BeST
Beryllium Science & Technology Association

Brussels, July 2018

Beryllium Safety Bulletin - Overview

The following information is provided to those who process metallic beryllium-containing alloys, especially copper beryllium alloys. We urge all employers to make sure that their employees receive proper hazard notification and safety instructions.

1. Potential Health Effects from Exposure to Beryllium Alloys

Copper beryllium (CuBe) and other beryllium alloys, in solid form and as contained in finished products, presents no special health risks. Most manufacturing operations, conducted properly on well-maintained equipment, are capable of safely processing copper beryllium-containing materials. However, like many industrial materials, copper beryllium may present a health risk if handled improperly. The inhalation of dust, mist or fume containing beryllium can cause a serious lung condition in some individuals. The degree of hazard varies, depending on the form of the product, how it is processed and handled, as well as the amount of beryllium in the product. Read the product specific safety information for additional environmental, health and safety guidance before working with copper beryllium alloys. This information is available at http://beryllium.eu.

ROUTES OF ENTRY

Copper beryllium can enter the body in three ways: eye or skin contact, ingestion or swallowing, and of most concern, inhalation or breathing.

EYE CONTACT - As with any metal processing operation, injury can result from particulate irritation or mechanical injury to the eyes from contact with metallic dust, chips or particles. Use proper protection, such as safety glasses with side shields, goggles or face shields, to prevent eye injury.

SKIN CONTACT - Skin contact with element in these alloys may cause irritation and, in some sensitive individuals, an allergic dermal response. Particulate that becomes lodged under the skin has the potential to induce sensitization and skin lesions. A cut or laceration received from a sharp edge of copper beryllium material is no different from cuts received by other metals and routine first aid treatment is appropriate. Cuts or lacerations must be thoroughly cleaned to remove all particulate debris from the wound.

INGESTION - There are no known cases of illness resulting from the ingestion of copper beryllium containing materials; however, the potential for irritation exists. Copper beryllium, as with most industrial materials, is not intended for internal human consumption. Ingestion can occur when metal dust, mist or fume contacts hands, clothing, food and drinks which is followed by eating, drinking, smoking, nail biting, etc. Always practice good personal hygiene by not eating, drinking or smoking in manufacturing areas, and wash hands before doing so in designated areas.

INHALATION - People who are sensitive to inhaled beryllium particles can develop a serious and sometimes fatal lung disease called chronic beryllium disease (CBD). Chronic *(long term)* health effects may take months or years to develop. CBD is a condition in which the tissues of the lungs become inflamed, restricting the exchange of oxygen between the lungs and the bloodstream. CBD does not occur in most people. However, it is not currently possible to tell who will potentially react and who will not. Therefore, all workers need to be protected and airborne beryllium particles must be controlled by implementing effective engineering and work practice controls. Three factors are required, and all must be present for a person to develop CBD. First, the individual must be exposed to airborne beryllium in the form of a dust, fume or mist. Second, the particles must be tiny enough to reach the air sacs deep in the lungs; and third, the person must react to beryllium in the lung.

BeST utilizes a Recommended Exposure Guideline (REG) of 0.6 µg/m^3 (inhalable sampling method) and 0.2 µg/m^3 (Total-Closed face filter cassette/CFC sampling method) which has proven effective when used as part of a comprehensive beryllium worker protection program.

Small, respirable beryllium particles depositing on hands, gloves and clothing could be transferred to the breathing zone and inhaled during normal hand to face motions. Care should be taken not to touch the face with contaminated hands or clothing. Wear proper personal protective equipment to prevent skin and clothing contact with beryllium particles. Wash hands if they become contaminated.

CANCER - Although beryllium has produced tumors in some laboratory animals, and is listed or suspected as a human carcinogen by some agencies, BeST believes there is no credible evidence that beryllium causes cancer in humans and is seeking reclassification based on the most recent scientific studies.

2. Main sources of exposure depending on operations

Processing Copper Beryllium Alloys

The amount of beryllium dust or other airborne beryllium contaminant released in the processing of a beryllium product determines the extent of exposure control needed to protect workers. While a foundry producing beryllium copper castings may require a far-reaching control program, a stamping house producing beryllium copper springs in great volume may operate hazard-free without special precautions. Between these extremes, variations in exposure are many in beryllium alloy fabrication.

The way to learn what the levels of beryllium exposure are in a given workplace is to collect air samples.. Measurements may be made both of the beryllium concentrations encountered by individual workers and of the levels in work areas. An industrial hygienist or other qualified professional should be used to establish a sampling plan.

