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DEPARTMENT OF LABOR

Occupational Safety and Health Administration

BERYLLIUM

Proposed Occupational Safety and Health Standard

DEPARTMENT OF LABOR

Occupational Safety and Health Administration

[29 CFR Part 1910]

[Docket No. H-005]

OCCUPATIONAL EXPOSURE TO BERYLLIUM

Notice of Proposed Rulemaking

Pursuant to sections 6(b) and 8(c) of the Occupational Safety and Health Act of 1970 ("the Act") (84 Stat. 1593, 1599; 29 U.S.C. 655, 657), and Title 29, Code of Federal Regulations (CFR), Part 1911, it is proposed to amend Part 1910 of 29 CFR by deleting the present standard for beryllium and beryllium compounds contained in § 1910.1000, Table Z-2, and by adding a new occupational safety and health standard for exposure to beryllium as § 1910.1026. This standard would apply to all employments in all industries covered by the Act, including "general industry," construction, and maritime. In addition, pursuant to section 4(b)(2) of the Act (84 Stat. 1592, 29 U.S.C. 653), if the new standard, when promulgated, is determined to be more effective than corresponding standards now applicable to the maritime and construction industries contained in Subpart B of Part 1910, Parts 1915, 1916, 1917, 1918, and 1926 of 29 CFR, the new beryllium standard will supersede the corresponding maritime and construction standards for exposure to beryllium. Appropriate conforming amendments will be made in Subpart B of Part 1910, and amendments to delete the superseded standards will be made in 29 CFR 1926.55 and in similar sections of Parts 1915–1918.

The accompanying document is a proposed standard issued pursuant to sections 6(b) and 8(c) of the Act. The agency requests the submission of written comments, data, and arguments from interested persons on a variety of issues addressed or implicit in the proposal. In addition to filing written comments, interested persons may also file written objections to the proposal and request an informal hearing on the proposal and attendant issues.

The proposed new standard reduces the current permissible employee exposure for an 8-hour time-weighted average concentration, based on a 40-hour work week, to 1.0 microgram of beryllium per cubic meter of air (1.0 $\mu g/m^3$), sets a 5 microgram per cubic meter of air (5 $\mu g/m^3$) ceiling limit for exposures to airborne concentrations of beryllium, eliminates the peak concentration level and proposes a dermal exposure limit.

The proposal also provides for regulated areas, employee exposure measurements, methods of compliance, personal protective equipment and clothing, training, signs and labels, medical surveillance, and recordkeeping.

The issues raised in the proposal include, among others, the following:

1. The selection of the time-weighted average and ceiling limits, and the technological feasibility of compliance with the permissible exposure limit of 1.0 ug/m^3.

2. OSHA's regulatory decision, based largely on animal data, to treat beryllium as a substance that poses a carcinogenic risk to man.

3. Whether human evidence suggests that beryllium exposure causes cancer in man.

4. The provisions for, among other things, regulated areas, employee exposure measurements, compliance procedures, medical surveillance, protective equipment and clothing, hygiene facilities, and recordkeeping.

5. The appropriateness of the recordkeeping and similar requirements as applied to small employers and those with transient workforces.

6. The determination as to what employment, protection can or should be afforded workers who are removed from their present jobs as a result of the medical surveillance program.

7. The environmental and inflationary impacts of the proposal.

8. The determination of the appropriate sampling method to be used for determining compliance.

I. Background

A. *General.* Beryllium, an extremely light metal, is widely distributed geographically.[1, 31] Because of its many unique properties, such as high strength-to-weight ratio, resistance to corrosion, and extreme hardness coupled with ductility, it has come to be used extensively in industry, especially as an alloy. Beryllium and its compounds are suited for a wide variety of uses, including among others, the manufacture of ceramic parts, household appliances electric circuitry, electrical measuring instruments, thermal coatings, switch-gear and welding apparatus. It also is used in the aerospace and nuclear industries in the manufacture of inertial guidance systems, rocket motor parts and fuels, aircraft brake systems, gyroscopes, heat shields, and moderator reflectors.[1, 31]

Exposures to dusts and fumes containing beryllium may occur in both large scale processing plants and in small plants which perform operations such as melting, casting, grinding, drilling and machining.[1] However, exposures are not limited to industrial operations concerned with the production and manufacture of beryllium products.

Poor industrial housekeeping, maintenance, and clean up operations in plants where beryllium products are manufactured or used may expose employees handling beryllium as well as disperse it into other employee work areas. Also maintenance of processing equipment containing beryllium may be a source of employee exposure, especially if operations such as welding, burning, or cutting[6] are involved.

