

# Beryllium Compounds

## BERYLLIUM COMPOUNDS<sup>(A)</sup>

107-02-8

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### Hazard Summary

Inhalation exposure to beryllium primarily occurs in the workplaces where it is mined, processed, or converted into alloys and chemicals, or from the burning of coal or fuel oil and in tobacco smoke. Acute (short-term) inhalation exposure to high levels of beryllium has been observed to cause inflammation of the lungs or acute pneumonitis (reddening and swelling of the lungs) in humans; after exposure ends, these symptoms may be reversible. Chronic (long-term) inhalation exposure of humans to beryllium has been reported to cause chronic beryllium disease (berylliosis), in which granulomatous lesions (noncancerous) develop in the lung. Human epidemiology studies are limited, but suggest a causal relationship between beryllium exposure and an increased risk of lung cancer. Inhalation exposure to beryllium has been demonstrated to cause lung cancer in rats and monkeys. EPA has classified beryllium as a Group B1, probable human carcinogen.

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Please Note: The main sources of information for this fact sheet are EPA's Integrated Risk Information System (IRIS) (3), which contains information on oral chronic toxicity and the RfD and inhalation chronic toxicity and the RfC, and the carcinogenic effects of beryllium including the unit cancer risk for inhalation exposure, EPA's Toxicological Review of Beryllium and Compounds (2), and the Agency for Toxic Substances and Disease Registry's (ATSDR's) Toxicological Profile for Beryllium. (1)

### Uses

- Pure beryllium and its metal alloys have applications in electrical components, tools, structural components for aircraft, missiles, and satellites, and other metal-fabricating uses. (1)
- Beryllium is also used in consumer products, such as televisions, calculators, and personal computers. (1)

### Sources and Potential Exposure

- The greatest exposures to beryllium occur in the workplace (i.e., where it is mined, processed, or converted into alloys and chemicals). (1)
- Individuals may also be exposed by inhalation of beryllium dust or fumes from the burning of coal or fuel oil and in tobacco smoke, by the ingestion of many fruits and vegetables and water, or through natural occurrence in soils. (1)
- The average concentration of beryllium measured in the air in the United States during the 1980s was 0.03 nanograms per cubic meter ( $\text{ng}/\text{m}^3$ ). Ambient concentrations measured in 50 cities between 1977 and 1981 were 0.1–0.4  $\text{ng}/\text{m}^3$ . (1)

### Assessing Personal Exposure

- Beryllium levels can be measured in urine and blood, but the levels in urine are quite variable, making it difficult to use these levels to assess total exposure. (1)
- Beryllium levels in tissues can be measured through biopsy procedures, however the relationship to exposure is not well documented. (1)

- A medical test, termed the antigen-specific lymphocyte transformation test, can be used to measure hypersensitivity in individuals previously exposed to beryllium and can also be used to diagnose chronic beryllium disease. (1)

## Health Hazard Information

### Acute Effects:

- Acute inhalation exposure to high levels of beryllium has been observed to cause inflammation of the lungs and acute pneumonitis (reddening and swelling of the lungs) in humans; after exposure ends, these symptoms may be reversible. (1–4)
- Acute animal tests have demonstrated beryllium compounds to vary in acute toxicity, ranging from high to extreme acute toxicity from oral exposure. (5)

### Chronic Effects (Noncancer):

- Chronic occupational exposure of humans to beryllium by inhalation has been reported to cause chronic beryllium disease (berylliosis), in which granulomatous lesions (noncancerous) develop in the lung. The onset of these effects may be delayed by 3 months to more than 20 years. Symptoms of chronic beryllium disease include irritation of the mucous membranes, reduced lung capacity, shortness of breath, fatigue, anorexia, dyspnea, malaise, and weight loss. (1–4)
- Chronic inhalation exposure has also been observed to cause immunological effects in humans and animals. (1–3)
- A skin allergy may result from dermal exposure to beryllium. Eye contact with beryllium dust has been observed to cause acute conjunctivitis in humans. (1)
- Animal studies have also reported effects on the lung, such as chronic pneumonitis, from chronic inhalation exposure. (1–3)
- The Reference Concentration (RfC) for beryllium is 0.00002 milligrams per cubic meter ( $\text{mg}/\text{m}^3$ ) based on respiratory effects in humans. The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncancer effects during a lifetime. It is not a direct estimator of risk but rather a reference point to gauge the potential effects. At exposures increasingly greater than the RfC, the potential for adverse health effects increases. Lifetime exposure above the RfC does not imply that an adverse health effect would necessarily occur. (3)
- EPA has medium confidence in the RfC due to: (1) medium confidence in the study on which the RfC is based because no NOAEL was identified in the study, but a NOAEL slightly below the LOAEL was suggested in another study; and (2) medium confidence in the database due to lack of adequate exposure monitoring in the epidemiology studies and some uncertainty regarding the mechanism associated with progression to chronic beryllium disease in beryllium-sensitized individuals. (3)
- The Reference Dose (RfD) for beryllium is 0.002 milligrams per kilogram body weight per day ( $\text{mg}/\text{kg}/\text{d}$ ) based on small intestinal lesions in dogs. (3)
- EPA has low to medium confidence in the RfD due to: (1) medium confidence in the study on which the RfD was based because there were small groups of animals, early mortality at the high dose level, no measure of immune response or function, and no control for potential litter effects, and (2) low to medium confidence in the database because there is only one chronic study in dogs showing adverse effect levels and other chronic studies in rodents demonstrated NOAELs at the highest doses tested. (3)