The air-sampling survey will identify concentrations expressed as micrograms of beryllium per cubic meter of air. The employer will wish to compare the beryllium levels found in the survey with the legally enforceable limits imposed by the standard adopted for occupational exposure to beryllium. Besides serving as an index of compliance, the survey results will, if exposure measurements are made at individual operations, show where to concentrate control efforts. A well-designed control program strives to reduce exposure to as low as reasonably achievable (ALARA), not merely reduce it to some numerical maximum. Though the ALARA goal may in many instances be unattainable, it is better for exposures to be as low as reasonable achievable than just below the legal limit.

The primary instruments of exposure reduction are engineering controls. Of these, local exhaust ventilation, which captures airborne contaminants at the point of release, is usually the most effective. Process modification, another engineering control, may also reduce exposure by eliminating, for example, a manual operation. Valuable, and often essential, supplements to engineering measures are work-practice controls. An illustration is providing vacuum-sweeping equipment equipped with a high efficiency filter instead of permitting the use of brooms in the workplace. The importance of a strong housekeeping program to prevent accumulations which might become airborne cannot be overemphasized. Work-practice controls may also take the form of written standard operating procedures (SOP's) that specify safe handling practices.

Wet processing is often an effective means of controlling the generation of airborne particles. Care must be given to prevent splashing or misting that could carry alloy particles away from the operation. Inadequate coolant flow or high tooling speeds may necessitate the need for additional containment or ventilation controls. Machining lubricant should be filtered and changed frequently to reduce the accumulations of particulate.

Still another type of exposure control is the respirator. For a number of reasons, it is the least satisfactory. The worker may wear the wrong type respirator for the level or type of exposure; improper fit may admit dust into the air stream; and finally, respirators are uncomfortable. The best practice is to confine the use of respirators to operations for which engineering or work-practice controls are not effective, to maintenance work, to emergency situations, and to operations awaiting the results of exposure measurement.

Clothing issued to workers, laundering work clothing, showers, and special lockers may be necessary under conditions of potential high exposures

In brief, potential for exposure to beryllium-containing particulate should be determined by conducting a workplace exposure characterization which includes air sampling in the worker's breathing zone, work area and throughout the department. Use an industrial hygienist or other qualified professional to establish the frequency and type of air sampling necessary. Develop and implement a sampling approach that identifies the extent of potential exposure variation and provides statistical confidence in the results. Provide air sample results to workers.

Facilities handling beryllium-containing materials in ways which generate particulate are encouraged to use engineering and work practice controls, including personal protective equipment, to control potential worker exposure. Use exposure controls to keep beryllium work areas clean and keep beryllium particulate out of the lungs, off the skin, off of clothing, in the work process, in the work area and on the plant site. It remains the best practice to maintain levels of all forms of beryllium exposure as low as reasonably achievable, and continue to work to improve exposure control practices and procedures.

Machining Copper Beryllium Alloys
Drilling, Boring, Milling, Turning, Tapping, Reaming, Sawing, etc.

Copper beryllium is a ductile metal that machines easily, generally producing large chips and turnings. Processes that generate large particles are usually performed in an open shop environment with no special ventilation or housekeeping practices required. Machining processes that do generate small particles must be controlled with appropriate work practices and engineering controls.

Sanding, Grinding, Buffing, Lapping and Polishing

These machining processes are capable of generating small particles. These processes must be controlled with appropriate work practices and engineering controls.

Stamping Copper Beryllium Alloys

Copper beryllium alloys are stamped into a variety of shapes, sizes and designs for use in electrical and electronic equipment. The manufacturing operations commonly associated with precision stamping can safely process copper beryllium alloys. The latest scientific evidence indicates that airborne beryllium exposure levels experienced at precision stamping operations are not sufficient to adversely affect health. Special controls are not required during the precision stamping, die repair, and inert atmosphere heat treating of stamped copper beryllium alloy parts.

In an effort to quantify the potential for worker exposure to airborne beryllium, a case study was conducted at four precision stamping facilities processing copper beryllium. These facilities performed a variety of mechanical and thermal activities during the manufacture of copper beryllium containing components for the electronic industry. The study found that one hundred percent (100%) of the 145 samples obtained from mechanical, thermal and support operations were below REG (CFC Total Method). The following is a summary of the results:

Process Category	Number of Sample Observations	Number of Samples Greater than 0.2 $\mu g/m^3$ (CFC Total Method)
Mechanical		
Stamping	49	0
Press Operators		
Die Repair	27	0
Assembly	14	0
Dry Tumble Deburring	4	0
Thermal		
HeatTreating	9	0
(inert atmosphere)		
Resistance Welding	8	0
Support		
Inspection	17	0
Shipping/Packing	17	0

Welding

Welding or cutting (with a gas flame or electric arc) indoors, outdoors, or in confined spaces, involving beryllium-containing base or filler metals shall be done using local exhaust ventilation and airline respirators unless atmospheric tests under the most adverse conditions have established that the workers' exposure is within the acceptable concentrations.

