Exemption Request Form

Date of submission: 16 January 2015

1. Name and contact details

1) Name and contact details of applicant:

American Chamber of Commerce to the European Union (AmCham EU) ID number: 5265780509-97	**European Partnership for Energy and the Environment (EPEE)** ID number: 22276738915-67	**Information Technology Industry Council (ITI)** ID number: 061601915428-87
DIGITALEUROPE ID number: 64270747023-20	**European Passive Components Industry Association (EPCIA)** ID number: 22092908193-23	**National Electrical Manufacturers Association**
European Committee of Domestic Equipment Manufacturers (CECED) ID number: 04201463642-88	**European Power Tool Association (EPTA)** ID number: 85810161889-67	**TechAmerica Europe (TAE)** ID number: 2306836892-93
European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry (COCIR) ID number: 05366537746-69	**European Semiconductor Industry Association (ESIA)** ID number: 22092908193-23	**Zentralverband Elektrotechnik- und Elektronikindustrie e. V. (ZVEI)** ID number: 94770746469-09

2) Name and contact details of responsible person for this application (if different from above):

Company: National Electrical Manufacturers Association

Name: Mark Kohorst

Function: Senior Manager – Environment, Health & Safety

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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: Annex III, exemption 8b

Proposed or existing wording:

Existing wording: Cadmium and its compounds in electrical contacts

Duration where applicable:

We apply for renewal of this exemption for categories 1 to 7, 10 and 11 of Annex I for an additional validity period of 5 years. For these categories, the validity of this exemption may be required beyond this timeframe. Although applications in this exemption renewal request may be relevant to categories 8 & 9, this renewal request does not address these categories. Further, categories 8 & 9 have separate maximum validity periods and time limits for application for renewals.

☐ Other: _____

3. Summary of the exemption request / revocation request

We apply for renewal of this exemption under its existing wording, “Cadmium and its compounds in electrical contacts”.

Cadmium is being used in electrical contacts in the form of silver cadmium oxide (AgCdO). Electrical arcs occuring at the opening and closing of the electrical contact will alter the surface and layer of the contact after a certain number of arcs, impacting the contact material properties, and consequently, its response and performance.

Surface damages resulting from arcing can lead to contact failure, jeopardizing the reliability and safety of the equipment.

In a number of applications no substitutes have been found yet which offer the same reliability as the exempted application.

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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:

   The exemption request is relevant to various EEE making use of electrical contacts, in particular,

   - Electrical contacts used in power switching of electric motors, specifically thermal protectors and switches
   - Electrical contacts used in relays and contactors
   - Electrical contacts in switches for power tools and appliance switches
   - Electrical contacts in circuit breakers for switching equipment
   - Electral contacts in power packs, occupancy/time delay sensors, lighting control panels, line voltage switching control devices (1A-20A, 120V AC-480V AC)

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:

   Although applications in this exemption renewal request may be relevant to categories 8 & 9, this renewal request does not address these categories, and we have not completed section 4(A)1.c. Further, categories 8 & 9 have separate maximum validity periods and time limits for application for renewals.

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

Whereas this exemption request does not cover applications in category 8 and 9, please note that the application may be used in all of the above listed product groups.

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:

The cadmium in the form of the silver cadmium oxide alloy (AgCdO) is used in electrical switching contacts as well as thermal protectors. The way surface dynamics of AgCdO work contributes to its good arc erosion properties. The contact surface renews itself at each electrical arc.

Referencing the work done by Frédéric Pons on electrical contact material arc erosion[1]:

> Arc erosion induced by the electrical arc at each contact opening and closing plays a major role in reliability (life of power switching devices) and safety (failure modes and effects). Surface damages resulting from arcing can lead under a certain number of operations to contact failure, i.e. the power switching device can not fulfil anymore one of the functions it has been designed to due to contacts welding, contacts destruction, etc..
>
> During one breaking operation of electrical contacts, arc erosion results from the combination of:
> - material removal due to vaporization of the contact material
> - material removal because of the ejection of contact material particles
> - redeposition of vaporized or ejected contact material

[1] F. Pons, “Electrical contact material arc erosion: experiments and modeling towards the design of an AgCdO substitute”, PhD Thesis, May 2010, Georgia Institute of Technology

The way the surface and the layer change after a certain number of arcs will directly impact the contact material properties and will consequently influence its response and performance.

