Consultation 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
TPLS	Transient Phase Liquid Sintering

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.

Knowles Precision Devices (Knowles) 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. The applicant has been requested to answer additional questions and to provide additional information, available on the request webpage of the stakeholder consultation (http://rohs.exemptions.oeko.info/index.php?id=365).

For further details, please check the applicant’s exemption request under the link available above.

The objective of this consultation and the review process is to collect and to evaluate information and evidence according to the criteria listed in Art. 5 (1) (a) of Directive 2011/65/EU (RoHS 2), which can be found under:

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32011L0065:EN:NOT

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

If you intend to contribute to the stakeholder consultation, please read the summary of the argumentation provided and answer the questions that follow.

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

1.1. Background

Knowles (2020) requests 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 exemption 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 Knowles or also by other suppliers. (Knowles 2020)

- For electromagnetic interference (EMI) filtered connectors: Knowles estimates 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.

Knowles (2021) later explains that the typical solders used under this exemption include solders such as 50Pb/50In solder, 95Pb/5In solder and 93.5Pb/5Sn/1.5Ag solder. The latter two are considered high melting point solders (HMP) and are not covered in this case by Ex. 7(a) of Annex III[2] which excludes applications covered by Ex. 24 from its scope. The 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 Pb alloy such as 50PB/50In is preferred and subsequently enables a reduction of the amount of Pb placed on market through the alternative 50Pb/50In solder. In the Knowles 2020 portfolio, the allocation nof the use of these solders is roughly, ~ 10% cases in which HMP solder is used and ~ 90% where it is not used.

1.3. Applicant's justification for the requested exemption

Knowles (2020) argues 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

[2] Ex. 7(a), Annex III wording as of 16.3.2021: "Lead in high melting temperature type solders (i.e. lead-based alloys containing 85 % by weight or more lead)"

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)

In a later communication, Knowles (2021) provides further detail as to the materials used in TPLS for interconnects, which are generally Indium(In)-Silver(Ag) or Copper(Cu)-Tin(S) based. Development of these materials is done by the TPLS material manufacturers. As to date, samples provided by such suppliers have not 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.

1.3.2. Environmental and health arguments

Knowles does not provide environmental arguments to justify the exemption.

2. Questions for stakeholders

1. The applicant has requested an exemption, proposing the following wording formulation:

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

   a) Do you agree with the scope of the exemption as proposed by the applicant?

   b) Please suggest an alternative wording and explain your proposal, if you do not agree with the proposed exemption wording.

   c) Please explain why you either support the applicant's request or object to it. To support your views, please provide detailed technical argumentation / evidence in line with the criteria in Art. 5(1)(a) to support your statement.

2. Please consider that the exemption covers among others also LHMP solders. Such solders are also covered by Ex. 7(a), though with an exclusion of Ex. 24 applications to avoid overlaps of these exemptions.

   a) What advantages and disadvantages do you see of maintaining the current exemption formulation?

   b) What advantages and disadvantages do you see of excluding LHMP from Ex. 24 and including LHMP used "for the soldering to machined through hole discoidal and planar array ceramic multilayer capacitors" under Ex. 7(a)?

3. Please provide information concerning possible substitutes or developments that may enable reduction, substitution or elimination, at present or in the future, of *"lead solders for the soldering to machined through hole discoidal and planar array ceramic multilayer capacitors"*;

   a) In this regard, please provide information as to alternatives that may cover part or all of the applicability range of *"lead solders for the soldering to machined through hole discoidal and planar array ceramic multilayer capacitors"*;

   b) Please provide quantitative data as to application specifications to support your view.

4. Please provide information as to research initiatives which are currently looking into the development of possible alternatives for some or all of the application range of *"lead solders for the soldering to machined through hole discoidal and planar array ceramic multilayer capacitors"*.

   a) Please explain what part of the application range is of relevance for such initiatives (in what applications substitution may be possible in the future).

b) Please provide a roadmap of such on-going research (phases that are to be carried out), detailing the current status as well as the estimated time needed for further stages.

5. Please provide any further information and/or data that you think is of importance to substantiate your views.

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. References

Knowles (2020): Exemption Request Form. Knowles Precision Devices (ed.), 10 Jan 2020.

Knowles (2021): Answer to clarification questions regarding Ex. 24 of Annex III. Knowles Precision Devices (ed.), 15 Mar 2021.