Exemption Request Form - Exemption #7(c)-II

Date of submission: **19 December 2019**[1]

1. Name and contact details of applicant:

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On behalf of the Company/Business organisations/Business associations listed below participants in the **RoHS Umbrella Industry Project ("the Umbrella Project")**:

American Chamber of Commerce to the European Union (AmCham EU) EU Transparency Register ID number: 5265780509-97	ANIE Federation EU Transparency Register ID number: 74070773644-23	Communications and Information Network Association of Japan (CIAJ)	DIGITALEUROPE (DE) EU Transparency Register ID number: 64270747023-20
European Association of Internal Combustion Engine Manufacturers (EUROMOT) EU Transparency Register ID number: 6284937371-73	European Ceramic Industry Association (Cerame-Unie) EU Transparency Register ID number: 79465004946-12	European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry (COCIR) EU Transparency Register ID number: 05366537746-69	European Copper Institute (ECI) EU Transparency Register ID number: 04134171823-87

[1] Revised on 31 January 2020

European Garden Machinery Industry Federation (EGMF) EU Transparency Register ID number: 82669082072-33	European Partnership for Energy and the Environment (EPEE) EU Transparency Register ID number: 22276738915-67	European Passive Components Industry Association (EPCIA) EU Transparency Register ID number: 22092908193-23	The European Semiconductor Industry Association (ESIA) is an industry association working under the umbrella and legal entity of the European Electronic Component Manufacturers Association (EECA) EU Transparency Register ID number: 22092908193-23
The European Steel Association (EUROFER) EU Transparency Register ID number: 93038071152-83	GAMBICA - The UK Association for Instrumentation, Control, Automation & Laboratory Technology	Information Technology Industry Council (ITI) EU Transparency Register ID number: 061601915428-87	Interconnect Technology Suppliers Association (ITSA)
IPC – Association Connecting Electronics Industries EU Transparency Register ID number: 390331424747-18	Japan Analytical Instruments Manufacturers' Association (JAIMA)	Japan Business Council in Europe (JBCE) EU Transparency Register ID number: 68368571120-55	Japan Business Machine and Information System Industries Association (JBMIA)
Japan Electric Measuring Instruments Manufacturers' Association (JEMIMA)	Japan Electrical Manufacturers' Association (JEMA)	Japan Electronics and Information Technology Industries Association (JEITA)	Japan Federation of Medical Devices Associations (JFMDA)
Japan Inspection Instruments Manufacturers' Association (JIMA)	Japan Lighting Manufacturers Association (JLMA)	Japan Measuring Instruments Federation (JMIF)	Japan Medical Imaging and Radiological Systems Industries Association (JIRA)
Korea Electronics Association (KEA)	Knowles Precision Devices	LightingEurope (LE) EU Transparency Register ID number: 29789243712-03	MedTech Europe EU Transparency Register ID number: 433743725252-26

Nippon Electric Control Equipment Industries Association (NECA)	Photonics France	SPECTARIS - German Hightech Industry Association EU Transparency Register ID number: 55587639351-53	Wirtschaftsverband Industrieller Unternehmen Baden e.V. (wvib)
ZVEI - German Electrical and Electronic Manufacturers´ Association EU Transparency Register ID number: 94770746469-09			

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2. Reason for application:

Please indicate where relevant:

☐ Request for new exemption in:

☐ Request for amendment of existing exemption in

☒ Request for extension of existing exemption in

☐ Request for deletion of existing exemption in:

☐ Provision of information referring to an existing specific exemption in:

☒ Annex III ☐ Annex IV

No. of exemption in Annex III or IV where applicable: 7(c)-II

Proposed or existing wording: Existing wording **Lead in dielectric ceramic in capacitors for a rated voltage of 125 V AC or 250 V DC or higher**

Duration where applicable:

We apply for renewal of this exemption for the categories marked in section 4 further below for the respective maximum validity periods foreseen in the RoHS2 Directive, as amended. For these categories, the validity of this exemption may be required beyond those timeframes. Although applications in this exemption renewal request may be relevant to other categories not marked in section 4 further below, this renewal request does not address those categories.