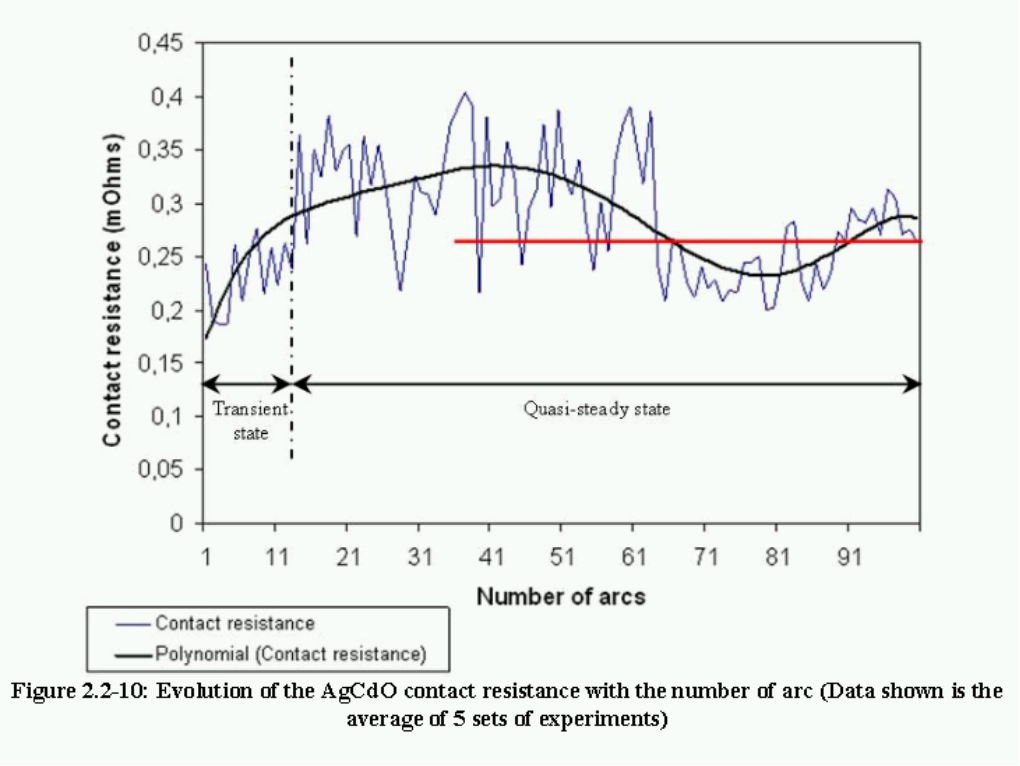


Figure 2.2-10: Evolution of the AgCdO contact resistance with the number of arc (Data shown is the average of 5 sets of experiments)

For AgCdO with increasing numbers of electrical arcs, we reach a quasi-steady state where properties oscillate around an average value. During this phase, the size and distribution of cadmium oxide clusters change. These clusters become smaller and are homogeneously and finely dispersed. This gives good contact erosion properties:

- Higher viscosity preventing contact material from splash erosion
- Higher thermal conductivity allowing heat to go through the contact layer faster and so to reduce the temperature elevation
- Higher electrical conductivity giving better electrical features to the contact
- Lower contact resistance preventing the contact from heating up

The high cadmium oxide ratio gives good anti-welding properties.

Therefore cadmium is used as a material to provide long life electrical contacts and reduce tack welding of contacts.

Its reliability ensures long term performance and safety.

4. Content of substance in homogeneous material (%weight):

   Electrical contacts in electrical switching devices like switches, relays, contactors and thermal protectors typically contain 10-25% Cadmium in the homogeneous material.

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

   The amount of Cadmium entering the EU market related to the application of Cadmium and its compounds in electrical contacts is estimated to be less than 10 tonnes.

