Clarification Questionnaire Exemption No. 24

Exemption for „Lead in solders for the soldering to machined through hole discoidal and planar array ceramic multilayer capacitors “

Abbreviations and Definitions

Be	Beryllium
CCTV	Closed-circuit Television
Cu	Copper
EMI	Electro Magnetic Interference
HMP	High Melting Point
In	Indium
Knowles	Knowles Precision Devices
Pb	Lead
RoHS	Directive 2011/65/EU on the Restriction of Hazardous Substances in Electrical and Electronic Equipment
Sn	Tin

Background

The Oeko-Institut has been appointed by the European Commission, within a framework contract[1], for the evaluation of applications for exemption from Directive 2011/65/EU (RoHS), to be listed in Annexes III and IV of the Directive.

Your organisation (Knowles Precision Devices) has submitted a request for the renewal of the above-mentioned exemption, which has been subject to an initial evaluation. A summary of the main argumentation for justifying the request is provided below as a first basis to be used in the stakeholder consultation planned as part of this assessment.

Please read the summary of the argumentation provided to ensure that your line of argumentation has been understood correctly and provide answers to the questions that follow that address aspects requiring additional information and/or clarification.

[1] The contract is implemented through Framework Contract No. ENV.B.3/FRA/2019/0017, led by Ramboll Deutschland GmbH.

1. Summary of argumentation of applicant on the justification of the exemption

1.1. Background

Knowles (2020) request the renewal of exemption 24 of Annex III of the ROHS Directive for:

“Lead in solders for the soldering to machined through hole discoidal and planar array ceramic multilayer capacitors”

The exemption is requested for RoHS Annex I categories 1-10 and for the maximum duration applicable according to the Directive (5-7 years, depending on category).

It is noted that Ex. 7(a) of Annex III of the RoHS Directive for “*Lead in high melting temperature type solders (i.e. lead-based alloys containing 85 % by weight or more lead)*” excludes applications covered by point 24 of the annex from its scope.

1.1.1. Volume of lead to be placed on the EU market through the exemption

Knowles (2020) explains that the amount of lead placed on the market through this exemption varies depending on filter design, but that typically 5 mg to 10 mg per solder joint, equating to ~1.0% of the total component weight (maximum) is needed. More complex designs such as filter connectors will be proportionally less than 1 % of the total weight. The following figures are provided, though it is not completely clear if this represents only Pb placed on the market through applications marketed by Knowels or also by other suppliers. (Knowles 2020)

- For electromagnetic interference (EMI) filtered connectors: Knowles estimate from client feedback that only around 10% of parts are supplied into applications covered by the RoHS directive, meaning ~3.9 million capacitive holes. Other equipment is out of scope such as aerospace and military applications. Based on earlier calculations that each hole requires between 5 mg to 10 mg of lead in a typical solder joint, the total lead from EMI filtered connectors entering the EU through RoHS applications per annum is estimated at ~29 kg;
- For EMI single line filters: Knowles estimates that ~48kg of lead was placed on the EU market in 2019;
- High melting point (HMP) soldered EMI filters have been excluded from the scope of exemption 7(a) and included in the scope of exemption 24:Here the total market is estimated to be similar to the EMI filter market using low lead (50%) solders, accounting for ~88 kg of lead placed on the market per annum;

Adding these three estimated quantities together gives the total estimate of 164 kg lead per annum supplied into applications covered by the RoHS directive. To allow for errors and assumptions, and applying the same ratio as previous exemption applications, Knowles estimates the total usage at <250 kg lead per annum. (Knowles 2020)

1.2. Technical description

In applications of relevance to this exemption, signal carrying feedthrough pins are passed through the ceramic element and connected to the internal bore to make a mechanical and electrical connection. This connection must have low electrical resistance and inductance for optimum performance, as high resistance / inductance will inhibit the high frequency electrical path to ground through the filtering capacitor. The function of lead in components of relevance to this exemption is

to impart ductility to the solder joint. The solder must also have good wetting properties as it is not physically possible to apply the solder directly into the joint area, so the wetting action is vital for the solder to flow into the holes through capillary action. (Knowles 2020)