The first major use of beryllium in the United States was in the production of fluorescent and neon lamp tubes. However, after the discovery of an epidemic of beryllium disease among workers in this industry, use of beryllium phosphors for these products was completely discontinued by the early 1950's.[6]

Domestic production of beryl, the principal beryllium-containing ore of commercial importance, was approximately 500 tons in 1950. Domestic production has remained relatively constant as contrasted with domestic consumption which, in 1969, reached 8,500 tons and is expected to reach 20,000 tons by the year 2000. A survey conducted by the United States Public Health Service in 1970 estimated that 30,000 persons in the work force could have potential exposure to dust or fumes containing beryllium.[1]

B. *History of Regulation.* Although the incidence of occupational disease associated with beryllium use has been recognized since the early 1940's, evidence regarding the cause and effect relationships between beryllium and disease developed slowly. One reason for the lack of data on the subject was the unavailability of sensitive analytical methods for measuring trace amounts of beryllium. However, as it was known that the incidence of beryllium related disease was increasing, a meeting was held in Saranac Lake, New York in 1947 to review the entire beryllium problem.[29]

The information gained from this 6th Saranac Symposium, coupled with research and recommendations of Eisenbud and his co-workers,[12, 13] published in 1948 and 1949, provided the basis for the United States Atomic Energy Commission Control Requirements, established in 1949. Based on his own investigations, Eisenbud recommended a maximum permissible peak exposure limit of 25 $\mu g/m^3$ for control of *acute* beryllium disease.[12]

Attempts by Eisenbud to establish a level for control of *chronic* exposure to beryllium for the AEC proved more difficult. Eisenbud [12] commented in 1961 that "There was not then, nor is there today, any substantial body of environmental information that could be correlated with clinical reports of occupational berylliosis, and such data as do exist are puzzling." Lacking empirical data for establishment of a limit for chronic exposure, Eisenbud and Machle arrived at a figure of 2.0 $\mu g/m^3$, based on information on animals and man gained from the Saranac Symposium, and by analogy with industrial air limits for such toxic heavy metals as mercury, cadmium and thallium.[29]

In 1949, on the recommendation of an ad hoc committee, the AEC adopted Eisenbud's limits for exposure to beryllium in the workplace and added requirements for air levels in neighborhoods in the vicinity of plants handling beryllium compounds. In summary, the AEC levels permitted a daily average concentration of 2.0 $\mu g/m^3$ with the provision that no person be exposed to beryllium in excess of 25 $\mu g/m^3$. These exposure limits were adopted by all AEC installations handling beryllium, and were binding on all AEC contractors involved in the handling of beryllium.

In 1959, the American Conference of Governmental Industrial Hygienists also

NOTE: Notes and references contained in part VII of the introductory material.

adopted an eight-hour time-weighted average limit of 2.0 $\mu g/m^3$.[16] This level has not been changed since then.[17]

In 1956, The American Industrial Hygiene Association published a Hygienic Guide in which it also recommended the AEC exposure levels.[18] In 1969, however, the World Health Organization, in a joint statement with the International Labor Organization,[20] recommended a permissible level for beryllium and its compounds as 1.0 to 2.0 $\mu g/m^3$.

The present Occupational Safety and Health Administration (OSHA) standard for beryllium, found in 29 CFR 1910.1000, Table Z-2, was adopted from the American National Standards Institute's (ANSI) Z37.29-1970 standard, "Acceptable Concentrations of Beryllium and Beryllium Compounds." The present OSHA standard prescribes an 8-hour time-weighted average of 2.0 ug/m^3 with a ceiling concentration of 5.0 ug/m^3. In addition, the present standard allows a peak concentration above the acceptable ceiling concentration for an 8 hour shift of 25 ug/m^3, for a maximum duration of 30 minutes.

II. Occupational Health Implications of Beryllium

Toxic effects of beryllium and its compounds on humans occur in both acute and chronic forms. Tepper, Hardy and Chamberlin [2] characterized acute beryllium diseases as "those beryllium-induced disease patterns of less than one year's natural duration." The same authors described chronic beryllium disease as a pattern of more than 1 year's duration. In addition, it has been suggested that beryllium may be involved in the production of cancer.