☐ Other: _____

3. Summary of the exemption request / revocation request

We investigated the substitution of lead in lead-containing dielectric ceramic in discrete ceramic capacitor components for a rated voltage of 125V AC or higher, or for a rated voltage of 250V DC or higher before the last review and have continued the investigation after 2015. However, a technical alternative to allow substitution has not been found up to the present day and there are no prospects of finding it within the foreseeable future. The reason for the exemption presented by the stakeholders in 2015 is still valid. Consequently, it is necessary to extend the exemption

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4. Technical description of the exemption request / revocation request

(A) Description of the concerned application:

1. To which EEE is the exemption request/information relevant?

   Name of applications or products:

   All types of electrical and electronic equipment (EEE) with the following providing a non-exhaustive list: Large and small household appliances; IT and telecommunications equipment; consumer equipment; lighting equipment; electrical and electronic tools; toys, leisure and sports equipment; medical devices; monitoring and control instruments (including industrial monitoring and control instruments); automatic dispensers and other .

a. List of relevant categories: (mark more than one where applicable)

☒ 1	☒ 7
☒ 2	☒ 8
☒ 3	☒ 9
☒ 4	☒ 10
☒ 5	☐ 11
☒ 6	

b. Please specify if application is in use in other categories to which the exemption request does not refer: <u>Applications in this exemption renewal request may be relevant to categories not marked above.</u>

c. Please specify for equipment of category 8 and 9:

   The requested exemption will be applied in

   ☒ monitoring and control instruments in industry

   ☒ in-vitro diagnostics

   ☒ other medical devices or other monitoring and control instruments than those in industry

2. Which of the six substances is in use in the application/product?

   (Indicate more than one where applicable)

   ☒ Pb ☐ Cd ☐ Hg ☐ Cr-VI ☐ PBB ☐ PBDE

3. Function of the substance:
   Control of electrical properties, in particular capacitance and dielectric loss.

4. Content of substance in homogeneous material (%weight): 0,1- 60 wt%

5. Amount of substance entering the EU market annually through application for which the exemption is requested: **7 t**

   Please supply information and calculations to support stated figure.

   Worldwide amount of lead used in 7(c)-II related application was extracted based on the annual worldwide shipment volume of ceramic capacitors applicable to 7(c)-II shipped by representative electrical and electronic component manufacturers in Japan and Europe.
   As a result, the market volume of lead was calculated as 33 ton. Next, the amount was multiplied by the global GDP ratio of Europe (22%) to calculate the amount of exemption 7(c)-II lead to be placed on the EU market.

6. Name of material/component:
   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.

7. Environmental Assessment: _____
   LCA: ☐ Yes
   ☒ No

(B) In which material and/or component is the RoHS-regulated substance used, for which you request the exemption or its revocation? What is the function of this material or component?

Lead-containing dielectric ceramic in discrete ceramic capacitors for a rated voltage of 125 V AC or higher, or for a rated voltage of 250 V DC or higher. Discrete ceramic capacitors bear the capability of storing and releasing electric charges (electrostatic capacitance) and are incorporated into high voltage circuits in a wide variety of electrical and electronic equipment.
Discrete ceramic high voltage capacitors are used in various electronic applications in, for example, the following markets:

- Social infrastructure system, industry automation, oil and mineral exploration, power conversion, high power supply, telecommunication networks and medical...etc.

Typical applications are:

- power electronic inverters, pulsed power electronics, pulse forming networks, capacitive discharge units, transient high voltage suppression, magnetization/demagnetization devices, plasma generators, high-energy flash lamps, radio frequency interference suppression and electrical safety...etc.

The above are non-exhaustive list indicating representative examples only to partially showing markets and applications in which the requirement for the exemption is applicable.

Ceramic capacitors are used in electrical circuits to store electrical energy. Those types that are covered by exemption 7c-II have a range of specific characteristics necessary for the applications in which they are used. This is explained below.

Discrete ceramic high voltage capacitors are used in ALL types of markets and applications and thus it is impossible to mention all of them.

(C) What are the particular characteristics and functions of the RoHS-regulated substance that require its use in this material or component?

The major trend within the electrical and electronic industry is miniaturization, which is partly due to low voltage rating, and low power (e.g. battery power consumer devices).. However, for the high voltage rating ceramic capacitors used in the types of circuits in applications listed above, other optimization parameters are often required, as for example the need for high capacitance at high voltage and high power.
The function of lead in the dielectric ceramic is to obtain:
(a) High dielectric constant at high operating voltage

(b) High energy storage capability (also at high temperatures),
(c) Low leakage at high voltage and high temperatures,
(d) Low loss at high current, frequency, and temperatures.

