Consultation Questionnaire Exemption No. 7c-I (renewal request)

Exemption 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"

- For Publication -

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Answers to the consultation questionnaire Exemption No. 7c-I (following link)
http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Consultation_Questionnaires/Ex-7c-I_Consultation-Questionnaire.pdf

Questions

1. JEITA and Murata et al. requested the renewal of exemption no. 7c-I of Annex III, however, with a slightly changed wording as explained above:

"Electrical and electronic components containing lead in a glass or ceramic other than dielectric ceramic in ***discrete*** *capacitor* ***components****, e.g. piezoelectronic devices, or in a glass or ceramic matrix compound"*

a. Do you agree with the scope and proposed formulation of the exemption as proposed by the applicants?

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.

Answer to question No. 1. :

a. Yes, we agree with the scope and proposed formulation of the exemption as proposed by the applicants.

c. To our opinion, the scope of the exemption 7c-I is not changed or enlarged due to the new formulation. We understand that the new formulation prevents that the term "capacitors" may be mistaken for "electronic capacitance". Consequently we support the rewording.

2. Provided the above proposed change of wording is acceptable, and provided the exemption does not require a further rewording as an outcome of the review, the entire 7c series of exemptions could be simplified, and the scope could be clarified as follows:

7c-I: Electrical and electronic components containing lead in a glass or ceramic, e.g. piezoelectronic devices, or in a glass or ceramic matrix compound. This exemption does not cover the uses of lead in the scope of exemptions 7c-II and 7c-III.

7c-II: Lead in dielectric ceramic in ***discrete*** *capacitor* ***components*** *for a rated voltage of 125 V AC* ***or higher****, or* ***for a rated voltage of*** *250 V DC or higher*[3]

7c-III Lead in dielectric ceramic in discrete capacitor components for a rated voltage of less than 125 V AC, or ***for a rated voltage of*** *less than 250 V DC; Expires on 1 January 2013 and after that date may be used in spare parts for EEE placed on the market before 1 January 2013*

Please explain whether you deem the above rewording of the exemption viable and appropriate.

[3] ZVEI et al. submitted an exemption request for the continuation of exemption 7c-II. ZVEI et al. proposed this rewording of exemption 7c-II in this exemption request in order to clarify the scope.

Answer to question No. 2:

We support the above rewording and see it as viable and appropriate. The scope of the exemption is unchanged and the rewording of 7c-I with the second sentence "*This exemption does not cover the uses of lead in the scope of exemptions 7c-II and 7c-III."* is clear and unambiguous.

3. Please provide information concerning possible substitutes or developments that may enable reduction, substitution or elimination, at present or in the future, of the Pb use in the scope of exemption 7c-I;

a. In this regard, please provide information as to alternatives that may cover part or all of the applicability range of Pb in high melting point solders;

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

Answer to question No. 3:

Information regarding the development of state of the art in the scope of exemption 7c-I is provided under question Number 5.

The use of Pb in high melting point solders is covered - from our understanding - by exemption No. 7(a). Pb containing high melting point solders may be used e.g. to contact

components which are under the scope of 7c-I and which, due to application requirements, afford such a Pb high melting point solder as described in exemption 7(a).

4. So far, the following application fields have been identified for exemption no. 7c-I:

I. PZT ceramics

II. Dielectric ceramics

III. PTC ceramics

IV. Thick-film technology

If the provided information suggests that the scope of Ex. no. 7c-I should be specified, please explain whether the above application specification is adequate, otherwise complete it or propose a different specification.