Where secondary soldering operations are required (solder-mount filters) there is an additional requirement to maintain the ductility of the joint and have a high enough melting point alloy to allow the user to mount the filter by conventional reflow soldering techniques without the internal solder joint suffering secondary reflow. (Knowles 2020)

Lead containing solders, often in conjunction with other metals such as indium, imparts a degree of ductility to the solder joint, allowing stress release within the joint and absorbing the forces applied to the ceramic. This good ductility is retained also in low temperatures. The lead-indium compounds used are the only alloys in the 'standard' melting temperature range that have the required ductility. The alloy used is usually InPb for mechanical mount applications, and PbSnAg for applications demanding secondary soldering operations by the end user. (Knowles 2020)

Knowles (2020) specifies typical applications for assemblies incorporating these components and covered by the RoHS directive to include: professional audio equipment, maritime monitoring (coastguard radar) and Closed-circuit television (CCTV) systems. Such components include specialist capacitors used in EMI filters and EMI filtered connectors for high end applications, where the elimination of electrical interference is critical and where performance is more important than cost. These are said to mainly be used for high end applications where technical performance outweighs cost.

1.3. Applicant's justification for the requested exemption

Knowles (2020) argue the justification of the exemption on the basis of the lack of substitutes with sufficient reliability: Knowles currently sees no scope for replacing solder as the primary method of making electrical and mechanical connection between the capacitor and the through lead, as at present there are no viable alternatives to lead containing alloys.

1.3.1. Availability of alternatives

Knowles (2020) explains that when lead free solder is used to make the connection, the shrinkage of the solder and pin assembly within the bore exerts a tension force on the inside of the bore sufficient to form micro-cracks in the ceramic element. These cracks have a recognisable shape and form. If the crack propagates through the electrically active portion of the design, where electrodes of opposing polarities overlap each other, then the result can be a low resistance path or an electrical short circuit resulting in failure of the electrical system and potentially health and safety risks to operators. Alternative solder alloys, such as tin (Sn) based lead-free alloys and SnPb alloys, do not have sufficient ductility to prevent stress damage to the ceramic and can represent a reliability / safety risk during the operating life of the component.

Where secondary soldering operations are required, Knowles (2020) explains that the only other alloys having appropriate ductility and associated high melting points are Pb containing HMP alloys.

Additional information is given by Knowles on alternative solders in an annex to the application, differentiating between cases with long bow crack (these usually lead to short circuit) and corner cracking (these can be eased by limiting the volume of solder in the meniscus or reducing the pad size. On very small size parts, it is common to remove the pad entirely). Test results with other solders are shown, where only 50Pb/50In solder, 95Pb/5In solder and 93.5Pb/5Sn/1.5Ag solder showed absence of cracks.

As a technological alterative, Knowles (2020) explains that beryllium-copper (BeCu) spring clips are used in some cases to make the contact, replacing solder. However, this is not possible for the majority of applications for several reasons:

- The BeCu clips take up more space than a conventional solder joint (typical diameter of capacitive hole ~25% larger) due the mechanical requirements of the clip.
  - This reduces the values of capacitance that can be achieved in the filter by restricting the available active electrode overlap area;
  - It also means that clips cannot be used where the component dimensions do not allow or where an epoxy seal is used as it will interfere with the electrical and mechanical contact of the clip;
  - Finally, the technique is explained not to provide a 100% grounding ring (a 100% electrical contact through 360º between the conductor pin and the capacitor), so it can reduce EMI performance and allow high frequency (HF) noise to pass through.

Transient Phase Liquid Sintering (TPLS) is also mentioned as a possible candidate substitute for future applications, with improvements in this field of 'soldering' being monitored. TPLS theoretically allows reflow using lead free alloys to achieve a joint with a high secondary reflow temperature. To date, trials with TLPS alloy in these applications have not identified an alloy with a suitable wetting characteristic to allow the jointing material to fill the joint area. (Knowles 2020)

1.3.2. Environmental and health arguments

Knowles does not provide environmental arguments to justify the exemption.