A. *Acute effects.* Acute effects on the skin and eye area include contact dermatitis, beryllium ulcers and various ocular effects. Abscesses and ulcerations occur as a result of crystal implantation of soluble or insoluble beryllium materials in cutaneous areas previously injured as a result of cuts or abrasions. Ocular effects may occur either as a result of a "splash burn" which causes inflammation of the conjunctiva, or in association with contact dermatitis.[3] Beryllium splashes may also result in corneal burns.[4]

Beryllium-induced acute respiratory effects range from a mild inflammation of the nasal mucous membranes and pharynx, to tracheobronchial involvement and severe chemical pneumonitis. Recovery is generally rapid, ranging from 1 to 6 weeks for mild cases. However, recovery from acute pneumonitis may be prolonged and severe cases may become fatal.[1,2]

B. *Chronic Beryllium Disease (Berylliosis).* The clinical nature of chronic beryllium disease differs from the acute in that the former is often separated by a period of years from the time of beryllium exposure. A number of case histories have revealed a delay ranging from 5–10 years between the last beryllium exposure and the appearance of detectable evidence of disease, and in some cases a delay of 20 years or more.[5,6] Further, chronic illness is characterized as being a systemic disease, prolonged in duration and commonly progressive in severity despite cessation of exposure.[5]

Chronic beryllium disease results from inhalation of beryllium particulates. Its most familiar symptom is pneumonitis, with its accompanying cough, chest pain and general weakness.[4] Pulmonary dysfunction and systemic effects, such as heart enlargement, leading to cardiac failure; enlargements of the liver and spleen; cyanosis; and the appearance of kidney stones also characterize the chronic illness.[5]

The Beryllium Case Registry was instituted in 1952 at the Massachusetts General Hospital to provide a central source of information for cases of diagnosed acute and chronic beryllium disease.[7] By 1974, 853 cases of the disease were on record at the Registry.[24]

Annually reported Registry cases decreased considerably following discontinuance of the use of beryllium phosphors by the fluorescent lamp industry.[7, 12] Prior to 1949, exposure levels had been extremely high in all facets of industry. For example, a 1946 survey of a beryllium plant by Laskin, Turner and Stockinger [9] indicated beryllium dust concentrations of 110 to 533 $\mu g/m^3$ during the beryllium furnace coke removal operation. Also, Zielinski [9] reported levels of 11,330 to 43,300 $\mu g/m^3$ in a beryllium alloy plant.

After 1949, however, environmental exposure levels were markedly reduced.[10, 11, 27] Breslin and Harris [10] stated in a 1958 report that beryllium air concentrations in one Ohio extraction plant operated by the AEC were recorded at 2.0 $\mu g/m^3$ or less during most of a seven year period. Surveys by Breslin and Harris [10] and by Mitchell and Hyatt [11] reported concentrations of 0.1 $\mu g/m^3$ or less for sites such as beryllium fabrication and machine shops.

Despite these great reductions in beryllium exposure levels, an average of 10–12 new cases of beryllium disease have consistently been added to the Registry each year since 1962.[7, 25] It has been suggested that new cases continue to emerge for two reasons. First, because of the long latency period between beryllium exposure and the development of chronic beryllium disease, new cases continue to be reported involving workers exposed before the 1949 limits were adopted. However, this does not account for all the new cases added. A recent report on the Registry Hasan and Kazemi [25] of cases of chronic beryllium disease reported since 1966 produced 76 such new case histories. While approximately 40 of these cases involved workers with exposures before 1949, it appears that at least 36 were first exposed to beryllium subsequent to 1949. The Director of the Registry has also indicated that the incidence of confirmed beryllium disease is continuing even though the Registry's file may not include all cases of the disease resulting from beryllium exposure.

Second, because beryllium has come to be used in many diverse types of products and processes, it is suggested that beryllium disease continues to occur among the employee population as a result of exposures exceeding the permissible limits due to inadequate engineering and work practice controls, engineering control failures, improper use of respirators and, in some cases, lack of awareness of the degree of hazard involved in employee exposure.[6, 20]

Hasan and Kazemi [25] (1974) found that of the 36 patients exposed to beryllium after 1949, 29 or 81 percent have a history of handling, grinding or machining beryllium metal and alloys in the aircraft industry, electronics and the manufacture of nuclear reactors. NIOSH, in referring to some of these new cases, stated: "Of interest is that recent cases are occurring not only in smelting and extraction operations, but also in alloy and ceramics operations where contaminant control reportedly has been quite successful."

C. *Carcinogenic Effects.*—(1) *General Considerations:* In the case of beryllium, we are dealing with a substance that poses a range of health risks to the working population. These include the threat of cancer, as well as acute and chronic toxicological effects. In considering the controversial issue of carcinogenicity, OSHA is relying upon leading scientific principles and opinions believed to reflect the research conclusions of international cancer experts. In such an inquiry, we recognize that we are operating on the frontiers of knowledge. We rely however, upon what we believe to be the best available evidence and interpretations and are prepared to modify our views if new evidence or future scientific advances show we are in error.