   In reality the actual amount will be much lower as the current estimate is based on worst case, taking into account

   - the maximum of the tonnage band in the REACH registration dossier
   - the relative use of Cadmium for Minor uses, including but not limited to Cadmium in electric contact alloys

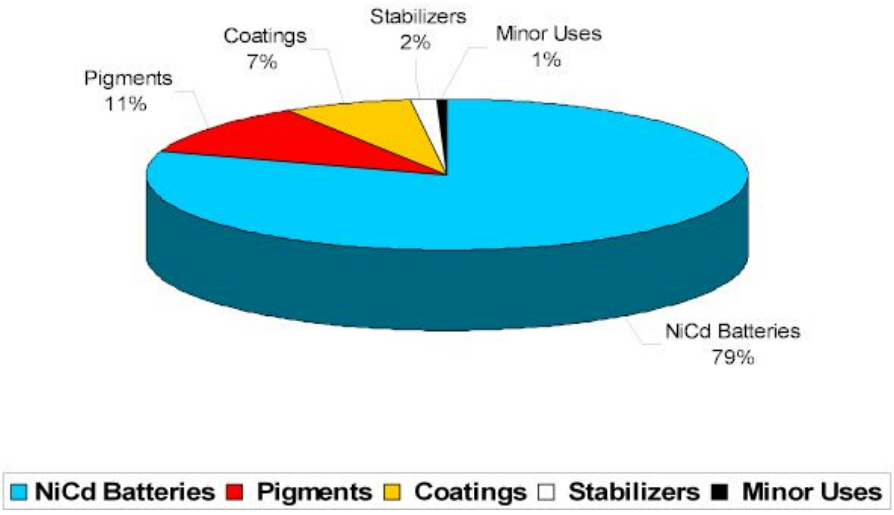
   Please supply information and calculations to support stated figure.

   According to the REACH registration information for Cadmium the total tonnage band is 1 000 – 10 000 tonnes (17 February 2013)[2].

   The International Cadmium Association (ICdA) presents relative data on the use of Cadmium in applications as follows[3]

[2] REACH registration information on cadmium:
http://echa.europa.eu/documents/10162/13641/annex_xv_cd_in_artist_paints_en.pdf
("B.2.1 Manufacture, import and export of cadmium", p. 15)

[3] The International Cadmium Association – Cadmium applications: http://www.cadmium.org/pg_n.php?id_menu=9



Cadmium in electrical contacts is considered one of the applications identified under the group of “Minor uses”.

If we consider the maximum values of these data then we can conclude that we can consider 10 tonnes of Cadmium as the maximum amount which would enter the EU market.

6. Name of material/component:
   Cadmium is being used in the form of AgCdO in electrical contacts. Cadmium is used in the contacts which are fused to the copper movable contact holders and stationary contact supports.

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?

The material is used in electrical switching contacts and the contacts of thermal protectors used in electric motors.

Electrical contact materials are used in many electromechanical devices as component which can carry current intermittently through contact surfaces. The basic properties required for these materials are that they should

possess high electrical and thermal conductivity, high melting point and good oxidation resistance.

High melting point is required to avoid any accidental overheating because of fusion of the contact points whereas high thermal conductivity helps to dissipate heat effectively.

In order to keep the contacts clean and free of insulating oxides, it is essential that the material possesses good oxidation resistance.

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

Electrical arc erosion plays a crucial role in the reliability and life of power switching devices. Depending on the contact material's behavior in response to an electrical arc, surface damage can induce severe changes in contact material properties that will impact the power switching device's functioning. Consequently, electrical arc effects and consequences on the contact material surface are of first importance.

Welding of contacts could present a safety concern if the contacts are welded and the contactor cannot open the circuit.

Cadmium prevents tack welding, both under severe operation conditions and when the product nears end-of-life.

The following characteristics have made cadmium an essential element for contact materials:

- Superior performance – lasts longer
- Quenches arcs – resists contact welding
- Higher conductivity – smaller size of contacts
- Less contact erosion - Essential for critical and safety applications
- Relatively easy to manufacture compared to alternatives

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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.)

Electrical contacts are typically components in other end-use applications. Therefore it is not possible to make any statements as to the existence and specifics of closed loop systems for waste collection of electrical and electronic equipment incorporating electric motors benefiting from the current exemption.

Equipment and components containing the substance are collected and recycled under the existing provisions of the WEEE recast Directive 2012/19/EU.

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

As the range of products in which the concerned applications are being used is quite broad it is difficult to make statements whether or not parts are actually being refurbished.

Considering the concerned applications are to be integrated in equipment / product categories in scope of WEEE they should however be subject to proper collection and waste treatment.

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 _____

We have no information available on the amount of the substance in articles being recycled. However, due to the nature of the applications, as the contacts wear out, the amount of Cadmium present in the contact/support assembly is greatly reduced. It is the heat coming from electrical arcs which vaporizes the contact material.