These are all parameters frequently called upon by design engineers in meeting technical requirements.
Lead-containing dielectric ceramic has the outstanding feature of stably bringing out the functions shown in (a)-(d). Even for use at the condition of a rated voltage of 125 V AC or higher, or 250 V DC or higher, lead elimination can be achieved in practice for some partial applications, nevertheless in applications requiring all of the functions (a)-(d) the addition of lead is indispensable.

Efforts for Substitution of Lead in the Scope of Exemption 7(c)-II

Even before the adoption of the RoHS Directive in 2003, industry has endeavoured to find substitutes for lead in "glass, ceramic or glass or ceramic matrix compounds" for over 20 years. Industry itself (as well as academia) has proactively promoted these efforts for the following reasons:

1) Corporate Social Responsibility of businesses to accomplish the stated goal of the RoHS Directive of "contributing to the protection of human health and the environment",

2) Businesses which develop substitutes can, through their scientific and technological innovation, gain strong support from the market and earn commercial profits as first-movers to supply products compliant to the revision of the RoHS Directive exemption triggered by them.

It was through such efforts that industry managed to substitute an estimate of 99% "lead in dielectric ceramic in capacitors for a rated voltage of less than 125 V AC or 250 V DC" by lead free alternatives.

This was a significant achievement concerning adaptation to scientific and technological progress, mirrored by the expiration of exemption 7(c)-III as set up by Commission Decision 2010/571/EU.

However, ever since that achievement took place, further substitution of lead in dielectric ceramic in capacitors for a rated voltage of 125 V AC or 250 V DC or higher could not be accomplished in the scope of exemption 7(c)-II. Substitution of lead is not easy on a practical level since the intended properties of lead-containing dielectric ceramics for high voltage capacitor applications are closely linked to the physical and electronic structural properties of elemental lead.

In principle the cases reviewed in "MRS Bulletin, 43 (8). pp. 581-587, A. J. Bell and O. Deubzer" can be referenced from a perspective outside the industry concerning lead-free piezoelectric ceramics in the scope of exemption 7(c)-I and applies to 7(c) II as well.

There are lead-free dielectric ceramics for high voltage applications that have scientific and pure technical potential, however their physical properties such as dielectric properties and low energy loss properties, and their temperature dependence will be considerably different, so industry still has to find applicable substitutes which can be used in practice.

Given the above, it was concluded in the last renewal request that exemption 7(c)-II should be extended and the situation has not changed since then.

Efforts to substitute lead in the scope of exemption 7(c)-II are less active compared to those on the identification of lead-free substitutes to PZT, and industry has not been able to find cases proposing lead-free substitute materials in published papers available.

For this reason, device engineers with products that incorporate high-voltage capacitors will not use lead-free material that have no practical applicability in the evaluation of their devices, and the result is that no viable substitution efforts can be implemented.

Industry has conducted its search for substitution research cases focusing on information from public documents, however only limited examples have been published since the last renewal request in 2015.

There are numerous cases of unsuccessful research and development within businesses. However, they are rarely made available to the public and are usually treated as confidential information, as they cannot become Intellectual Property (IP) of the business by the issuance of patents. Consequentially if they are disclosed, they may end up as knowledge that can be used by competitors.

For this reason, it can be said that the investment and efforts put forth by industry to substitute lead in exemption 7(c)-II have been underestimated when seen from the viewpoint of publically available information.

Illustrative Cases of Lead-Free Substitution Research by Industry

As described in the introduction section Industry has been undertaking and investing in work to identify a technical alternative. The following are illustrative cases on substitution research of lead-containing dielectric ceramics for high-voltage capacitor applications.*[1]

Industry is also ready to provide confidential information directly to the consultant concerning details not disclosed in this renewal request.*[2]

*[1]. *Please note that confidential information cannot be disclosed in this renewal request form (as it is would be necessary to reach a consensus among the relevant stakeholders as well as process IP information).*

*[2]. *If necessary, please indicate for which cases confidential information should be provided. Please be aware that an estimated period of about 2 weeks should be necessary for processing an information request.*

As is well known, capacitors are indispensable constituent elements of circuits in EEE and they are equally important for high-voltage circuits as well. Thus, as it will be explained in detail in the next pages, capacitors used in high-voltage circuits must achieve high capacitance while also satisfying all required high-voltage resistance characteristics. In lead-containing dielectric ceramics the dielectric constant can be increased while satisfying all high-voltage withstand characteristics, so high-voltage capacitors with high capacitance that can be used under high voltage conditions, where the rated voltage is 125V AC or higher or 250V DC higher, can be obtained.