(a) *The Latency of Carcinogenic Effects.* In man, the latency period for chemical carcinogens may well be as long as 20, 30 or more years. Analogous periods exist for test animals. This means that the disease may undergo a long development before a tumor is actually detected. At that point, it has reached a stage where removal of the worker from the workplace may be of no avail and where treatment may be extremely difficult, if not futile. Prudent policy would therefore seem to indicate that every reasonable measure should be taken to eliminate human exposure to chemical compounds as soon as their carcinogenic nature is identified.

(b) *The Variability in Individual Susceptibility in Relation to the Concept of a Threshold.* Cancer development may be influenced by such factors as the differing susceptibility of various body organs. Further, in animal studies it has been found that individual variability in response to carcinogens is great, depending upon such factors as age, sex hormonal status, diet, and genetic factors. Thus, it may be concluded that certain groups in the working population, such as those already biologically compromised, may be more susceptible than other groups.

(c) *A "Threshold" Limit.* Because of the variability of individual response to carcinogens and other factors, the concept of a "no effect" or "threshold level" may have little real significance on the basis of existing knowledge. While such a level, below which exposure to a carcinogen does not cause cancer, may conceivably exist for any one individual, other individuals in the working population may have cancer induced by doses so low as to be effectively zero. This is not to say that researchers will never find a threshold level for a carcinogenic substance, but it does mean that the threshold concept for carcinogens is at present more a matter of responsible regulatory policy than matter of a precise, scientific determination.

(d) *Identification of Carcinogens.* A carcinogenic agent may be identified either by experiments with laboratory animals exposed to an agent or by properly conducted epidemiological studies. While epidemiological studies are valuable in general, the overwhelming logical and ethical considerations of not using humans as test subjects to determine the carcinogenic potential of a compound has led to reliance upon animal testing in the laboratory. Moreover, often severe reliability problems exist which further reduces the value of such epidemiological studies.

(i) *Acceptability of Animal Testing.* The use of animal test data to aid in the formulation of public policy has long been supported by community and official agencies such as NIOSH, the United States Environmental Protection Agency, the National Cancer Institute, the World Health Organization, and the National Academy of Sciences.

Animal testing is particularly appropriate with respect to cancer because the relatively short life span of test animals allows for testing for the entire latency period for tumor development and because of our relatively well-defined understanding of the pathological development of tumors in mice, rats, and certain other mammalian species. Moreover, this reliance on animal testing is supported by the fact that, at least at this time, all chemical substances or mixtures that have been proved carcinogenic by direct observation in man have also been shown to be carcinogenic in test animals, with the possible exception of arsenic. Thus, laboratory animals provide a reliable and accepted means of evaluating the potential carcinogenicity of chemical agents in man.

(ii) *Animal or Organ-Specificity.* It has been suggested that some carcinogens are animal or organ specific. However, in a recent survey by Dr. Tomatis of 58 chemicals known to produce liver tumors in mice, 40 also induced tumors in a variety of other organs in the same species. Further, Dr. Tomatis found that chemically induced tumors in one species need not appear in the same organ in other species. Thus, a carcinogen which induces liver tumors in mice might, for example, produce mammary cancers in rats and lung tumors in men. However, where the available human epidemiological data indicate induction of cancer in a specific organ, and where the animal data clearly demonstrates the development of cancer in the same organ from the same substance, the extrapolation from the animal tests to man is even more compelling and justifiable.

(e) *Conclusion.* These theoretical concepts have a bearing on the questions of how beryllium exposure should be treated as to man and whether there is or is not a threshold level of carcinogenic effect.

In previous rulemaking proceedings, OSHA has considered these issues and determined that in the absence of evidence to establish a safe level on the basis of present knowledge, employee exposure must be reduced as low as feasible (See the preambles to the carcinogen standards, 29 CFR 1910.1003–1016 (39 FR 3753) and the vinyl chloride standard, 29 CFR 1910.1017 (39 FR 35892)). See also the preamble to the proposed coke oven standard (40 FR 32268).

OSHA believes that in setting prudent public policy as to how to deal with substances that give positive results for cancer in test animals, recognition must be given to the fact that an animal carcinogen, as a matter of science or research, may be different from a positive proven carcinogen to man. Nevertheless, we do not know that they are different, and no data are available that would so prove.

