Beryllium Science & Technology Association

Brussels, 4 April 2014

Response of the Beryllium Science & Technology Association to the stakeholders' consultation on "Study for the review of the list of restricted substances under RoHS 2 – Analysis of impacts from a possible ban of several new substances under RoHS 2"

Questions:

1. Contact Information

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2. Area of activity (more than one is possible):

- x **Industry;**
- Retail/distribution;
- Rent/repair business;
- Industry/business association;
- RoHS enforcement;
- RoHS analysis;
- Environmental NGO;
- Consumer NGO;
- Institute/consultancy;
- EU Member State Representative;
- International agency / organisation;
- Other - Please specify:

3. Please indicate which substance the information provided in this document concerns:

- Di-(2-ethylhexyl)phthalate (DEHP) *
- Di-n-butyl phthalate (DBP) *
- Butyl benzyl phthalate (BBP) *
- Diisobutyl phthalate (DiBP) **

- Tris(2-chloroethyl)phosphate
- Hexabromocyclododecane (HBCDD) *
- 2,3-dibromo-1-propanol
- Dibromoneopentyl-glycol5
- Antimony trioxide
- Diethyl phthalate (DEP)
- Tetrabromobisphenol A (TBBPA) and
- Medium-chain chlorinated paraffins (MCCP)
- Poly Vinyl chloride (PVC)
- x **Beryllium metal**
- x **Beryllium oxide (BeO)**
- Nickel sulphate
- Nickel sulfamate (=Nickel bis sulfamidate)
- Indium phosphide
- Di-arsenic pentoxide; (i.e. Arsenic pentoxide; Arsenic oxide)
- Di-arsenic trioxide (i.e. Arsenic trioxide)
- Cobalt dichloride
- Cobalt sulfate
- Cobalt metal
- Nonylphenol.

* These substances have been reviewed by the Austrian Umweltbundesamt. If you would like to submit further information concerning the quantity usage aspects of these substances, please see the information compiled by the Austrian Umweltbundesamt referred to on the consultation page (link).

** A substance review is being prepared for this substance; please use this questionnaire for DIBP, only if you do not intend to submit further input concerning the draft substance assessment dossier. For this purpose, please refer to this link.

4. Applications in which substance is in use

a. Please provide information concerning products and applications in which the sub stance indicated in Question 3 is in use.

Industry cannot do without materials containing beryllium. Beryllium brings unrivalled advantages to its end-use applications, whether used in its pure metallic form, as a beryllia (BeO) ceramic or as combined or alloyed in small amounts with other metals. In many instances, no other materials can deliver the same combination of performance and reliability demanded by today's high technology products and systems. Beryllium metal, beryllium oxide (beryllia) ceramics and beryllium-containing alloys are making the world better through enhanced product life, waste minimization, energy utilization, miniaturization, and decreased raw material utilization. Beryllium and beryllium-containing alloys are used by the aerospace industry in components used in the manufacture of high performance military and commercial aircraft in such critical components as guidance systems and electronic connectors and components. Throughout the medical arena, beryllium is indispensable for use in X-Ray sources used in mammography, medical imaging equipment, and as components of robotic surgical devices. Lasers surgery devices manufactured with beryllia ceramic components are providing the gift of restored or improved sight to millions around the world. Beryllium-containing ceramics are integral components in advanced cancer therapy machines, medical lasers for DNA analysis, equipment for skin resurfacing, non-invasive surgery, kidney stone removal, detection of blindness and HIV testing. Use of beryllium containing alloys in electronics provides greater reliability and longer product life. It is recognised by material experts and design engineers that the combination of strength, resistance to loss of strength over time, corrosion resistance, reliability, and electrical conductivity that is provided by beryllium-containing copper alloys that makes it so unique that it cannot be substituted without a substantial loss in performance. Copper beryllium alloys used in springs, switches, and the terminals of electrical connectors allow manufacturers of aircraft, automobiles, computers, cell phones, telecommunications equipment and other electronics to reliably design for the protection of the public, life-saving applications, miniaturization and energy conservation.

b. In your answer please specify if application is relevant to EEE products and applications or not.