Casting and Alloying

Safe foundry practices must be employed when working with beryllium alloys. Furnace ventilation is required to capture fume and particulate generated during melting operations. The configuration and extent of ventilation must be designed for the specific application. One type of melting furnace, for example, may by its very design create little air contamination, while another may require elaborate engineering controls. Implicit in all foundry operations are the difficulties of handling molten metal and drosses plus the cutoff and finishing operations that are usually involved. A full range of control techniques may be required for adequate control.

The importance of controlling airborne beryllium contaminant from drosses in an alloy foundry cannot be overlooked. Chemical analysis has shown that drosses frequently carry higher concentrations of beryllium than the alloys originally melted. Drosses can easily become airborne, a characteristic which intensifies the need for careful management.

There is a more compelling need in foundries for company-issued work clothing, laundering on the premises or in a specialized commercial laundry, compulsory showers, and separate lockers for street and work clothes than in other workplaces handling beryllium alloys. The use of disposable coveralls may make it possible to avoid laundering. However, molten metal safety risks must be considered.

MAIN SOURCES OF EXPOSURE AT A GLANCE

The following table provides a summary of those copper beryllium processes that typically present low inhalation concern (green).

Low Inhalation Concern Operations			
Cold Rolling Cold Forging Stamping Slitting Plating Milling	Turning Boring Hand Filing Reaming Sawing (tooth blade)	Deburring (non-grinding) Wet Machining CNC Machining Age Hardening Drilling	Tapping Physical Testing Handling Inspection Assembly

Notes:

Operations in the "Low Inhalation Concern" category represent operations that typically release non-respirable (>10 micrometer) particles, are not expected to generate significant ultra-fine particulate, and/or are not expected to result in exposures in excess of the REG.
This list is not all-inclusive and variation can exist within specific processes. To verify the adequacy of engineering and work practice controls, conduct an exposure characterization of all copper beryllium processing operations.
Age hardening, as included in this table, is a heat treatment process conducted at <950^{o}F.
When evaluating operations, consideration must be given to potential exposures from activities in support of these operations such as setup, preparation, cleanup and maintenance.

The following table provides a summary of those copper beryllium processes that may present a likely inhalation hazard (yellow).

Likely Inhalation Hazard Operations			
Melting Casting Dross Handling Hot Forming Hot Forging Hot Rolling Abrasive Sawing Abrasive Blasting	Sanding Grinding Honing Lapping Polishing Buffing Deburring (grinding) Brushing	High Speed Machining Laser Cutting Soldering Annealing Pickling Brazing Electrical Discharge Machining (EDM)	Electro Chemical Machining (ECM) Welding Torch Cutting Coolant Management Ventilation Maintenance Abrasive Processing

Notes:

Operations in the "Likely Inhalation Hazard" category represent those operations which may release respirable (<10 micrometer) particles, may generate ultra-fine particulate, may generate beryllium oxide and/or may result in exposures in excess of the REG.
This list is not all-inclusive and variation can exist within specific processes. Determine, then verify, the adequacy of engineering and work practice controls by conducting an exposure characterization of all copper beryllium processing operations.
Effective ventilation, work practices and personal protective equipment use can control a "Likely Inhalation Hazard".
When evaluating operations, consideration must be given to potential exposures from activities in support of these operations such as setup, preparation, cleanup and maintenance.
High temperature annealing (>1000^{o}F) conducted in air can generate a loose beryllium-containing oxide scale that can flake off during processing and become airborne. Annealing in an inert or reducing atmosphere can minimize the formation of surface metal oxides.
Pickling, as included in this table, involves the use of strong acid and/or caustic solutions to remove metal oxides from the surface of beryllium-containing alloys. Other chemical cleaning or surface preparation operations should be characterized to determine potential exposure risk.
The use of the term "may generate ultra-fine particulate" to categorize the hazard of particular operations addresses the hypothesis that exposure to a large number of beryllium-containing particles with low mass and an aerodynamic diameter of 1 micrometer or less increases the risk of developing CBD.