Therefore; OSHA believes that, as to any substance, a valid carcinogenic reaction in test animals must be considered sufficient, without other circumstances unique to that substance, to describe the test compound as a carcinogen to the test species and thus a potential carcinogenic hazard to man.

We welcome all views and comments on these subjects as well as the other issues raised by the proposal.

(2) *Evidence of Beryllium Carcinogenicity*—(a) *Animal Studies.* In the course of OSHA's investigations, it was found that beryllium compounds have been reported to readily produce malignant tumors in laboratory animals. For example, beryllium sulfate and beryl ore were found to produce lung tumors in rats following inhalation. Beryllium oxide and beryllium sulfate produce lung cancer in monkeys following intrabronchial implantation or inhalation. Zinc beryllium silicate, beryllium metal, and beryllium phosphate produce bone tumors in rabbits following intravenous administration. The following is a summary of several relevant studies of beryllium carcinogenesis in animals.

(a) *Pulmonary Cancer in Experimental Animals by Inhalation.* Schepers *et al.* (1957) [62] reported the induction of malignant pulmonary neoplasms in rats exposed to an aerosol of beryllium sulfate at an average dose level of 35 $\mu g/m^3$ for periods of up to six months, and thereafter observed without treatment for periods of up to 18 months.

Reeves *et al.* (1967) [70] exposed 75 male and 75 female rats continuously to the inhalation of beryllium sulfate aerosol at a mean concentration of 34 $\mu g/m^3$ for periods of up to 56 weeks. Sample animals were killed at 4-week intervals during the 56-week exposure period, and also after the end of treatment until the 82nd week of age. From the 40th week onwards, Reeves reported that alveolar adenocarcinomas began to be found and tumors of this type were seen in all of 43 rats killed after the 56th week of exposure. No lung tumors were reported to have developed in 150 unexposed control rats.

Wagner *et al.* (1969) [18] exposed rats, monkeys and hamsters for 6 hours per day, 5 days per week to an atmosphere containing 15 mg/m^3 of bertrandite or beryl ore dust. The atmospheric concentrations in terms of beryllium (Be) were 210 $\mu g/m^3$ and 620 $\mu g/m^3$, respectively. After 17 months, 18 out of the 19 rats exposed to beryl ore at levels of 620 μg Be/m^3 had developed pulmonary tumors of various types. Lung changes, including granulomatous lesions, but no tumors, were seen in rats exposed to bertrandite dust. Monkeys and hamsters did not exhibit pre-neoplastic or neoplastic lesions as a result of exposure to either ore.

Schepers (1964) [51] found a 3-mm diameter neoplasm in a female monkey of the *Macacus mulatta* species that died 82 days after the last of 10 daily exposures (6 hours per day) to an aerosol of beryllium phosphate ($BeHPO_4$) at a concentration of 10,556 μg per cubic meter. The monkey was one of 20 females of the same species exposed variously to beryllium sulfate, beryllium fluoride or beryllium phosphate. Most of the monkeys died or were killed early in the experiment. Chemical pneumonitis was a common cause of death. The author could not rule out the possibility that the tumor was spontaneous in origin.

In 1966, Stokinger et al. reported upon beryllium induced pulmonary cancer in rats as found by Vorwald in various studies. Stokinger stated that:

> Primary pulmonary cancer appeared as early as 8 months after completion of the intratracheal injection and after 9 months of inhalation, 7 hours daily, 5 days a week. The incidence of the cancer was almost 100% in a large number of rats that had survived 18 months of daily exposure to beryllium sulfate aerosol, at a concentration averaging either 42 or 21 $\mu g/m$ of chamber air. Even at the very low concentration of 2.8 $\mu g/m$, which incidentally approaches the maximum allowable concentration of beryllium for human subjects, a substantial number (13 of 21) of rats developed pulmonary cancer. Pulmonary cancer had never been discovered in thousands of rats of many different strains that for purposes of control had lived in clean air.

In 1966, Vorwald et al.[74] gave each of the 20 young Rhesus monkeys a single intrabronchial and/or bronchomural implantation of pure beryllium oxide (5% suspension in physiological saline). They exposed an additional 10 monkeys intermittently, over a prolonged period, to an atmospheric concentration of beryllium sulfate aerosol of 35 $\mu g/m^3$. During the first 8 years of the study, three of the

monkeys exposed to beryllium oxide and two of those exposed to beryllium sulfate developed pulmonary cancers.

(b) *Bone Cancer in Experimental Animals by Intravenous Administration.* Gardner and Heslington (1946) were the first of many investigators to report the induction of osteosarcomas in rabbits following intravenous injection of zinc beryllium silicate or beryllium oxide. All of the 7 rabbits that survived treatment with zinc beryllium silicate for 7 months or more developed malignant osteosarcomas, often with

the site of the cancer, so the causative agent can be identified only through work histories."