In its attempts to obtain lead-free dielectric ceramic materials with good high-voltage withstand characteristics, industry has investigated the addition of zirconium (an element with the effect of increasing high-voltage withstand characteristics) to strontium titanate ceramics (with high dielectric constant) and barium titanate ceramics (that can produce high dielectric characteristics under low voltage conditions), however for both cases the dielectric constant decreased as the high-voltage withstand characteristics were improved and capacitance obtained during operation was less than one-tenth that of the existing products. Since high-voltage withstand and high dielectric characteristics necessary for high-voltage circuits cannot be simultaneously achieved, lead-free dielectric ceramics for high-voltage applications could not be put into practical use.

If capacitors are manufactured using the materials at the research stage described above and applied to high-voltage circuits, the size of the components will have to be increased by a factor of 10 or more to that of the existing ones, or capacitors will have to be configured in parallel in order to ensure the necessary capacitance for the entire system. As a result the size of the equipment will largely increase. Increasing the size of equipment causes an increase in environmental impact due to energy and resource consumption, as described later, and in manifold cases will be technically not feasible.

It must be noted that it is impossible in practice to apply capacitors that do not satisfy the required high-voltage withstand performance to the design of high-voltage devices since the equipment may be destroyed by heat generation or electrostriction.

The main applications of high-voltage capacitors include power supply devices and protection devices which are used in almost all types of EEE. If, in order to compensate for the degradation of the required properties, these circuits which have become smaller, lighter and more efficient with the advancement of higher functionality in EEE need to be made larger, auxiliary functions such as cooling mechanisms need to be attached to the equipment, etc. the equipment itself will also need to become larger and size and thickness reduction of EEE will not be achievable any longer. As a consequence, not only the achievement of portable, handheld equipment will become difficult, but this will also cause an increase of the environmental load due to the consumption of energy and resources related to the production and disposal of larger equipment.

Based on these substitution research cases and their results, industry concluded that lead-free materials have not achieved a comprehensive substitution level for the lead-containing materials in the scope of 7(c)-II.

Because lead-free dielectric ceramics for high-voltage capacitor applications with sufficient functionality, high reliability and low environmental impact are not available to device manufacturing businesses, industry considers that the efforts still necessary in order to substitute all devices incorporating lead in the scope of 7(c)-II will be many times what has already been spent in materials research.

Furthermore, as shown in the illustrative cases below, lead-free materials generally lack characteristics compared to lead-containing materials, so it is difficult to ensure reliability of the devices that use them. As explained in the next section, the negative impact caused by these substitute materials on the environment, human health and safety of consumers is likely to exceed the overall benefits brought to environment, human health and safety of consumers.

In the following section, we describe the required properties of EEE obtained by lead-containing dielectric ceramics for high-voltage capacitor applications.

Specific Properties of Lead in Dielectric Ceramics

As explained in our previous renewal request, lead-containing dielectric ceramics can form crystal structures with a particular distortion in their atomic arrangement under a broad range of usage conditions and, concerning electrical functions, they have the remarkable characteristic to stably achieve dielectric properties with high efficiency even when high voltage is applied.

Moreover, it can be densely sintered under a wide range of firing conditions.

Lead-containing dielectric ceramics have a high dielectric constant sufficient to achieve the necessary capacitance for devices even when under high voltage conditions (rated voltage of 125V AC or higher or 250V DC or higher). They also make EEE operate normally with high reliability due to their low energy loss and thermal properties under the various usage conditions. Furthermore, these properties of lead-containing dielectric ceramics can contribute to energy and resource saving along the whole lifecycle of the EEE. Looking at it another way, the various properties of dielectric ceramics depend strongly on their crystal structure which is obtained by the presence of **lead**. So it can be said that, since elements other than lead have different properties such as valence, ionic radius, etc., their crystal structures are also different and properties indispensable for EEE cannot be achieved as intended. The need for these properties is common to all EEE and more than one property is often required at the same time. Therefore, high-voltage capacitors using lead-containing dielectric ceramics are indispensable for almost all

EEE that incorporate devices with rated voltage of 125V AC or higher or 250V DC or higher and substitution is not possible.