3. WORK PRACTICES & CONTROL MEASURES

Some combination of the following control measures may be required when processing copper beryllium alloys:

Wet Methods

- The proper use of machining lubricants as a flood or in heavy flows is usually an effective method for controlling the airborne generation of copper beryllium particles.
- Care should be given to lubricant containment that prevents excessive splashing onto floor areas or operators' clothing.
- Inadequate coolant flow and higher tooling speeds may require additional containment and ventilation controls.
- Please note that the recycling of liquid lubricant/coolant containing finely divided copper beryllium in suspension can result in the concentration building to a point where the particulate becomes airborne during use.
- Machining lubricant should be filtered, settled, centrifuged or changed regularly to reduce the accumulation of fine particles.

Exhaust Ventilation

- Local exhaust ventilation is not necessary for machining processes which produce only large (>0.0005"), non-respirable chips. Machining of heat-treated or cast parts with surface oxidation requires special controls.
- Local exhaust ventilation must be used on dust-producing operations when lubricants or coolants are not being used or are not effective in controlling the release of airborne dust.
- The type and capacity of local exhaust ventilation required will depend upon the speed of particle generation. For example, hand sanding operations produce relatively slow moving particles, while powered grinders and roto tool operations produce very fast moving particles.
- Positioning of a close capture, high velocity ventilation duct/hood at the point of particle generation on a stationary grinder is critical to the system's effectiveness. The duct/hood must be positioned as close as possible to the source and in line with the direction of particle travel.
- The dust generated when using handheld grinders or roto tools can be very difficult to control due to the random nature of particle generation. Handheld grinders and roto tools are generally used in a ventilated partial or full enclosure designed to draw particles away from the operator. Alternative methods to hand grinders, such as filing or wet sanding, should be used where possible.
- Disruption of the airflow in the area of a local exhaust inlet, such as by a man cooling fan, should be avoided.
- Ventilation equipment should be checked regularly to ensure it is functioning properly.
- Ventilation training is recommended for all users.
- To be effective, ventilation systems should be designed, installed and maintained by qualified professionals.

Speeds/Feeds/Tooling

- These machining variables must be considered when determining the extent and type of engineering controls and work practices which may be required.
- Similar to the machining speed discussed above, stock feed rates can be an important factor in determining whether a process will generate airborne particles.
- Tooling condition is another important variable. Sharp-tooled machining processes generally produce only large chips while dull tooling may produce a mixture of large and smaller chips.
- Strict control of process speeds/feeds and tooling condition will assist in reducing airborne particle generation from machining processes.

Respiratory Protection

- Whenever possible, appropriate work practices, use of local exhaust ventilation or other engineering controls are the preferred methods for controlling exposure to airborne particles. When these methods are ineffective, or are being developed and potential exposures are above the REG, approved respirators must be used as specified by an Industrial Hygienist or other qualified professional.
- Respirator users must be medically evaluated to determine if they are physically capable of wearing a respirator.
- Quantitative and/or qualitative fit testing and respirator training must be satisfactorily completed by all personnel prior to respirator use.
- Users of any style respirator must be clean shaven on those areas of the face where the respirator seal contacts the face.

- Pressure-demand airline respirators are required when performing jobs where a potential for high exposure exists, such as changing filters in a baghouse air cleaning device.

Protective Clothing

- Protective overgarments or work clothing must be worn by persons who may come in contact with dusts, fumes, powders or beryllium particulate-containing solutions during activities such as grinding, sanding, furnace rebuilding, air cleaning equipment filter changes, maintenance, furnace tending, etc.
- Used disposable clothing should be containerized and disposed of in a manner which prevents airborne exposure during subsequent handling activities.
- Contaminated work clothing and overgarments must be managed in such a manner to prevent secondary airborne exposure to family or laundry personnel handling soiled work clothing.
- Never use compressed air to clean work clothing.

Housekeeping

- Copper beryllium machining equipment and associated support systems (e.g., dust collectors, heat treat furnaces, coolant trays and reservoirs) should be cleaned on a regular basis to prevent the accumulation of copper beryllium-containing materials.
- The use of compressed air or brooms for cleaning dust must be prohibited. Such activity can result in unnecessary airborne dust exposure.
- Wet cleaning and vacuuming are effective methods for cleaning machining and support equipment.
- Rags, towels or wipes used to dry or wipe parts clean should not be allowed to dry and must be maintained in a closed container. Rags and towels should not be reused. They should be containerized and disposed of in a manner which prevents airborne exposure during subsequent handling activities.
- Portable vacuums should be of a type equipped with High Efficiency Particulate Air (HEPA) rated filters.