When the contacts are worn out, the remaining contact material is likely less than 15% of the original material. Consequently the remaining Cadmium is also less than 15% of what was originally present in the contacts.

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

For electrical contacts a number of alternative substances are suggested, of which $AgSnO_2$ is considered the most suitable alternative, particularly for higher switching currents.

$AgSnO_2$

According the study of Pons on arc erosion behaviour we can both for AgCdO and $AgSnO_2$ describe following 2 states:

- A transient state phase corresponding to the first few electrical arcs where the formation of oxide clusters at and in the immediate surrounding of the contact surface has been noticed. This accumulation damages its electrical and thermal properties. The arc erosion properties are however enhanced since this accumulation raises the viscosity of the molten bath, and therefore reduces material removal by splash erosion.

- A quasi-steady state phase corresponding to changes of the distribution and the size of oxide particles within the contact layer, of the morphology

and the composition of the contact surface, back and forth around a stable configuration.

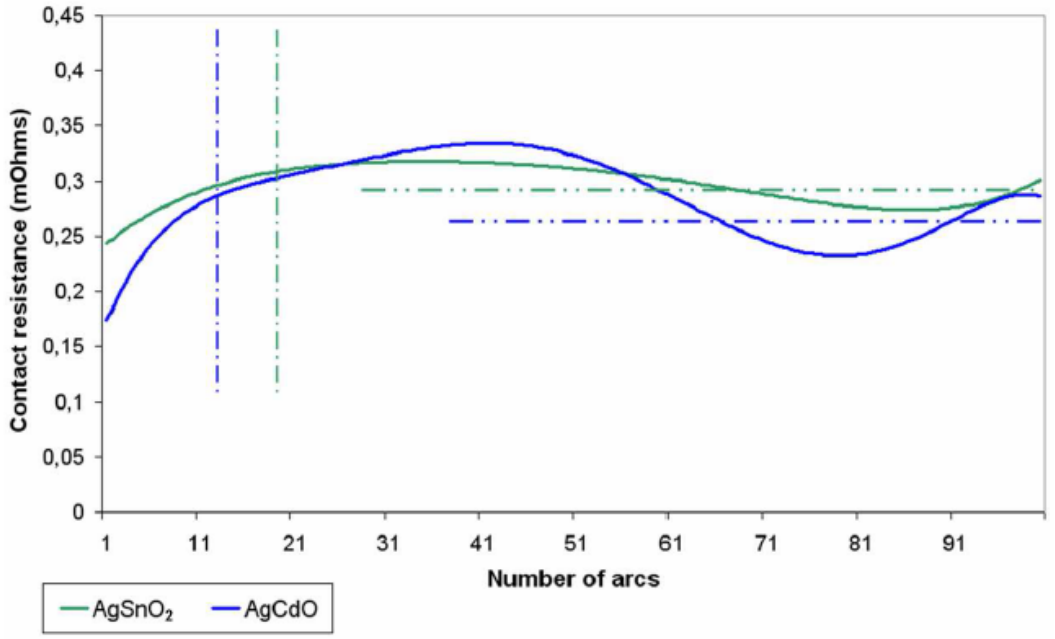

Figure 3.3-1: Evolution of the AgCdO and $AgSnO_2$ contact resistances with the number of arc

We can notice that the contact resistance of AgCdO is lower than that of $AgSnO_2$.

Earlier reported work on erosion behaviour on silver-metal oxide has also shown that continuous increase in temperature from 45°C to 85°C occurs for a switching operation between 2000-16000 cycles for $AgnSnO_2$ alloys whereas very little fluctutation was observed for AgCdO when tested under similar conditions. The reason for it was non-uniform dispersion of SnO_2 phase in silver matrix.

Apart from this the eroded surface exhibited volcanic craters, which is because of segregation of SnO_2 phase along grain boundaries thus exposing the silver matrix, which is soft, and gets eroded.

In his conclusion Pons notes that alternatives to AgCdO consist of compromises to meet requirements such as arc erosion that affect other parameters which may ultimately result in early failures and/or inconsistent performance:

The conclusion that has been drawn is that to raise the tin oxide composition of the AgSnO2 alloy reduces the amount of material removed by arcing and so enhances its arc erosion behavior. However, it damages the thermal and electrical properties of the contact material

since tin oxide has smaller thermal and electrical conductivities than silver. Therefore, a compromise has to be made to find out the perfect contact material composition.

