Questionnaire Exemption Request No. 8

"Lead in solder for electrical circuitry that is used at temperatures below -20 °C"

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

1. You calculate around 450 kg of lead put on the market in Europe in circuitry related to the exemption request. Please substantiate this calculation: Further calculations indicated that the correct figure is nearer to 200 kg in the EU most being due to MRI (180kg for MRI reported in the ECO Vision Locem submissions for 2010).

   a) Which types of equipment would use this exemption (MEG, MRI, …)?

      MRI (magnetic resonance imaging) equipment is the main application although smaller amounts will also be used in nuclear magnetic resonance (NMR) spectrometers, MEG and cyclotrons that are used for particle therapy, all of which are also liquid helium cooled and have solder bonds at very low temperature for the same reasons as MRI.

   b) How much lead per circuit and how many circuits per device?

      We can answer this for the largest user of lead which is MRI.

      Within the sealed vessel of MRI there are typically 2 to 3 PCB assemblies comprising of approximately 100 joints per board. The MRI magnet also contains of a number of small wire gauge cable looms which comprise at one end of various sensors and devices that monitor and/or control the operation of the superconducting magnet, which are brought out to the external world via hermetic connectors. This results in approximately 100 to 200 joints.

The magnet also has Mains Current Leads (max current approximately 700A) that are crimped and soldered that form the main current path for ramping up the superconducting magnet.

From the above one manufacturer has calculated that approximately 0.5 kg lead is used per MRI magnet. Another manufacturer has calculated: Approximately 1.8Kg for 1.5T magnets, 0.97Kg for 1.0T, and 2.7Kg for 3.0T

c) How many of such devices are sold annually worldwide and in the EU? Approximately 700 Worldwide and 280 in the EU

d) How much lead would be used in this exemption in equipment put on the market in Europe and worldwide?

Approximately 450 Kg Worldwide and 180Kg in the EU.

2. What are the temperature ranges in which the circuitry would be used?

During normal operation parts of the circuitry are exposed to a temperature range of 4 Kelvin to 100 Kelvin. During ramp up of the magnet the temperature range in parts of the circuitry can be approximately 100 Kelvin to 200 Kelvin. During construction and under certain fault conditions this rises to room temperature values.

3. Why can the construction not be changed so that the circuitry could be placed in warmer zones thus making the requested exemption obsolete?

MRI magnets generating a magnetic field strength greater than a few tenths of a Tesla rely on superconducting wires (wires with zero electrical resistance) carrying electrical currents of a few hundred Amperes to generate the magnetic field. Use of non-superconducting wires would result in very high energy consumption and heat generation which would make the MRI magnet extremely costly and impractical. Superconducting wires only have zero electrical resistance at cryogenic temperatures. The actual temperature below which the wire has zero electrical resistance is dependent upon the wire material, operating current and magnetic field. Typical MRI magnets use NbTi superconductor which must remain at a temperature below ~ 5K (-268 °C) in order for the magnet to operate. Other superconducting materials do exist which can operate at higher temperatures. The only material available in commercial quantities is Nb_3Sn which is technically more challenging to work with, significantly more expensive and is not superconducting above ~ 20K (-253 °C). So-called High Temperature Superconductors (HTS) are not expected to become cost competitive with NbTi and they are not produced in the quantities that the MRI industry requires. In addition, many technical challenges have to be overcome to enable their use in whole body MRI magnets and these HTS materials are still limited to operating at temperatures below ~ 150K (-83 °C). No material exists which would allow whole body MRI magnets to operate at temperatures above -20°C.

For its operation a superconducting magnet relies on cryogenic liquids and therefore by extension the control and monitoring of the superconducting magnet through the use of various sensors and devices are exposed to these temperatures. At a fundamental level the magnet would not work without many of these devices and a number of these devices are integral to the safety of the magnet system e.g. ensuring uncontrolled high voltages do not appear externally during fault conditions or that the magnet can be brought to zero field in the event of an emergency.

Furthermore it is important that the number of connections between the cryogenic parts of the magnet and the external world (at room temperature) is as small as possible to minimize cooling needs and thus energy consumption and avoid loss of liquid helium. Therefore the connections to each sensor and to the superconducting coil need to be made within the cryogenic sealed vessel which is at low temperature. Solder connections are the only type that will be reliable at low temperature. Sensors and other devices are not made with very long leads and if they were, these could not be passed through the wall of the sealed vessel. There are also older bonds inside sensors and devices so these must withstand the low temperatures.