Answer to question No. 4:

The applications of lead containing ceramics, lead containing glasses, lead containing glass and/or ceramic composites are numerous and varied. Moreover there are many cases in which it may simultaneously correspond to different applications. Therefore we support the views of the applicants that it is impossible to provide a complete list of all applications. We refer for illustration to the list of application examples (which is not exhaustive) given on page 2 in the answer of the following applicants:
http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_7_c_-I/Murata/RoHS_7c-I_Murata__1st_Questionnaire_answers_final_20Aug.pdf

We are concerned that the above given application fields may be misunderstood and may cover only partially the scope of the exemption 7c-I:

- The term “PZT” means “lead zirconate titanate” and is the name of families of material compositions with the (simplified) chemical compositions $Pb[Zr_xTi_{1-x}]O_3$ ($0 \leq x \leq 1$). “PZT” serves a wide range of applications which functionalities are based on a physical e.g. dielectric, piezoelectric, pyroelectric, ferroelectric, or semiconductor effect.
- The term “PTC” means “positive temperature coefficient” and describes a functionality of the material. “PTC” ceramic is a part of semiconductor ceramics.
- The term “thick-film” describes rather a geometry and/or technology factor and cannot be considered as an application field. The lead containing material is in the case of a “thick film” applied on a substrate with a thickness varying e.g. from a few µm to mm. The same lead containing material can be used – taking technological and processing conditions into account – as thin films (few nms to µm), as bulk or massive material or as a composite material.
- In the above given enumeration, glass, glass frits, glass-ceramic matrix compounds and glass-ceramic materials are omitted.

We understand the above proposed specification as a kind of clustering or guidance which is helpful to structure and review the development of the state of the art. This clustering may however not describe the scope of the exemption exhaustively.

According to the development of state of the art (see also questions 5 and 6), we do not see that any of these application fields can be replaced by a lead free alternative at present and in the foreseeable future.
That´s why we support the request for the renewal of exemption 7c-I with the actual wording or with the proposed rewording given in question 2) : *“7c-I: Electrical and electronic components containing lead in a glass or ceramic, e.g. piezoelectronic devices, or in a glass*

or ceramic matrix compound. This exemption does not cover the uses of lead in the scope of exemptions 7c-II and 7c-III", for product categories 1 to 7, 10 and 11 of Annex I at least until the next revision (21 July, 2021).
Moreover we would like to emphasize that the scope of exemption 7c-I is also of technical relevance for category 8 (medical devices and equipment) category 9 (control and monitoring equipment) and other kind of applications like large industrial tools, which are currently exempted from ROHS compliance.
For all of these categories, the validity of the exemption 7c-I may be required beyond the given timeframe, since it is not foreseeable yet, that the technical functionalities given by materials covered by exemption 7c-I could be obtain by lead free alternatives.

5. 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 Pb in Ex. no. 7c-I.

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.

Answer to question No. 5:

a. Question 5a:

Bosch continuously reviews the possibility of alternative lead-free piezoelectric materials and has done internal and external developments towards lead free materials in the last 10 years (e.g. funded BMBF-projects DELLEAD Germany, REALMAK Germany). Moreover we regularly ask for lead-free samples and musters by research institutes and material suppliers we can test under relevant industrial and application conditions.
We advise of following selected literature to get an overview of the research initiatives and developments on the topic lead-free piezoelectric ceramics during the last 10 years.

2015	Jürgen Rödel, Kyle G. Webber, Robert Dittmer, Wook Jo, Masahiko Kimura, Dragan Damjanovic, Transferring lead-free piezoelectric ceramics into application, Journal of the European Ceramic Society, Volume 35, Issue 6, June 2015, Pages 1659-1681, ISSN 0955-2219, (http://www.sciencedirect.com/science/article/pii/S0955221914006700)
2013	Jing-Feng Li, Ke Wang, Fang-Yuan Zhu, Li-Qian Cheng, Fang-Zhou Yao, (K, Na)NbO3-Based Lead-Free Piezoceramics: Fundamental Aspects, Processing Technologies, and Remaining Challenges, Review, Journal of the American Ceramic Society, Volume 96, Issue 12, pages 3677–3696 http://onlinelibrary.wiley.com/doi/10.1111/jace.12715/abstract
2012	Shashank Priya,Sahn Nahm; Lead-Free Piezoelectrics (book), ISBN: 978-1-4419-9597-1 (Print) 978-1-4419-9598-8 (Online) http://rd.springer.com/book/10.1007%2F978-1-4419-9598-8
2011	YI-QING LU, YONG-XIANG LI, A REVIEW ON LEAD-FREE PIEZOELECTRIC CERAMICS STUDIES IN CHINA, Journal of Advanced Dielectrics, Volume: 1, Issue: 3(2011) pp. 269-288 http://www.worldscientific.com/doi/pdfplus/10.1142/S2010135X11000409
2010	D. Damjanovic, N. Klein, J. Li, V. Porokhonskyy , WHAT CAN BE EXPECTED FROM LEAD-FREE PIEZOELECTRIC MATERIALS?, Functional Materials Letters, Vol. 3, No. 1 (2010) 5–13 http://infoscience.epfl.ch/record/143651/files/Functional%20Materials%20Letters%203%20%282010%29%205-13.pdf
2009	J. Rödel, W. Jo, K. T. P. Seifert, E.-M. Anton, T. Granzow, and D. Damjanovic, "Perspective on the Development of Lead-free Piezoceramics," Journal of the American Ceramic Society, vol. 92, no. 6, pp. 1153–1177, Jun. 2009. http://onlinelibrary.wiley.com/doi/10.1111/j.1551-2916.2009.03061.x/abstract