### Reproductive/Developmental Effects:

- The potential for beryllium to induce developmental or reproductive effects has not been adequately assessed.
- Limited information is available on the reproductive or developmental effects of beryllium in humans following inhalation exposure. A case control study found no association between paternal occupational exposure and the risk of stillbirth, pre-term delivery, or small-for-gestational-age infants, although this

study has limited sensitivity. (2,3)

- No data are available on reproductive or developmental effects in animals following inhalation. (2,3)

#### Cancer Risk:

- Several human epidemiological studies have investigated the relationship between beryllium exposure in workers and lung cancer deaths. Although there are shortcomings in all the studies, the results are suggestive of a causal relationship between beryllium exposure and an increased risk of lung cancer. (2,3)
- Beryllium compounds have been shown to cause lung cancer from inhalation exposure in rats and monkeys. (1,2,3)
- EPA has classified beryllium as a Group B1, probable human carcinogen. (3)
- EPA uses mathematical models, based on animal and human studies, to estimate the probability of a person developing cancer from breathing air containing a specified concentration of a chemical. EPA calculated an inhalation unit risk estimate of  $2.4 \times 10^{-3} (\mu\text{g}/\text{m}^3)^{-1}$ . EPA estimates that, if an individual were to continuously breathe air containing beryllium at an average of  $0.0004 \mu\text{g}/\text{m}^3$  ( $4 \times 10^{-7} \text{mg}/\text{m}^3$ ) over his or her entire lifetime, that person would theoretically have no more than a one-in-a-million increased chance of developing cancer as a direct result of breathing air containing this chemical. Similarly, EPA estimates that continuously breathing air containing  $0.004 \mu\text{g}/\text{m}^3$  ( $4 \times 10^{-6} \text{mg}/\text{m}^3$ ) would result in not greater than a one-in-a-hundred thousand increased chance of developing cancer, and air containing  $0.04 \mu\text{g}/\text{m}^3$  ( $4 \times 10^{-5} \text{mg}/\text{m}^3$ ) would result in not greater than a one-in-ten thousand increased chance of developing cancer. For a detailed discussion of confidence in the potency estimates, please see IRIS. (3)

## Physical Properties

- The chemical symbol for pure beryllium is Be, and its atomic weight is 9.012 g/mol. (1)
- Pure beryllium is a hard gray metal that does not occur naturally but does occur as a chemical component of certain kinds of rocks, coal and oil, soil, and volcanic dust. (1)
- Beryllium is also present in a variety of compounds such as beryllium fluoride, beryllium chloride, beryllium sulfate, beryllium oxide, and beryllium phosphate. (1)
- Pure beryllium is insoluble in water; however, some of its compounds are soluble in water. (1)

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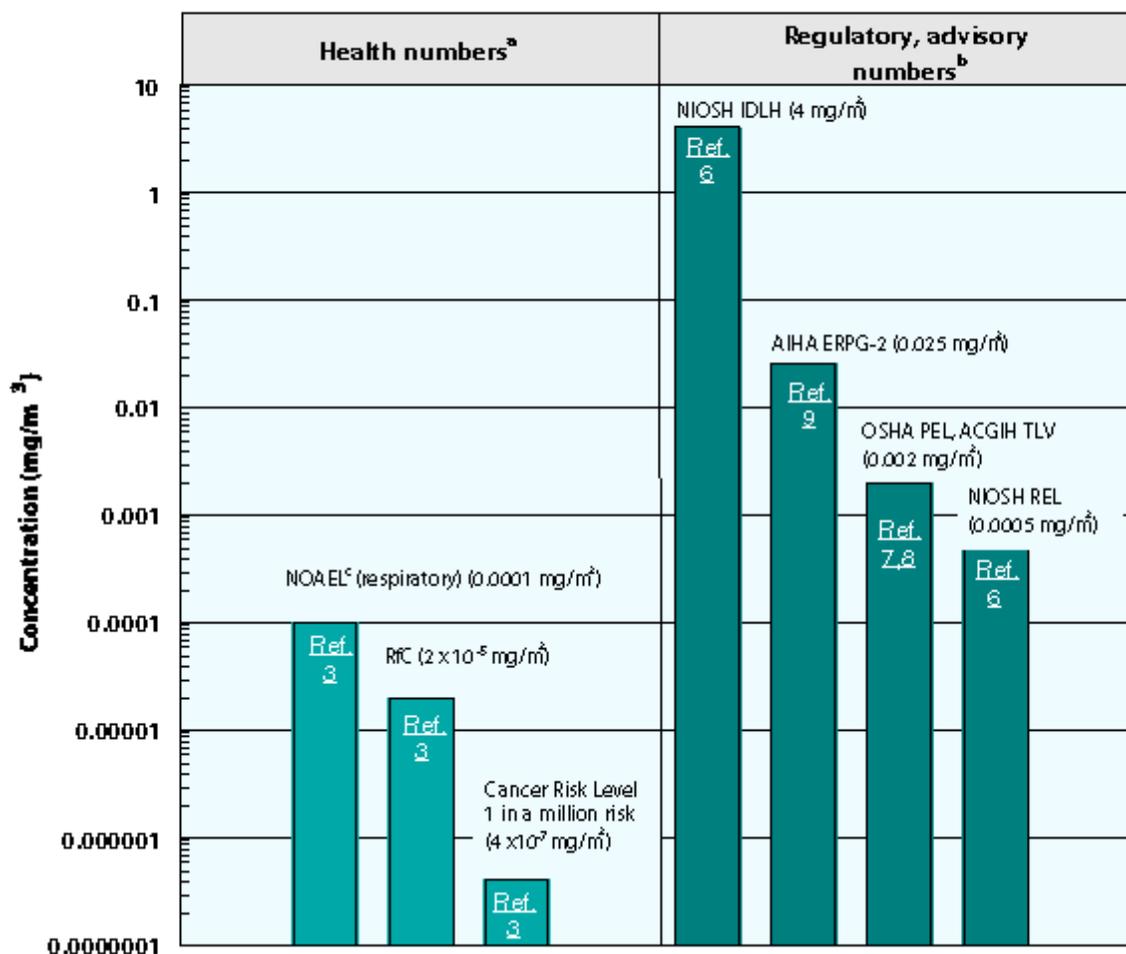
Conversion Factors (only for the gaseous form):

