables an MRI experiment to produce an image. NMR is very widely used because its flexibility enables analysis of solids, liquids, liquid crystals and even nano materials. Even "squishy" materials – such as gels, resins or tissue samples – which are very hard to analyse with any other technique, can be analysed. Furthermore samples can be analysed in a non-destructive fashion. In **biological NMR**, the technology is used by pharmaceutical companies in drug discovery; note also this is not a MRI or SQUID medical application. NMR can determine the structure of proteins and nucleic acids in complex molecules.

2. Please indicate in more detail the functionality and technical necessity of lead and cadmium in metallic bonds to superconducting materials in the mentioned applications (MRI, SQUID, NMR, FTMS). We would need to understand which technical properties of the substances are needed for the specific applications.

Referring to ERA report section 10.11.1 at

http://ec.europa.eu/environment/waste/pdf/era_study_final_report.pdf

Section 10.11.1 identifies correctly the requirements of the use of Pb and Cd in the manufacture of superconducting magnets. The final use of the magnetic field generated by the superconducting magnet is not limited to MRI or indeed NMR applications.

3. Please describe the technical difference between superconductors and a “normal” conductor (lower performance machines).

A superconductor is an element or metallic alloy which, when cooled to a few degrees Kelvin, dramatically loses all electrical resistance. In principle, superconductors can allow electrical current to flow without any energy loss, or a power source. In contrast a normal conductor has a finite resistance and electrical current will dissipate typically in the form of heat.

4. Please, specify the type and quantity of the lead and cadmium in absolute numbers and in percentage by weight in homogenous material. Please also provide an estimate of the annual quantities of the lead and cadmium used in the specific applications (MRI, SQUID, NMR, FTMS).

Two materials are used for superconducting metallic bonds at present:

1. "Woods" alloy Bi (50%) Pb (27%);Sn(13%) Cd(10%) estimated annual use 140kg
2. Superconducting Solder Pb(60%) Bi(40%) estimated annual use 42kg

These are the estimated annual weights used in the manufacture of superconducting electromagnets at our facility and represent approximately 30% of the global NMR market. Note this constitutes <0.03% Pb by weight to the final product. The magnet is a specialised component which after manufacture, is kitted with electronics by OEMs who determine its final application. As the supply chain is short (suppliers of solder) and we are one of just a few global suppliers, we are able to provide good estimates in answer to this question.

5. In the ERA study report in section 10.11.1 it is reported that substitutes are available (e.g. cadmium free based on PbBi or lead free alloys by using InSn).

   a) Why have no research activities yet been done on these mentioned possible substitutes and what was the outcome to prove your argumentation that no success is guaranteed?

   In the ERA study report, section 10.11.3 mentions the industry situation on alternatives. We already use PB Bi where possible and commercially sensitive development is on-going on other alternatives. It should be noted that superconducting magnets are commonly in operation for 10-20 years. Long term reliability is critical and is addressed in 3.2.2 of the ERA report "Additional Exemptions from RoHS Directive needed by the medical industry".

   b) Please provide test results/protocols that clearly indicate that superconductors containing lead and/or cadmium cannot be substituted by lead- and cadmium-free applications.

   In the ERA study report sections 10.11.3 shows the technically challenging operating conditions required for this unique superconducting state to be achieved.

c) Please give information on current research activities on substitutions for lead and/or cadmium in superconductors carried out by yourself and/or other sector players. Please refer to relevant studies. Is there a timeline for the next ten years for possible substitutes?

The process and materials used are key business technologies, and as a result there are no lead and cadmium free accessible alternatives from other sector players. Agilent Technologies does not yet have any alternative methods that allow the business to move away from the use of lead in these processes; however we are making some progress in cadmium free bonds that may take several years to complete depending on the magnet design specifications.

d) Please indicate if the negative environmental, health and/or consumer safety impacts caused by substitution are likely to outweigh the environmental, health and/or consumer safety benefits. If existing, please refer to relevant studies on negative impacts caused by substitution.

The NMR technique is sufficiently flexible to be used for example to measure the water/fat ratio in foods, monitor the flow of corrosive fluids in pipes, or to study the structure of catalysts. Industrial applications can be divided into chemical, biological, drug research, paramedical, data processing, and non-destructive testing. This is not exhaustive, but it gives some highlights of the applications. The socio-economic impact of not having these NMR systems is far reaching across many sectors worldwide.

The impact environmentally is minimised by the extended potential life time of the product 10-20 years, and the small quantities' of material used in this low volume product. Category 9 products are produced in vastly smaller quantities compared to categories already in scope of RoHS. The entirety of Category 9 product volumes in total are representative of less than 0.25% of e-waste[1]. Furthermore super conducting magnets are large products (ranging from 0.5 to 100 tons) that are installed and decommissioned at end of life by professionals ensuring they treated without environmental impact in the waste phase.

[1] UN study at http://ec.europa.eu/environment/waste/weee/pdf/final_rep_unu.pdf

6. You are proposing an exemption valid until 2021 and claim that in many products, substitution is impractical as the design and qualification effort required is equivalent to that for a wholly new product introduction. Will research and market penetration of alternatives, as well as innovation cycle in superconducting magnetic circuits allow a complete substitution after 2021? (It is clear that you cannot give perfect forecast for the technical and market developments for the next ten years. Nevertheless, a sound and justified outlook could help in the evaluation and stakeholder process).

The path to finding a lead and cadmium free proven reliable alternative is unknown at this time and we cannot predict if such a substitute can be found far less widely available in ten years. It is analogous to the global search for a high temperature superconductor. However we believe there is a high probability that by 2021 cadmium free but not lead free material for metallic bonding will be sufficient for superconducting magnets.