	Jürgen Rödel, Alain B.N. Kounga, Marion Weissenberger-Eibl, Daniel Koch, Antje Bierwisch, Wolfgang Rossner, Michael J. Hoffmann, Robert Danzer, Gerhard Schneider, Development of a roadmap for advanced ceramics: 2010–2025, Journal of the European Ceramic Society, Volume 29, Issue 9, June 2009, Pages 1549-1560 http://www.sciencedirect.com/science/article/pii/S0955221908005761 P. K. Panda, Review: environmental friendly lead-free piezoelectric materials, Journal of Materials Science, Volume 44, Number 19 / Oktober 2009 http://rd.springer.com/article/10.1007%2Fs10853-009-3643-0#

We advise also for the category “lead containing ceramics and piezoceramics” of the review documents and summary given by the applicants JEITA et al. and Murata et al. e.g. in annex 1 and annex 2 of the following document:
http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_7_c_-I/Murata/7c-I_RoHS_V_Application_Form_7c1_20140116_combined_final.pdf

We recognize a great effort done in the last years towards the development of lead free alternatives. However we evaluate that none of the potential lead-free candidates in research status up to now matches the application requirements and reaches the properties level met by PZT which is the absolute necessary level for e.g. Bosch applications. We do not see a potential breakthrough in lead-free substitutes in a foreseeable future since fundamental problems, like mandatory improvements in properties, reproducibility, upscaling for relevant industrial mass production, evaluation and understanding of material properties under relevant application conditions (e.g. temperature stability, electro mechanical behavior under stress and thermal shock, aging and fatigue behavior among others) still have to be resolved.

Consequently we support the request of the applicants to extend the exemption 7c-I at least until the next revision (21 July, 2021) for product categories 1 to 11.

Bosch is concerned to supply the best technical, technological and sustainable solutions taking into account strict environmental criteria and socio-economical responsibilities, for present and future products.

We consider piezoelectric ceramics as an enabling technology since their outstanding physical properties. In respect thereof piezoelectric ceramics can serve sensor and actuator solutions for present and future products with great functional advantages like e.g. sharp control windows and fast reaction time, high signal sensitivity, high accuracy, miniaturization etc….These advantages are not achievable with alternative technologies. Application areas among others are e.g. piezoelectric sensors and actuators for microelectronics (MEMS), piezoelectric transducers for consumer, industrial and medical applications, energy harvesting, sensors and actuators (positioning, piezo-motors, ultrasonic transducers) for consumer, industrial and medical applications. All of these application areas rely on lead based piezoelectric ceramics like PZT and enable technical developments towards safety applications, medical and health care applications, to avoid batteries in some energy harvesting applications or improve the use of resources (e.g. PZT actuators to reduce fuel consumption and CO2 emission, ultrasonic cleaning: minimizing of detergents, ultrasonic welding: process stability and safety, PZT based level sensors, pressure sensors in the industry for safety etc…..)

b. Question 5b:

We support the view and approach given e.g. by the applicant Murata et al. on pages A-2-4, A-2-5 and A-2-6 as well as in the Dechema roadmap[1] from 2009 which still has validity.
http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_7_c_-I/Murata/7c-I_RoHS_V_Application_Form_7c1_20140116_combined_final.pdf

[1] Jürgen Rödel, Alain B.N. Kounga, Marion Weissenberger-Eibl, Daniel Koch, Antje Bierwisch, Wolfgang Rossner, Michael J. Hoffmann, Robert Danzer, Gerhard Schneider, Development of a roadmap for advanced ceramics: 2010–2025, Journal of the European Ceramic Society, Volume 29, Issue 9, June 2009, Pages 1549-1560

There are no prospects concerning the technical scope of exemption 7c-I for a comprehensive substitution to "lead-free" ceramics at least until the next revision (21. July 2021).

6. Are there any other aspects you deem to be of importance for the requested exemption?

Up to now we do not see in a foreseeable future any lead-free alternatives for the technical scope of exemption 7c-I. We see the technical advantages that piezoceramics have as an enabling technology that´s why we will further support research on lead-free alternatives in the future and are willing to test lead-free samples and compositions under relevant components and applications requirements.

Two big lead-free material classes have been investigated in the last 10 years: the so called alkali niobate (KNN) based family as well as the bismuth sodium titanate based family (BNT).

For these two material classes as well as for future research directions on the topic of lead-free piezoelectric ceramics, we still have the following concerns, which also should be taken into account when evaluating potential lead-free substitutes comparing to lead-based piezoceramics like PZT:

1. Resources: use of critical or conflict metals:

Reports on critical resources can be taken from the following links:
EU: http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical/index_en.htm
DERA: http://www.deutsche-rohstoffagentur.de/DERA/DE/Home/dra_node.html

- For alkali niobate based material class: compositions are based on an lithium-sodium-potassium-niob-tantal chemistry, with compositions containing also antimony:
  - Tantal is categorized as a conflict metal by the Dodd-Franck act. Consequently the source of the tantal used in potential PZT substitutes should be well known and the political and socio-economical responsibilities should be taken into account.
  - Niob as well as antimony are considered by the EU as critical raw materials with high supply risks. KNN contain 50-55% niob. Niob is expected to have one of the strongest annual demand growths to 2020 among the critical raw materials.
  - Antimony may also be an issue due to its toxicity

  Consequently, the supply risks, the consequences on environment and society as well as the European industrial competitiveness should be taken into account by assessing the suitability of the KNN material class toward PZT as a potential future candidate for lead-free applications. This will require in depth understanding of supply chains and of potential future availability, which is nevertheless not the case at the moment.

- For bismuth-based compositions: bismuth is mostly a byproduct e.g. from lead. Here also is a better understanding about the long time availability and supply chain of Bismuth a necessity.

2. Environmental impacts:

At the moment, there is little knowledge about the overall environmental impact on potential lead-free substitutes compared to PZT. These points should also be taken into account by assessing potential alternative candidates compared to PZT:

- Environmental footprint of potential substitutes (like bismuth, niob, tantal,...) from extraction and purification of raw materials to end of life.
- Processing conditions: current PZT production is mostly based on water processing. KNN synthesis imposes the use of organic solvents due to the use of alkali elements. Consequently higher efforts and risks in health and environment protection should be taken into account.

3. Health impact:

The finished product PZT does not contain lead oxide and has a much lower solubility than lead oxide. The PZT components are solid parts and no dust or abrasion is present in the finished products. The PZT-components are mostly encapsulated or packaged, so that the end user does not have a direct contact with the material and exposure is therefore excluded.

The processing of PZT is done under controlled worker conditions since years. Regulations exist and are observed (e.g. Wasserhaushaltsgesetz, Verordnung über Anlagen zum Umgang mit wassergefährdenden Stoffen, Bundes-Immissionsschutzgesetz, Technische Anleitung zur Reinhaltung der Luft). The production does regularly check and maintain its equipment and the legal documents are on site.