Maintenance

- Under certain conditions, the repair or maintenance of equipment can generate airborne particles.
- Protecting workers can require the use of specific work practices or procedures involving the combined use of ventilation, wet and vacuum cleaning methods, respiratory protection, decontamination, special protective clothing, and when necessary, restricted work zones.
- Detailed procedures for safely maintaining the process equipment and ventilation systems should be developed.
- All operators and maintenance personnel need to be trained in the established procedures prior to performing maintenance or service activities. The procedure should detail the use of wet methods or vacuuming, ventilation and appropriate personal protective equipment required to prevent exposure to airborne particles.

Workplace Exposure Characterization

- Air samples should be taken for all operations where a potential for beryllium exposure exists.
- Air monitoring is the primary method for determining the degree of exposure and effectiveness of engineering and work practice controls.
- Characterization of worker exposure should only be performed by trained personnel.

Recycling

- Copper beryllium machining scrap should be kept segregated from other metals to retain its higher value as a recyclable material.
- Product importers and producers purchases clean, segregated copper beryllium scrap.

Disposal

- Copper beryllium wastes are not considered hazardous under most member state regulations.
- When spent products are declared solid wastes (no longer recyclable), they must be labeled, managed and disposed of in accordance with federal, state and local requirements.
- Some copper beryllium products contain specific metals (e.g., chromium, lead) that are regulated waste materials.

4. Overview of Occupational Exposure Limits (OEL) for Beryllium in Europe (July 2018)

Country	OEL (2018)
Austria	For general work with Beryllium and 8h TWA - 2 µg/m^3; for grinding 8h TWA - 5 µg/m^3; and for short time interval 4 x 15 min 20 µg/m^3 and 8 µg/m^3 respectively
Belgium	2 µg/m^3
Bulgaria	2 µg/m^3
Denmark	1 µg/m^3
Estonia	2 µg/m^3
Finland	0.1 µg/m^3
France	2 µg/m^3
Germany	AGS adopted 0.06 µg/m^3 respirable and 0.14 inhalable µg/m^3.
Ireland	0.2 µg/m^3
Latvia	1 µg/m^3
Poland	0.2 µg/m^3
Portugal	0.5 µg/m^3
Romania	2 µg/m^3
Slovenia	General work with Beryllium 2 µg/m^3 and for grinding 5 µg/m^3
Spain	0.2 µg/m^3
Sweden	2 µg/m^3
United Kingdom	2 µg/m^3
USA	0.2 µg/m^3
Japan	1 µg/m^3
BeST Recommended Exposure Guideline	**0.6 µg/m^3 (inhalable sampling method)** **0.2 µg/m^3 (total CFC sampling method)**

5. Data Collection from Member States on Disease Data

BeST conducted surveys of all member states, along with Norway and Switzerland, in 2014 and 2015 to assess the prevalence of respiratory disease and cancer that has been attributed to exposure to beryllium.
The CBD (Chronic Beryllium Disease) case data were obtained by contacting the relevant authorities.
Information was requested **covering the past 10 years.**

Within the entire EU, only 2 cancer cases were registered, one in Denmark and one in Spain. Our occupational health experts believe the Danish case is highly questionable since it was assigned to the car painting industry. To the knowledge of BeST, no beryllium is sold to or used in the car painting industry. Although beryllium is needed and is used in the automotive industry, it is not known to have any applications in car bodies or in any painted components, which eliminates beryllium as a potential causative agent in that application. There was not sufficient detail available on the circumstances surrounding the second case for the beryllium experts of BeST to evaluate.

Within this entire EU, 21 cases of CBD were registered, 8 were related to dental alloys (the professional use of beryllium in this domain is not recommended) and 5 were not based on a specific diagnostic of CBD but on a manifestation of a pulmonary disease with no evident link with beryllium use. Most of the 8 remaining cases were related to casting industries in countries where there was no Occupational Exposure Limit in place for beryllium. This data collection clearly demonstrates that **countries that have an OEL for Beryllium do not have cases of CBD.**

In addition, the members of BeST also undertook customer surveys between April and June 2015, which were evaluated by the consultancy UMCO. 57 European companies have contributed. 27 companies provided information on exposure levels, representing 1,036 exposed workers. None of the 57 companies reported a case of CBD. 75% of those companies have an exposure level below 0.2 µg/m^3, none of them is over 2 µg/m^3.

ADDITIONAL INFORMATION

If there are concerns about potential beryllium exposure in your workplace, contact an industrial hygienist or other qualified occupational health and safety specialist to perform a workplace assessment and exposure characterization.

The information contained in this Beryllium Safety Bulletin applies only to the subject referenced in the title. Read the safety information provided to you by the supplier for more detailed environmental, health and safety guidance specific for the products in use at your facility.

Additional information may also be available by contacting:

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