Stoeckle et al. (1969)[28] reported the longterm follow-up of 60 selected cases of chronic beryllium disease first diagnosed between 1944 and 1966. The nature of the exposure to beryllium varied. At the time of the report, 18 patients had died: 13 from corpulmonale, 1 from respiratory insufficiency, 1 from cardiac arrest, 1 from virus pneumonia, 1 from renal insufficiency and 1 from an unstated cause. It is interesting that can-

with recent exposure died from leukemia." The report states further, that the "Incidence of lung cancer was higher than expected (four cases), although the small series does not allow a definitive conclusion."

The American Conference of Governmental Industrial Hygienists[27,32] in their "Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1975" have included beryllium in the category of "Occupational Substances Suspect of Oncogenic Potential for Workers." Beryllium was included in

such other information as may be appropriate. In addition to the attainment of the highest degree of health and safety protection for the employee, other considerations shall be the latest available scientific data in the field, the feasibility of the standards, and experience gained under this and other health and safety laws. [Section 6(b)(5)].

Sections 2(b) (5) and (6), 20, 21, 22, and 24 of the Act reflect Congress' recognition that conclusive medical or scientific evidence including causative factors, epidemiological studies or dose-response data may not exist for many toxic materials or harmful physical agents. Nevertheless, standards cannot be postponed because definitive medical or scientific evidence is not currently available. Indeed, while final standards are based on the best available evidence, the legislative history makes it clear that "it is not intended that the Secretary be paralyzed by debate surrounding diverse medical opinion." [House Committee on Education and Labor, Report No. 91–1291, 91st Cong., 2d Session, p. 18 (1970).] This Congressional judgment is supported by the courts which have reviewed standards promulgated under the Act. In sustaining the standard for occupational exposure to vinyl chloride (29 CFR 1910.1017), the U.S. Court of Appeals for the Second Circuit stated that "It remains the duty of the Secretary to act to protect the working man, and to act even in circumstances where existing methodology or research is deficient." ["Society of Plastics Industry, Inc. v. Occupational Safety and Health Administration," 509 F. 2d 1301, 1308 (2d Cir. 1975), *cert denied* ____ U.S. ____ 95 S.Ct. 1998, 44 L. Ed.2d 482 (1975).]

A similar rationale was applied by the U.S. Court of Appeals for the District of Columbia in reviewing the standard for occupational exposure to asbestos (29 CFR 1910.1001). The Court stated that

> some of the questions involved in the promulgation of these standards are on the frontiers of scientific knowledge, and consequently as to them insufficient data is presently available to make a fully informed factual determination. Decision making must in that circumstance depend to a greater extent upon policy judgments and less upon purely factual analysis.

["Industrial Union Department, AFL–CIO v Hodgson," 499 F. 2d 467, 474 (D.C. Cir. 1974).]

In setting standards, the Secretary is expressly required to consider the feasibility of the proposed standards. Senate Comm. on Labor and Public Welfare, S.Rep. No. 91–1282, 91st Cong., 2d Sess. 58 (1970). Nevertheless, considerations of technological feasibility are not limited to devices already developed and in use. Standards may require improvements in existing technologies or require the development of new technology. ["Society of Plastics Industry, Inc. v Occupational Safety and Health Administration," 509 F. 2d at 1309.]

Where appropriate, the standards are required to include provisions for labels or other forms of warning to apprise employees of hazards, suitable protective equipment, control procedures, monitoring and measuring of employee exposure, employee access to the results of monitoring, and appropriate medical examinations; moreover where a standard prescribes medical examinations or other tests, they must be made available at no cost to the employee [(Section 6(b)(7))]. Standards may also prescribe recordkeeping requirements where necessary or appropriate for enforcement of the Act or for developing information regarding occupational accidents and illnesses (Section 8(c)).

V. The Proposal

In the development of this proposal, the Occupational Safety and Health Administration (OSHA) has considered recommendations contained in the document "Criteria for a Recommended Standard . . . Occupational Exposure to Beryllium" which was developed for the Secretary of Labor by the National Institute for Occupational Safety and Health (NIOSH), Department of Health, Education, and Welfare. Further, OSHA has reviewed and considered the Atomic Energy Commission Control Requirements for beryllium exposure [1, 6, 12, 15, 22] as well as numerous reference works and journal articles.