The above applications are extremely relevant to EEE products. The vast majority of applications involve the use of copper beryllium components, which are inert, stable, and do not give off emissions during use. Market forces and commercial considerations ensure that the relatively high cost of beryllium-containing alloys are only used in key places in products where they provide the only solution that supports safety, reliability, extended service life, miniaturization, and/or improved energy management.

Copper beryllium connectors are found in a wide range of electrical equipment for use in automotive, aerospace, telecommunications computers and industrial and medical technologies. Applications within this category comprise by far the largest use of copper beryllium alloys and hence by far the largest use of beryllium metal.

Electrical circuits are only as reliable as their connections allow them to be, and connection failure is one of the greatest causes of electrical breakdowns. Such failure must clearly be avoided, especially in critical circuitry upon which the safe operation of equipment depends. Connector design and the choice of connector material greatly influence connector reliability

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and public safety. Connector materials must obviously be good electrical conductors to be able to carry the electrical power or signal. They must also be strong enough to ensure a robust mating force between the components in order to ensure good mechanical and electrical contact at all times, even while enduring high impact or vibration stresses and after repeated tens of thousands of make–and-break connections. Critical connectors must also be able to maintain their grip, or spring force, over long periods of time, and often at elevated temperatures in corrosive environments such as in an automobile engine or transmission compartment, which tend to gradually weaken connectors and cause a loss of conductivity. Furthermore, designs must enable the cost effective manufacturing of complex and miniaturized connector shapes.

An important requirement for many electrical devices is that they are shielded against electromagnetic radiation emanating from other sources, which could interfere with the functioning of the circuit, or prevent the radiation leaking out from its own circuitry which may cause interference in other devices. High performance electromagnetic radiation shielding seals are required for the metal circuit enclosures which, for mechanical and electrical contact reasons, need to maintain strong contact with the circuit board and other components and provide for opening access doors. The radiation shielding seals must have good electrical conductivity and be highly formable. Copper beryllium is an ideal material for this type of application and is used for this purpose in cellular phones and in cell phone tower base equipment racks, as well as, all wireless and microwave telephone systems.

The continuous trend in the design of electrical equipment is for the miniaturization of components, including connectors, to decrease overall size or weight, and to provide higher performance capability in the product. However, this must be achieved without sacrificing connector reliability. Miniaturized connectors still need to have sufficient strength and conductivity to perform their function reliably, even though both of these properties are reduced as the physical dimensions of the connector are reduced. Copper beryllium offers the designer the flexibility to employ smaller sized terminals and contacts while still obtaining the required reliability and performance. For example, electromechanical relays, switches, or connectors frequently require a design that have cantilevered beam sections, anchored by insert moulding into a plastic housing. The designer has available a wide selection of copper alloys that can be used in this application and by analyzing the mechanical and physical properties of each alloy, the designer will determine the contact size and subsequent price for each candidate alloy. The combination of strength, conductivity and resistance to deformation at elevated temperatures provided by copper beryllium allows a designer to use smaller section terminal beams than are not possible with other candidate alloys. In addition to reducing the weight of metal required, the use of copper beryllium allows the use of less plastic in the housing which results in using less weight and total energy, and less cost for end-of-life disposal. Up to 75% material weight savings have been achieved by using copper beryllium alloys compared to other common connector alloys. This weight reduction along with superior performance characteristics and reliability are the primary reasons why copper beryllium is selected. Though the cost per unit of weight that may be higher than many other alloys, the overall cost in the application is lower due to less material being used, while providing superior performance.

c. Please elaborate if substitution of the substance indicated in Question 3 is already underway in some of these applications, and where relevant elaborate which chemical or technological alternatives may be relevant for this purpose.