Beryllium and its compounds do not exist in the atmosphere in the vapor phase (in ppm); therefore, an air conversion factor is not applicable. (1)

To convert concentrations in air from  $\mu\text{g}/\text{m}^3$  to  $\text{mg}/\text{m}^3$ :  $\text{mg}/\text{m}^3 = (\mu\text{g}/\text{m}^3) \times (1 \text{ mg}/1,000 \mu\text{g})$ .

## Health Data from Inhalation Exposure

# Beryllium



ACGIH TLV--American Conference of Governmental and Industrial Hygienists' threshold limit value expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects.

AIHA ERPG--American Industrial Hygiene Association's emergency response planning guidelines. ERPG 1 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor; ERPG 2 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed up to one hour without experiencing or developing irreversible or other serious health effects that could impair their abilities to take protective action.

NIOSH IDLH-- National Institute of Occupational Safety and Health's immediately dangerous to life or health concentration; NIOSH recommended exposure limit to ensure that a worker can escape from an exposure condition that is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from the environment.

NIOSH REL--NIOSH's recommended exposure limit; NIOSH-recommended exposure limit for an 8- or 10-h time-weighted-average exposure and/or ceiling.

OSHA PEL--Occupational Safety and Health Administration's permissible exposure limit expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effect averaged over a normal 8-h workday or a 40-h workweek.

The health and regulatory values cited in this factsheet were obtained in December 1999.

<sup>a</sup> Health numbers are toxicological numbers from animal testing or risk assessment values developed by EPA.

<sup>b</sup> Regulatory numbers are values that have been incorporated in Government regulations, while advisory numbers are nonregulatory values provided by the Government or other groups as advice. OSHA numbers are regulatory, whereas NIOSH, ACGIH, and AIHA are advisory.

<sup>c</sup> This NOAEL is from the critical study used as the basis of the EPA RfC.

Summary created in April 1992, updated in January 2000.

## References

1. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Beryllium (Draft). Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1992.
2. U.S. Environmental Protection Agency. *Toxicological Review of Beryllium and Compounds*. In support of summary information on IRIS. National Center for Environmental Assessment, Washington, DC. 1998.
3. U.S. Environmental Protection Agency. *Integrated Risk Information System (IRIS) on Beryllium*. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 1999.
4. U.S. Department of Health and Human Services. Hazardous Substances Data Bank (HSDB, online database). National Toxicology Information Program, National Library of Medicine, Bethesda, MD. 1993.
5. U.S. Department of Health and Human Services. Registry of Toxic Effects of Chemical Substances (RTECS, online database). National Toxicology Information Program, National Library of Medicine, Bethesda, MD. 1993.
6. National Institute for Occupational Safety and Health (NIOSH). *Pocket Guide to Chemical Hazards*. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention. Cincinnati, OH. 1997.
7. Occupational Safety and Health Administration (OSHA). Occupational Safety and Health Standards, Toxic and Hazardous Substances. Code of Federal Regulations. 29 CFR 1910.1000. 1998.
8. American Conference of Governmental Industrial Hygienists (ACGIH). 1999 TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents. Biological Exposure Indices. Cincinnati, OH. 1999.
9. American Industrial Hygiene Association (AIHA). *The AIHA 1998 Emergency Response Planning Guidelines and Workplace Environmental Exposure Level Guides Handbook*. 1998.

A. \* This fact sheet discusses beryllium and beryllium compounds. Most of the information is on beryllium, except in those cases where there are differences in toxicity between beryllium and beryllium compounds. In these cases, information on the beryllium compound is presented.