Eric Streicher, Chi Leung and Dennis Fitzgerald acknowledged the following in their paper on “Arc Affected Surface Composition Changes in Silver Tin Oxide Contacts”

Typical high cycle usage on contacts causes modification to the contact surface due to arcing. This can cause rearrangement from a uniform material condition to one that has areas of depletion and segregation among the individual components of the contact composition. This type of behaviour is a particular concern for silver tin oxide systems since this results in higher temperature rises and more cracking. This necessitates the addition of dopants to control segregation to prevent formation of high resistance surface layers.

Cadmium free electric contacts in the silver metal oxide systems by internal oxidation method have long relied on silver tin indium alloys to form a homogeneous oxide distribution. The effect of indium is regarded as a metallurgical requirement controlling diffusion parameters during oxidation. The indium prevents the formation of dense oxide bands of SnO_2 and enables oxygen to diffuse at faster rate into the silver-tin alloys.

Use of indium however not only escalates the cost. Moreover, indium is recognized by the EU as being a critical raw material[4]. The EU defines

[4] http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm

critical raw materials on the basis of their economic importance as well as their supply risk.

Conclusion

For alternative substances the capability to extend life and reduce tack welding is not as good as Cadmium. In addition, typically the entire contactor will need major redesign in order to perform with the alternative substances.

Replacement contacts built with alternative contact materials would be larger, requiring larger contactors which may not fit in the space of the original contactor, which can result in disposal and replacement of the entire end-product, also resulting in increased volume of products disposed into the waste stream.

A drop-in replacement of Cadmium with other materials alone is therefore not feasible.

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

Scientific research as well as testing by several manufacturers shows that alternative substances are more prone to electrical arc erosion, which will result in more product failures.

Safety-related products (overload relays, circuit breakers, transfer switches, bypass contactors, fire pump controllers, etc.) built with

alternative contact materials would fail more often and in more dangerous modes, resulting in increased loss of life and property.

Power switching products (motor starters, contactors, pilot devices) built with alternative contact materials will fail more often, resulting in increased volume of products disposed into the waste stream.

Example – Switches in high frequency power tools (Large Angle Grinders)

Fein.xls

FEIN_HF catalogue [German].pdf

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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.

$AgSnO_2$ – semi-refractory tin oxide particles potentially could provide performance properties, especially resistance to contact welding and arc erosion, comparable to those of cadmium oxide

Advantages:

- Superior corrosion resistance
- Better anti-welding properties

Disadvantages:

- Rate of contact erosion
- Higher contact resistance
- Higher bulk resistance
- Higher temperature rise
- No standard composition

In general, the 10,12 and 15 wt% cadmium oxide grades are replaced with 8, 10 and 12 wt% tin oxide

To improve the electrical characteristics of the $AgSnO_2$, a range of additional oxides (dopants) can be added, e.g. tungsten oxide, molybdenum oxide, bismuth oxide. Dopants improve the arc-quenching characteristics and prevent the formation of high resistance oxide layers

on the surface of the contacts. The particular dopants required depend on the type of switching application of the electrical contact.

Higher SnO_2 increases weld resistance, contact resistance and hardness, but decreases conductivity and ductility

Individual manufacturers have tested various alternatives with little success. In the case where substitution is possible the nature of the alternative materials will however require redesign of the coils, magnets, armatures and contact springs.

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

Reference to ASTM B844 – Standard Guide for Silver-Tin Oxide Contact Material

The methods for manufacture (proprietary or otherwise) of these materials vary significantly among suppliers, and these methods influence such properties as arc erosion, contact resistance and tendency to weld in service.As part of the qualification on initial samples it is recommended

that the user electrically test the materials in a functional manner for all devices applicable to the material's use.

Discrete contact parts produced under this guide shall be sampled and tested on a lot basis.

This means that extensive testing will be necessary for each supplier:

- Voltage
- Switching current
- Steady current
- Switching speed
- Life cycle
- Mechanical wear
- Environmental

Because of the potential significant variation in properties from lot to lot, from supplier to supplier, much more extensive testing will be required as compared to AgCdO.

In the process of substitution we can distinguish following steps:

- Materials research
- Testing
- Implementation

The process of substitution will however take more time when potential substitutes are found not to be suitable to replace the exempted substance.