Almost all electrical connectors incorporate copper based terminals to carry the current or signal because of the conductivity provided by this metal. For most connectors, however, the copper must be strengthened in order to achieve the required spring force in the connector and this is generally done by a combination of alloying and "cold work", e.g. cold rolling the material, which makes it harder. Cold rolled brasses (copper plus zinc and other elements) and bronzes (copper plus tin and other elements) are common materials used for less critical connectors. However, both alloying and cold working, while increasing strength, generally tend to reduce conductivity significantly and furthermore are limited in the level of strengthening provided, while concurrently reducing the formability of the material. For example, brasses and bronzes have conductivities only 10-15% that of copper. Cold working and alloying reduce formability, limiting the shapes that can be made from the alloy. Furthermore, cold worked metals and alloys tend to suffer marked strength reduction and weakening after prolonged exposure to elevated temperatures as the heat "relaxes" the strengthening stresses that were put into the metal by the cold working. This is obviously a matter of concern for the connectors that must operate in hot environments, such as in automobile engine compartments, aircraft applications and in many household appliances such as coffee makers, washing machines and dishwashers. Copper beryllium alloys are significantly less susceptible to these adverse effects and offer the connector designer the highest combinations of strength, conductivity, elevated temperature stress relaxation resistance and formability of any of the copper alloys. For critical connections in circuitry where the highest performance and the greatest reliability are of paramount importance such as in medical device electrical connections, the superior properties of copper beryllium alloys are considered to be vital and unmatched. Safety devices made with beryllium-containing materials can make the difference between life or death, serious injury or walking away from a vehicle crash. The lifesaving technology behind automotive air bags relies on beryllium alloys to work in a fraction of a second. Anti-lock brakes trust beryllium alloys to transmit electrical signals through terminal connections when seconds make a critical difference in preventing a collision.

The inability to substitute beryllium has been recognized by material experts and has been designated by the European Commission as one of fourteen materials critical to the EU. A raw material is labelled "critical" when the risks for supply shortage and their impacts on the

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economy are high compared with most of the other raw materials. According to the European Commission:

"*The most significant threats originate from perceived risks associated with the use of beryllium in electronic products. EU regulatory fears and NGO propagated "banning" of the use of materials containing beryllium lead to unwarranted attempts to find substitutes* ***that do not offer the same qualities with respect to performance, sustainability and environmental protection****. "In general, authorities are reluctant to break from the past and are not open to new scientific studies even if they are conducted in accord with OECD guidelines or originate from proven workplace strategies."*

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5. Quantities ranges in which the substance is in use

a. Please provide information as to the ranges of quantities in which the substance indicated in Question 3 is applied in general and in the EEE sector.

World Beryllium consumption in 2011 was 400 MT, and is expected by a number of market research reports, the British Geological Survey and the US Geological Survey to grow to 465 MT by 2020 and 525 MT by 2030, driven by the ongoing demand for copper beryllium alloys used in high reliability electronics, aerospace and energy applications, and for beryllium metal used in the construction of fusion reactor power generators.

Market research reports provide the end-use market by sector as:

Telecommunications electronics (EEE):	51.7%
Automotive electronics (EEE):	13.3%
Aerospace / Defence: (EEE & Structural):	16.4%
Industrial Components:	11.6%
Other:	7.0%

b. If substitution has begun or is expected to begin shortly, please estimate how the trend of use is expected to change over the coming years.

There have been many attempts to use substitute materials for beryllium and alloys containing beryllium over the 90 years that it has been available as a material of commerce. With the availability of computer aided design, added to commercial pressures to reduce cost of materials used in the electronic and other applications for beryllium, all the potential substitutions in which reduced material properties do not lead to an unacceptable loss of performance or safety have been made. The types of material that have been used for substitution are:

Application Sector:	Attempted Substitute Materials:
Telecommunications electronic / Bronzes, CuNiSi alloys etc. Automotive electronics / Aerospace and Defence electronics:	Alloys of copper: e.g. CuZn Brasses; CuSn Issue - Insufficient combination of strength / formability / electrical conductivity / stress relaxation resistance / failure to resist vibration

Aerospace / Defence Structural	Titanium: Issue – Higher density / Lower specific stiffness (Modulus/Density) Carbon Fibre composites: - Issue - Formability / High and Low temperature properties / Specific stiffness / Weldability / Fracture toughness Impact resistance / Specific Heat /
Industrial Components: CuNiSi alloys etc.	Alloys of copper: e.g. CuZn Brasses; CuSn Bronzes, Issue - Insufficient combination of strength / formability / thermal conductivity / stress relaxation resistance / failure to resist vibration
Other: e.g. X-Ray Windows	Titanium / Aluminium / Polymers: Issue: Reduced resolution of the X-Ray or CT Scan images leading to reduced detection of tumours and medical issues.
e.g. Beryllium Oxide Laser Bores	Aluminium Oxide ceramic: Issue: Thermal conductivity
e.g. ITER fusion reactor lining	Tungsten: Issue: fail safe nuclear interaction of Beryllium as a neutron reflector is lost, reducing safety margin in the event of loss of magnetic control of the hot gas plasma.