In order to explain the necessity of high-voltage capacitors using lead-containing dielectric ceramics in EEE, and the status of investigation of substitutes to high-voltage capacitors using lead-free dielectric ceramics, examples for EEE are introduced below concerning each typical property of dielectric ceramics required for the operation of EEE. (It must be noted that the examples given below do not exhaustively cover all applications of lead-containing dielectric ceramics, but rather merely a small selected part thereof.)

Low Energy Loss Properties

When a high voltage is applied to dielectric ceramics, electrical energy is lost as heat due to thermal vibration of the constituent molecules, however energy loss can be suppressed with lead-containing dielectric ceramic materials.

In comparison, for capacitors using lead-free dielectric ceramics, when a high voltage is applied a large amount of heat is generated so that the energy loss is large and the capacitors become unstable due to the high temperatures achieved inside the EEE and, in the worst case, those capacitors will fail (e.g. the ceramic cracks) and lose their functions.

In addition, when high-frequency alternating currents are applied to lead-free dielectric ceramic materials the crystal structure of the constituent molecules changes due to sudden changes in short intervals of the direction in which electric charges are applied and the influence of energy loss due to thermal vibrations is larger than that of capacitors using lead-containing dielectric ceramic material.

In recent years, with the improvement of data processing speed and the enlargement of data transmission bandwidths, frequency bands of signals used in EEE have shifted to higher frequencies.
If the electrical energy loss is large for EEE where high-frequency signal devices are used such as telecommunications/broadcasting equipment or information technology equipment, the signals will be attenuated and will not be correctly transmitted, so product design of the equipment becomes impossible.
Consequently, substitution to lead-free dielectric ceramics is not possible in practice.

Thermal Properties

High-voltage devices operate under higher temperature conditions due to Joule heating caused by the above-described energy losses and electrical resistance in the circuits. The capacitance of dielectric ceramics varies with temperature changes, and above a certain temperature (Curie temperature) those ceramics lose their electrical function (capacitance). In this regard, lead-containing dielectric ceramics present both a small capacitance variation with temperature changes and high Curie temperatures, which enables them to operate with stability even in high temperature conditions exceeding 130℃.

In contrast to this, for dielectric ceramics that use lead-free materials it is difficult to increase their Curie temperature while keeping high capacitance, so it is not possible to design high-voltage devices for high temperature usage conditions in practice.

EEE requiring a large current and a high voltage at start-up incorporate capacitors using lead-containing dielectric ceramics that can withstand high temperatures and high voltages.

If these capacitors are substituted by capacitors using lead-free dielectric ceramics, since the latter have low Curie temperatures, the capacitors will lose their functions due to high temperatures at start-up and the equipment will become unable to start up. For this reason, it is not possible to put products with lead-free dielectric ceramics into practical uses under the above circumstances.

Capacitance

Dielectric ceramics generally have piezoelectric properties, so when an electric charge is applied, electrical energy is converted into mechanical deformation (electrostriction), and a mechanical load is applied onto the device. Lead-free dielectric ceramics exhibit large electrostriction when a high voltage is applied and since a large mechanical load due to oscillation is applied onto the device, EEE incorporating such material becomes destabilized and in the worst case loses its functions.

Since capacitance is directly proportional to electrostriction, capacitors for low voltage applications using lead-free dielectric ceramics have high capacitance but also have high electrostriction, so they cannot be incorporated into high-voltage devices. In comparison, lead-containing dielectric ceramic materials control and suppress electrostriction, so they can be incorporated into high-voltage devices even if they have high capacitance.

The use of strontium titanate has been investigated as a potential lead-free dielectric ceramics substitute, since it has small energy loss and no electrostriction. However, as described in the previous section as an illustrative case of lead-free substitution, it cannot satisfy the required functions due to its too small capacitance (less than one tenth that of lead-added barium titanate). In other words, it is impossible in practice to design high-voltage devices incorporating capacitors that use lead-free dielectric ceramic material.

Power supply devices are incorporated in most EEE, and in order to stabilize the electrical power output, capacitors must be incorporated in the power supply devices. Power supply devices using commercial power supplies for input usually require high voltage devices in whole or partially, so high voltage capacitors using lead-containing dielectric ceramic materials are indispensable for such applications.