2. Clarification Questions

1. Exemption 7(c)-I of annex III of the RoHS Directive is for "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." Among others it can be understood that lead-glass sealing materials, lead-glass solders or low-melting point (LMP) glass solders can be used to connect between different materials such as metal with ceramic or with glass. Some of the properties mentioned for such materials are similar to those mentioned for solders covered by Ex. 24.
   a. Please explain whether such materials could be applied for applications of relevance to this exemption request or why this would not be suitable.
   Our understand is that exemption 7 (c)-I applies to Lead (Pb) found in "glass or ceramics matrix compound" whereas exemption 24 applies to Lead (Pb) found in "solders for the soldering".
   b. Please clarify whether there is a potential overlap between these exemptions.
   In our understanding, there is no overlap.

2. In relation to Transient Phase Liquid Sintering (TPLS), please specify what materials are being looked at as potential candidates and provide a roadmap for further development stages currently planned.
   Transient Phase Liquid Sintering for interconnects are generally Indium(In)-Silver(Ag) or Copper(Cu)-Tin(S) based. Development of these materials is with the TPLS material manufacturers. No samples provided by the manufactures has demonstrated suitable wetting and flow characteristics to allow the jointing material to fill the joint area. Knowles

continues to monitor the market for direct material replacements of Lead (Pb) based solders.

3. In the annex provided with the application Knowles show test results with other solders, where only 50Pb/50In solder, 95Pb/5In solder and 93.5Pb/5Sn/1.5Ag solder showed suitable performance. The last two are understood to be lead based HMP solders.
   a. Please clarify if such solders would be covered by Ex. 7(a) or by Ex. 24 when used for “soldering to machined through hole discoidal and planar array ceramic multilayer capacitors”;
   Exemption 24 covers typical solders, such as 50Pb/50In solder, 95Pb/5In solder and 93.5Pb/5Sn/1.5Ag solder.
   Note: Exemption 7(a) excludes applications covered by point 24 of the annex from its scope.

   b. Please clarify if these HMP solders can be replaced with 50Pb/50In solder so that higher amounts of Pb are not needed, as long as Ex. 24 remains available for this application. In other words, does the provision of the exemption allow reducing the amount of lead placed on the market through the alternative HMP?
   HMP solders are only used where reflow is required at a lower temperature, commonly known as a “Step soldering” process.
   In applications with “Step soldering”, HMP solders cannot be replaced with 50Pb/50In solder.
   In applications where “Step Soldering” is not required i.e. mechanically mounted, then a low Lead (Pb) alloy such as 50PB/50In is preferred.
   Yes, the provision of the exemption does allow reducing the amount of Lead (Pb) placed on market through the alternative 50Pb/50In solder where “Step Solder” is not required.
   c. If you claim that all three solder types can be placed on the market through exemption 24 please give further detail as to cases where the HMP solders are needed and provide a rough share of the number of Ex. 24 application using HMP solders and the share using the solder with 50% lead content.
   As detailed above in part b. of question 3, HMP solders are needed where there is a “Step Soldering” requirement.
   In the Knowles 2020 portfolio, we have a rough share of,
   a) HMP solder used ~ 10%
   b) HMP solder not used ~ 90%
   This is reflective of our current customers’ requirement for “Step soldering” and may change in the future.

In case parts of your contribution are confidential, please provide your contribution in two versions (public /confidential). Please also note, however, that requested exemptions cannot be granted based on confidential information!

Finally, please do not forget to provide your contact details (Name, Organisation, e-mail and phone number) so that Oeko-Institut can contact you in case there are questions concerning your contribution.

3. Literaturverzeichnis

Knowles (2020): Exemption Request Form. Hg. v. Knowles Precision Devices.