The following discussion analyzes the significant issues of the proposed standard for occupational exposure to beryllium and its compounds:

A. *Scope and Application.* The proposed standard would apply to all workplaces in all industries, including construction and maritime as well as "general industry, where beryllium or any of its compounds or alloys, is produced, released, packaged, repackaged, stored, handled, used or transported, and over which OSHA has jurisdiction.

B. *Exposure Limits.* The proposed standard includes requirements addressing the hazards associated with inhalation of beryllium and dermal and eye contact with beryllium.

(1) *Permissible Exposure Limits.* In setting a permissible exposure limit for beryllium, OSHA recognizes that many of the matters considered in this proposal are controversial and that, at best, gaps exist in the available scientific evidence. OSHA believes that in this case we are dealing with a substance that causes chronic disease and perhaps cancer.

As to chronic beryllium disease, we are dealing with a latency period in man which by its very nature makes more difficult the setting of a safe standard insofar as beryllium is concerned. What we do know is that 10–12 new cases of diagnosed chronic beryllium disease are added to the Beryllium Registry each year. Whether these cases result from exposures higher than the present 2 $\mu g/m^3$ standard is unknown. Nor do we know what margin of safety, if any, might exist as to the present standard and its relationship to the working populace.

However, this decision in the proposal as to an appropriate level is not made without sound support. Here we are dealing with a substance that is carcinogenic in test animals at levels comparable to exposure levels suggestive of cancer in man. Based on the best available evidence, we do not know whether "safe" levels or "no effect" levels exist for a carcinogen and, if so, what they may be. Therefore, attempts to control levels are compromises between the best medical and scientific evidence on the one hand and practical considerations of technological and economic feasibility on the other.

It is not possible at this time to state precisely how low beryllium exposures can be maintained in all cases through engineering controls, but it is clear that many employers have successfully achieved control to levels well below the present standard for many years. Based on data from AEC in the period 1950–1961, when concerted efforts were made to reduce concentrations, NIOSH found that the established level of 2 $\mu g/m^3$ could be met, and that, though uniform control was not attained throughout a plant, the survey data showed that at one time or another nearly every job category was within permissible limits.[1] In one Ohio extraction plant exposure levels were recorded at or below 2 $\mu g/m^3$ over a seven year period.[9] Williams, in 1961,[15] presented results of surveys of beryllium exposures in 15 plants of various types which indicate that exposures were effectively controlled to well below the current standard in the preponderance of cases.

In view of the information presently available to OSHA, including the above, it appears reasonable to consider a reduction in the permissible exposure limit to 1 $\mu g/m^3$. We hope that comments submitted concerning this proposal will assist OSHA in its final determination of this issue.

(2) *Dermal and eye exposure limit.* Numerous studies of both human and animal responses to beryllium and its compounds have shown the substance, upon contact, to be capable of producing skin irritation, dermatitis, and ulcerations and inflammation of the conjunctiva, and corneal burns. For this reason the proposed standard would not allow employers to expose employees to skin or eye contact with bulk forms of beryllium (see definition of "bulk forms" in the proposed standard).

C. *Action Level.* The proposed standard does not prescribe an action level, below the TWA, at which certain measures such as monitoring and medical surveillance must generally be initiated and below which no monitoring or medical surveillance need be conducted. The concept of an action level provides, statistically, a means by which the employer may assure himself that his employees will not be exposed to a substance over the permissible exposure level. Where, however, a permissible exposure level is not a "safe" level but rather a level predicated upon feasibility, every justification appears to exist to require certain pro-

tective measures such as monitoring if there is any exposure to the substance. This would be true in the case of a carcinogen, where a "threshold" or "no effect" level may not or does not exist. Accordingly, the proposal requires that monitoring be instituted at any level of exposure.

D. *Measurement of Exposure.* The employer would be required to monitor the exposure of all employees exposed to airborne concentrations or to bulk forms beryllium. In conducting the monitoring of employee exposure the employer should be certain that such monitoring reflects employee exposure conditions over the entire work day.

In establishments having more than one work operation involving the use of beryllium, monitoring must be performed for each operation and each type of employee exposure.

Where measurement indicates levels of exposure to be above the permissible exposure limit, employers are required to monitor monthly. Otherwise, monitoring shall be done quarterly.

When any employee may be exposed by skin contact to bulk forms of beryllium, the employer must provide affected employees with protective clothing impermeable to the beryllium-containing material being handled.