When substituted by capacitors using lead-free dielectric ceramics, for example, in household EEE, the power output of the attached AC adapters or the built-in power supply devices becomes unstable leading to equipment failure or malfunction. Similarly, if the power output of power supply devices of EEE for industrial use becomes unstable, the quality and reliability of the manufactured product will be largely impaired by equipment failure or malfunction. In addition, if power output of battery chargers becomes unstable, it may cause accidents such as fires or explosion of the battery.

As described above, if high voltage capacitors using lead-containing dielectric ceramic materials can no longer be used, the operation of EEE becomes unstable and reliability cannot be ensured. According with the examples above, if capacitors with rated voltages of 125V AC or higher or 250V DC or higher using lead-containing dielectric ceramics in the scope of exemption 7(c)-II are substituted by capacitors using lead-free dielectric ceramics, since the necessary properties for the operation of EEE cannot be achieved and product design becomes impossible, there are no technical prospects for comprehensively eliminating lead.

Reduction of Resource/Energy Consumption along the Product Lifecycle

The advantages of lead-containing dielectric ceramics include not only achieving the properties required for the operation of EEE, but also contributing to the saving of energy and resources throughout the product lifecycle.

Saving of Energy in the Production Process

As lead-containing dielectric ceramics can be sintered even at low temperatures, the temperature of the firing furnace can be lowered and the energy necessary for production can be decreased.

As sintering temperatures of lead-free dielectric ceramics are high, energy consumption in the production process increases with the substitution. In comparison to the typical sintering temperature of around 1300℃ for dielectric ceramics using lead-free materials, the typical sintering temperature of lead-containing dielectric ceramics is generally around 1000℃.

Since the sintering temperature of lead-containing dielectric ceramics is several hundred degrees lower, energy consumption can be greatly reduced for production in the EU and furthermore, similar effects can be obtained in production outside the EU, contributing to the reduction of CO_2 emissions on an international scale.

The table below shows a comparison of the production energy of lead-containing dielectric ceramics and production energy assuming substitution to lead-free dielectric ceramic in the EU/World.

	Amount Placed on the Market (M pcs)		Lead/Lead-free Process	Power Consumption Amount/Mwh		
	World	Europe		Per M pcs	World	Europe
Exemption 7(c)-II High-voltage ceramic capacitors	1000	220	Lead-containing ceramics process	2,4	2400	530
			Lead-free ceramics process	3,4	3400	750

The power consumption amount in the production process (sintering process) was estimated based on the amount of high-voltage ceramic capacitors using lead-containing dielectric ceramics in the scope of Exemption 7(c)-II placed on the market in 2018.

As there is no technical prospect of comprehensively eliminating lead from ceramic capacitors with rated voltage of 125V AC or higher or 250V DC or higher, the table above is merely a hypothetical estimation.

<u>Efficient Utilization of Resources</u>

High-voltage capacitors using lead-containing dielectric ceramics can ensure high capacitance under high voltage usage conditions even if they are reduced in size and thickness or surface mounted.
This makes it possible to reduce the size and thickness, so that the present mainstream surface-mount type high-voltage capacitors can be achieved. Moreover, size reduction is obtained not only for the high-voltage capacitor itself, but also for boards and housings due to the reduction of the mounting area/volume, thereby reducing the use and disposal amounts of resources throughout the lifecycle of the EEE.

If ceramic capacitors are not able to be miniaturised due to the dielectric constant of the ceramic being much lower than is possible with lead-based ceramics, the size of EEE will be increased with a resultant increase in the quantity of WEEE generated in the future in the EU

As shown in the above examples, energy and resource consumption during the product lifecycle is larger for high-voltage capacitors using lead-free substitute materials when compared with high-voltage capacitors using lead-containing dielectric ceramics. From this perspective, elimination of lead from high-voltage capacitors incorporated in EEE is not appropriate as it would rather increase environmental load and cause negative impacts to society.

Conclusion: Use and Necessity of Lead in Exemption 7(c)-II

Lead-containing dielectric ceramics are necessary to achieve the critical properties of high-voltage capacitors, so they are incorporated in high voltage parts that undergo voltages of 125V AC or higher or 250V DC or higher of circuits in all types of EEE. For this reason it is not possible to specify categories and items of all EEE in which high-voltage capacitors of the technical scope of exemption 7(c)-II are incorporated.