On the one hand a substitute may fail tests before reaching any stage of implementation. On the other hand substitutes may be succesfully implemented at one or more levels in the value chain, but fail when further

being integrated in specific equipment or equipment being used under specific conditions.

In either case the process of looking into suitable alternative substances should start all over again.

As a consequence it may take several years before substitution at the material level will lead to succesful implementation in final equipment.

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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:

Manufacturing of Cadmium containing-alloys listed under Identified uses of the REACH registration dossier on Cadmium: http://apps.echa.europa.eu/registered/data/dossiers/DISS-9ea7def6-ce71-0a3c-e044-00144f67d031/AGGR-be856a25-9953-4c24-9bcc-d5a5ac935464_DISS-9ea7def6-ce71-0a3c-e044-00144f67d031.html#section_3_5

(B) Elimination/substitution:

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

☐ Yes. Consequences? _____

☒ No. Justification: See section 4(C)

2. Can the substance named under 4.(A)1 be substituted?
   - ☐ Yes.
     - ☐ Design changes:
     - ☐ Other materials:
     - ☐ Other substance:
   - ☒ No.

     Justification: See sections 4(C) and 7(A)
3. Give details on the reliability of substitutes (technical data + information): See section 6(B)
4. Describe environmental assessment of substance from 4.(A)1 and possible substitutes with regard to
   1) Environmental impacts:
      Current alternative material alloys will fail more often, resulting in increased volume of products disposed into the waste stream
   2) Health impacts: _____
   3) Consumer safety impacts:
      Current alternative materials will cause the safety of the equipment to be compromised, which especially in safety-critical applications (for instance power tools) can lead to injuries or fatalities.

⇨ Do impacts of substitution outweigh benefits thereof?
Please provide third-party verified assessment on this: _____

(C) Availability of substitutes:

a) Describe supply sources for substitutes: _____
b) Have you encountered problems with the availability? Describe: _____
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? _____

(D) Socio-economic impact of substitution:

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

The current and pending US energy efficiency laws will impact the motor industry where it will shift many of the single phase ratings, with electrical power switches, to a “capacitor start/capacitor run” electrical type to meet those higher efficiency levels. This electrical type is more susceptible to contact welding and premature failure.

As a basic principle of a single phase motor to make it start to rotate and keep rotating, you need a capacitor. For the starting, it may be called a "capacitor start", and to keep it rotating (running) it may be called a "capacitor run".

For the smaller output motor, one capacitor can have both function of "capacitor start" and "capacitor run". For the larger output motor, separate capacitors are needed, one acting as "capacitor start" and the other acting as "capacitor run".

In this case, once the motor has started to rotate, the "capacitor start" should be cut off from the line, from the viewpoint of motor efficiency. To cut it off from the line, it uses a magnetic contactor, which contacts are using Silver Cadmium Oxide (AgCdO).

Cadmium used in Silver Cadmium Oxide (AgCdO) for electrical power switching contacts provides the best known performance for switching off electrical current quickly and cleanly, and avoiding contact welding and premature failure.

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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:

ANNEX I – REFERENCES

- F. Pons, “Electrical contact material arc erosion: experiments and modeling towards the design of an AgCdO substitute”, PhD Thesis, May 2010, Georgia Institute of Technology, https://smartech.gatech.edu/bitstream/handle/1853/33816/pons_frederic_201005_phd.pdf

- REACH registration information on cadmium: http://echa.europa.eu/documents/10162/13641/annex_xv_cd_in_artist_paints_en.pdf

- The International Cadmium Association, Cadmium Applications http://www.cadmium.org/pg_n.php?id_menu=9

- Eric Streicher, Chi Leung and Dennis Fitzgerald, “Arc Affected Surface Composition Changes in Silver Tin Oxide Contacts”

- European Commission – Critical raw materials http://ec.europa.eu/enterprise/policies/raw-materials/critical/index_en.htm

- Weiss, W. & Thekdi, H. et.al, unpublished testing, life cycle and comparison to silver tin oxide, December, 2008 to May, 2009, TE Connectivity, Berwyn, Pa

- ASTM Specification B844-98 (2010), Standard Guide for Silver-Tin Oxide Contact Material http://www.astm.org/Standards/B844.htm

- V. Cosovic et al., “State of the art and challenges in development of electrical contact materials in the light of RoHS directive”, Science of Sintering, 44, 2012

- N. A. Czarnecki, “Cadmium in electrical contacts”, NEMA white paper, revised May 18, 2012