It is not expected that any significant volume of beryllium usage can be substituted without an unacceptable loss of performance, particularly since almost all applications are in areas where high reliability is essential for lowering the risk of loss of life.

References:

Merchant Research & Consulting Ltd, London, 2012: Beryllium Market Review
Global Industry Analysts Inc., San Jose, CA, USA. Oct 2008: Beryllium – A Global Strategic Business Report
US Geological Survey, 2014: Mineral Commodity Summaries, Beryllium
British Geological Survey: Critical Metals Handbook, ed. G. Gunn, Pub. Wiley 2014 pp 99-121
http://beryllium.eu/about-beryllium-and-beryllium-alloys/facts-and-figures/production-statistics/

6. **Further information and comments**

a. **The substance profiles made available on the consultation page have been prepared as a summary of the publicly available information reviewed so far. If relevant please provide further information in this regard.**

Beryllium and beryllium-containing alloys are recyclable. Beryllium and beryllium oxide ceramic scrap can be sold back to the industry for direct recycling into new beryllium-containing products. The applications of beryllium metal and beryllium oxide ceramics, however, are highly specialized, and highly technological, rather than commercial or consumer in nature. As a result, many components have extremely long useful lives, and therefore return to the recycle stream very slowly. Some, because of their application in space or in long service medical devices or because of their sensitive military nature, do not return at all. It is unusual for metallic beryllium and beryllium oxide ceramic to directly enter the normal metals recycling stream, mostly because of its monetary value as a clean scrap metal. Copper beryllium materials that are not able to be separated due to being embedded in a device that is not disassembled at the end of its product life is normally processed in the copper waste recovery process. The processing of low beryllium content electronic/electrical devices in the general copper waste stream is usually done via melting which results in oxidation of much of the beryllium content from the melt, and the dilution of any remaining beryllium to levels comparable to new copper metal.

The most recent and the most relevant study by Paolo Bofffetta, Tiffani Fordyce and Jack Mandel “A mortality study of workers exposed to insoluble forms of beryllium”(European Journal of Cancer Prevention March 2014) is supportive of the growing and more recent scientific evidence that beryllium metal is not carcinogenic to humans. This study investigated lung cancer and other diseases related to insoluble beryllium compounds. The paper states: “A cohort of 4950 workers from four US insoluble beryllium manufacturing facilities were followed through 2009. Expected deaths were calculated using local and national rates. On the basis of local rates, all-cause mortality was significantly reduced. Mortality from lung cancer (standardized mortality ratio 96.0; 95% confidence interval 80.0, 114.3) and from nonmalignant respiratory diseases was also reduced. There were no significant trends for either cause of death according to duration of employment or time since first employment. Uterine cancer among women was the only cause of death with a significantly increased standardized mortality ratio. Five of the seven women worked in office jobs. **This study confirmed the lack of an increase in mortality from lung cancer and nonmalignant respiratory diseases related to insoluble beryllium compounds.”**

Please find attached:

1. Beryllium exposure studies during recycling of electronic scrap
2. A Review of Current Science Relating to the Association of Beryllium Metal with Lung Cancer 2014

b. Please provide further information and documents that you believe to have additional relevance for this review, as well as references where relevant to support you statements.

Please refer to the link http://beryllium.eu/resources/ for fact based materials relative to BeST position statements on beryllium as critical and strategic material, uses of beryllium, health & safety perspectives, and market forces information.