As shown in the section "Illustrative Cases of Lead-Free Substitution Research by Industry in the Scope of 7(c)-II", even if industry succeeds in the substitution of a specific E&E component in a device to a lead-free one, the negative impact of substitution is estimated to outweigh the benefits. That is to say that if the exempted applications in the technical scope of 7(c)-II are revoked it will not be possible to maintain the performance and reliability of all EEE and resource and energy consumption as well as waste amounts will increase.

According to the above described, lead of exemption 7(c)-II is indispensable in product design of EEE, and its elimination or substitution is not scientifically and/or technically feasible, and there is no actual prospect to achieve it at least until the next review.

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5. Information on Possible preparation for reuse or recycling of waste from EEE and on provisions for appropriate treatment of waste

1) Please indicate if a closed loop system exist for EEE waste of application exists and provide information of its characteristics (method of collection to ensure closed loop, method of treatment, etc.)

None

Note: Discrete ceramic high voltage capacitors are incorporated into EEEs and at the end of life, such WEEEs are collected and treated according to the WEEE directive. No closed loop system exists exclusively for capacitors, due to the very large variety of final applications for capacitors.

2) Please indicate where relevant:

☐ Article is collected and sent without dismantling for recycling

☐ Article is collected and completely refurbished for reuse

☐ Article is collected and dismantled:

☐ The following parts are refurbished for use as spare parts: _____

☐ The following parts are subsequently recycled: _____

☐ Article cannot be recycled and is therefore:

☐ Sent for energy return

☐ Landfilled

Note: Electrical and electronic equipment using capacitors is not separately collected or recycled from other types of electrical and electronic equipment and so it is recycled using the same procedures as for other WEEE.

3) Please provide information concerning the amount (weight) of RoHS substance present in EEE waste accumulates per annum:

☐ In articles which are refurbished _____

☐ In articles which are recycled _____

☐ In articles which are sent for energy return _____

☐ In articles which are landfilled _____

Note: EU industry complies with all applicable waste legislation.

The industry refurbishes EEE where this is practical, recycles materials where possible and uses landfill only as a last resort.

No data is available on the quantities of capacitors separately from whole EEE, which are refurbished, recycled or landfilled.

Energy recovery from capacitors is not applicable.

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6. Analysis of possible alternative substances

(A) Please provide information if possible alternative applications or alternatives for use of RoHS substances in application exist. Please elaborate analysis on a life-cycle basis, including where available information about independent research, peer-review studies development activities undertaken

As described above in question 4(C), there is no suitable substance for substituting lead. Therefore, such information and analysis are not applicable for this case.

(B) Please provide information and data to establish reliability of possible substitutes of application and of RoHS materials in application

According to the above described, lead of exemption 7(c)-II is indispensable in product design of EEE, and its elimination or substitution is not scientifically and/or technically feasible, and there is no actual prospect to achieve it at least until the next review.

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7. Proposed actions to develop possible substitutes

(A) Please provide information if actions have been taken to develop further possible alternatives for the application or alternatives for RoHS substances in the application.

See explanation in question **4(C)** – Section: **Illustrative Cases of Lead-Free Substitution Research by Industry and Appendix-I.**

Please elaborate what stages are necessary for establishment of possible substitute and respective timeframe needed for completion of such stages.

Ceramic capacitor manufacturers have been searching for lead-free substitutes for many years, but this has been unsuccessful. Unsuccessful research is not published. At present, there are no prospects concerning the technical scope of exemption 7(c)-II for a comprehensive substitution to "lead-free" ceramic at least until the end of the next validity period.

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8. Justification according to Article 5(1)(a):

(A) Links to REACH: (substance + substitute)

1) Do any of the following provisions apply to the application described under (A) and (C)?

   ☐ Authorisation

   - ☐ SVHC
   - ☐ Candidate list
   - ☐ Proposal inclusion Annex XIV
   - ☐ Annex XIV

   ☐ Restriction

   - ☐ Annex XVII
   - ☐ Registry of intentions

   ☐ Registration

2) Provide REACH-relevant information received through the supply chain.
   Name of document:

Based on the current status of Annexes XIV and XVII of the REACH Regulation, the requested exemption would not weaken the environmental and health protection afforded by the REACH Regulation. The requested exemption is therefore justified as other criteria of Art. 5(1)(a) apply

(B) Elimination/substitution:

1. Can the substance named under 4.(A)1 be eliminated?

   ☐ Yes. Consequences? ______

   ☒ No. Justification: Please see answers in questions 4(C), 7(A) and 7(B).

2. Can the substance named under 4.(A)1 be substituted?

   ☐ Yes.

   ☐ Design changes:

   ☐ Other materials:

   ☐ Other substance:

   ☒ No.

   Justification: Please see answers in questions 4(C), 7(A) and 7(B).

As there are no substitutes, we are not able to provide "reliability and environmental assessment data for substitutes" in 3. and 4. below.
For the same reason, we are not able to evaluate "availability of substitutes" and "socio-economic impact of substitution" in (C) and (D) below.

3. Give details on the reliability of substitutes (technical data + information):

Not applicable

4. Describe environmental assessment of substance from 4.(A)1 and possible substitutes with regard to
   1) Environmental impacts: Although more energy to fire lead-free ceramics is required than for lead-ceramics, this is not the main justification for this exemption so this is not applicable
   2) Health impacts: Not applicable
   3) Consumer safety impacts: Not applicable

⇨ Do impacts of substitution outweigh benefits thereof?
Please provide third-party verified assessment on this: Not applicable

(C) Availability of substitutes:

a) Describe supply sources for substitutes: None

b) Have you encountered problems with the availability? Describe: Not applicable

c) Do you consider the price of the substitute to be a problem for the availability?

   ☐ Yes ☒ No

d) What conditions need to be fulfilled to ensure the availability? Unknown

(D) Socio-economic impact of substitution:

⇨ What kind of economic effects do you consider related to substitution?

Not applicable

- ☐ Increase in direct production costs
- ☐ Increase in fixed costs
- ☐ Increase in overhead
- ☐ Possible social impacts within the EU
- ☐ Possible social impacts external to the EU
- ☐ Other: _____

⇨ Provide sufficient evidence (third-party verified) to support your statement: _____

9. Other relevant information

Please provide additional relevant information to further establish the necessity of your request:

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10. Information that should be regarded as proprietary

Please state clearly whether any of the above information should be regarded to as proprietary information. If so, please provide verifiable justification:

There is no information which should be regarded as proprietary information.

Appendix I

In order to describe the current status of substitution research of lead-free dielectric ceramics, we introduce below some selected illustrative examples. However, as lead-containing dielectric ceramics are used in all categories of electrical and electronic equipment (hereinafter, “EEE”) it is impossible in practice to exhaustively present all applications and cases. Therefore, it must be noticed that the examples shown below do not cover an exhaustive list of the whole substitution research of lead-containing dielectric ceramics, but it is merely a selected small part thereof.

Example 1:

In this example, a company performed research to find a lead-free dielectric ceramic material that would replace the lead titanate / strontium titanate (PbTiO3/SrTiO3) type ceramic materials which is a typical series of lead-containing dielectric ceramic materials used in high voltage ceramic capacitors. The company attempted to apply two types of barium-strontium-bismuth titanate (Ba-Sr-Bi TiO3) type ceramic materials and barium-calcium-bismuth titanate (Ba-Ca-Bi TiO3) type ceramic materials as alternative lead-free dielectric ceramic materials. In the laboratory, high voltage ceramic capacitors made with these alternative lead-free dielectric ceramic materials have obtained a similar level of capacitance and good dielectric loss as those made with lead-containing reference materials. However, these alternatives have poor temperature characteristics, and the capacitance fluctuates greatly according to voltage fluctuations. Therefore, these alternatives cannot obtain stable performance under the actual use conditions of equipment in which temperature and voltage fluctuate during operation. For these reasons, high voltage ceramic capacitors using these alternative lead-free dielectric ceramic materials have not been put into practical use.

Example 2:

In this example, a company researched the application of alternative lead-free dielectric ceramic materials to high-voltage ceramic capacitors for high-voltage circuit breakers. The company applied alternative lead-free dielectric ceramic materials based on barium titanate with the addition of zirconium. High voltage ceramic capacitors for this application must meet both impulse withstand voltage performance and high capacitance. Although the impulse withstand voltage performance was improved by the addition of zirconium, the required capacity could not be achieved due to a decrease in the capacitance, so that it was not possible to put it to practical use.

Conclusion

It can be seen from the above examples that although alternatives can demonstrate benefits in a singular property, the combined properties, which are essential for the function of components, cannot be matched technically in comparison with lead containing ceramic dielectric material.