- **BeST Positions and Statements**
- **Handouts and Brochures**
- Beryllium - An Essential Element In Medical Equipment
- Beryllium Critical Material Assessment Summary
- BeST Beryllium Brochure EU
- BeST Handout On Beryllium Metal
- Strategic Importance Of Beryllium And The Negative Trade Impacts Of Impractical Regulatory Initiatives
- Strategic Importance Of Beryllium To The EU
- World Without Beryllium
- **Health & Safety**
- A Case for Reclassification by Dr. David Deubner
- Evaluation of beryllium exposure during recycling of WEEE - Feb 2013
- Expert Study Evaluation Of The Epidemiological And Toxicological Literature On Carcinogenicity
- Overview Of Cancer Papers By Christian Strupp English
- Scientific Perspectives on Establishing an Occupation Exposure Limit Value (OEL) Beryllium Metal
- Summary And Discussion Of Key Studies And Issues Relevant To Establishing An OEL For Beryllium
- Update On Beryllium Cancer Classification
- **Critical Material And Market Forces Literature**
- Annex V To The Report Of The Ad-hoc Working Defining Critical Raw Materials
- Beryllium Hits The Target For Optical Guidance Systems
- Beryllium Production And Outlook Roskill Mineral Services
- British Survey Of Metal Risks
- Competitiveness Of The EU Metalworking And Metal Articles Industries
- CSPRT Report On Beryllium 2011
- EU Commission - Tackling The Challenges In Commodity Markets On Raw Materials
- EU Critical Raw Materials Report

- French Defense Geostrategic Perspectives For The Next 30 Years
- Microwire Uses Of CuBe In Medicine
- Mobile Phone Partnership Initiative
- US Department Of Defense Strategic Materials Protection Board Findings
- Use Of Copper Beryllium In Medical Devices Support
- Use Of Copper Beryllium In Stopping Macondo Oil Spill
- US Geological Survey - Beryllium 2013

- **Health & Safety Studies & Literature**
- **Cancer**

- BeST - Analysis of Papers Linking Exposure to Beryllium and Lung Cancer, 2012
- BeST - Current Scientific State on the Toxicology of Beryllium Metal, 2012
- Boffetta Et Al - Occupational Exposure to Beryllium and Cancer Risk - Review of the Epidemiologic Evidence, 2012
- Brown - Lung Cancer and Internal Lung Doses among Plutonium Workers at the Rocky Flats plant, 2004
- Cherrie - Exposure To Occupational Carcinogens Great Britain
- Comments By Trichopoulos - The Alleged Human Carcinogenicity Of Beryllium
- Deubner - Analysis of the Schubauer-Berigan et al Cancer Risk Estimate for Beryllium Exposed Workers, 2011
- Deubner - Empirical Evaluation of Complex Epidemiologic Study Designs - Workplace Exposure And Cancer
- Garabrant - Case-Control Study Design - Spurious Associations between Exposure and Outcome, 2007
- Harlan Project - Appendix 2, In Vivo Studies With Beryllium Metal, 2010
- Harlan Project - Appendix 3, Summary of Animal Studies Relevant for Carcinogenicity, 2010
- Harlan Project - Evaluation of the Epidemiological and Toxicological Literature on Carcinogenicity of Beryllium Metal and Alloys, 2010
- Hollins - Beryllium and Lung Cancer - A Weight of Evidence Evaluation of the Toxicological and Epidemiological Literature, 2009
- Industrial Injuries Advisory Council (UK) Position Paper on Beryllium and Lung Cancer, 2009
- IOM Research Report On Amendments To The EU Cancer Directive
- Levy - Beryllium And Lung Cancer A Reanalysis Of A NIOSH Cohort Mortality Study, 2002
- Levy - Exposure to Beryllium and Occurrence of Lung Cancer - A Reexamination of the Findings, 2007
- Levy - Exposure To Beryllium And Occurrence Of Lung Cancer, Findings From A Cox Proportional Hazards Analysis, 2009
- MacMahon - The Epidemiological Evidence Of The Carcinogenicity Of Beryllium In Humans, 1994
- Reeves-Evaluation Of Beryllium Animal Data
- Rothman And Mosquin - Sparse Data Bias Accompanying Overly Fine Stratification in Analysis of Beryllium Exposure and Lung Cancer Risk, 2012

- Rothman - Confounding after Risk-Set Sampling in the Beryllium Study of Sanderson et al, 2011
- Strupp - Beryllium Metal I Experimental Results On Acute Oral Toxicity, Local Skin And Eye Effects, And Genotoxicity, 2010
- Strupp - Beryllium Metal II A Review Of The Available Toxicity Data, 2010
- Wild - Lung Cancer and Exposure to Metals, Epidemiological Evidence, 2009

In case parts of your contribution are confidential, please clearly mark relevant text excerpts or provide your contribution in two versions (public /confidential).

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

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