E. *Methods of Measurement.* The proposal would require that exposure measurements reflect the actual exposure conditions for each employee. No specification is made for the location of the samples taken. Thus, the employer may choose to perform either personal, breathing zone, or general air samples, provided that the method chosen gives an accurate indication of the employee's exposures. Further, any appropriate combination of long-term or short-term samples would be acceptable. However, the proposal requires that all exposure measurements be calculated on an eight-hour time-weighted average basis, with the exception of the ceiling concentration measurements. The sampling method must collect both respirable and nonrespirable particles for analysis. Samplers which separate the collected material into size fractions are useful in indicating the relative particle size of the beryllium, but are of no value in assessing compliance with permissible limits, as these limits are based on the total airborne concentration.[18]

The proposal requires that the accuracy of the sampling method have a confidence level of 95%. The term "accuracy" refers to the difference between the measured value and the true concentration. It allows for both the random variation of the method (its precision) and the difference between the average result from the method and the true value (bias of the method). For beryllium, the required accuracy for concentration at or above 1.0 $\mu g/m^3$ is plus or minus 25% at a 95% confidence level. This means that out of a long series of measurements, 95% must be within 25% of the true value.

F. *Methods of Compliance.* The proposed standard would require the employer to immediately institute engineering controls to reduce employee exposures to or below the permissible limits except in situations where such controls are infeasible. Further, in situations where the engineering controls that can be instituted immediately will not reduce exposures to the time-weighted average limit, they must nonetheless be used to reduce exposures to the lowest practicable level, and be supplemented by the use of work practice controls. Where both engineering controls and work practice controls are insufficient to reduce exposure to the permissible limits, they must nonetheless be used to reduce exposures to the lowest practicable level. Where both engineering controls and work practice controls are insufficient to reduce exposure to the permissible limits, the use of personal protective devices, such as respirators, would be required. In addition, a program must be established and implemented to reduce exposures to within the permissible exposure limits or to the greatest extent feasible, solely by means of engineering controls. Written plans for this program must be developed and be furnished upon request for examination and copying to representatives of the Secretary and the Director. These plans must be reviewed and updated periodically to reflect the current status of exposure control.

Engineering controls are the preferred means of compliance because they reduce exposure hazards in the work place environment by removing the airborne contaminants. Engineering controls may include the installation of local exhaust ventilation or the modification of a process so as to reduce emission of the contaminant into the work place. When mechanical ventilation is used for engineering control, checks of air system efficiency, such as capture velocity, duct velocity or static pressure must be made at least every 3 months. These checks are necessary to assure that the primary control system (mechanical ventilation) is functioning effectively at all times.

When engineering controls prove to be infeasible or inadequate, work practice controls become the preferred means of compliance. Work practice controls include such items as the use of vacuum cleaners or water-spray cleaning methods, instead of compressed air. However, work practice controls are effective only when strong supervisory control is maintained.

Respirators are the least satisfactory means of control because of certain difficulties inherent in their use. Respirators are capable of providing good protection only if they are properly selected for the concentrations of airborne contaminants present, properly fitted to the employee, worn by the employee, and replaced when they have ceased to provide protection. While it is theoretically possible for all of these conditions to be met, it is more often the case that they are not, and as consequence, the protection of employees by respirators is not always effective.

G. *Regulated Area.* The proposal requires that regulated areas be established, that access be limited to authorized persons, and that a roster of persons authorized to enter be made weekly and maintained for at least 40 years or for the duration of the employment plus 20 years, whichever is longer. One purpose of establishing regulated areas is to limit the exposure to as few employees as possible. The burden on the employer is considered to be minimal since the provisions require the employer merely to identify and control such areas.

H. *Housekeeping and Waste Disposal.* Removal and prevention of accumulations of beryllium dust deposits on all surfaces in the workplace are important aspects in the control of air contaminants. To ensure that beryllium dusts and particles are not reintroduced into the workplace air, the proposal prohibits dry sweeping or the use of compressed air for cleaning of floors and other surfaces where beryllium dust is found.

Vacuuming and water-spray methods for dust removal are both safe and adequate provided the practices outlined in the proposal also calls for periodic cleaning of dust collection systems, i.e. ducts, filters, etc., to reduce dust accumulations which may create a fire hazard.

For disposal of beryllium wastes, scraps, equipment or debris, the proposal would require that such materials be collected and disposed of in sealed bags or other closed containers which will prevent dispersion of the beryllium outside of the bag or container.

I. *Medical Surveillance.* As discussed in Section II of this Notice, the toxic effects of overexposure to beryllium take many forms including perhaps cancer. Further, since the symptoms of chronic beryllium disease are often similar to those of other respiratory diseases, the real cause of the symptoms has often been incorrectly diagnosed as tuberculosis, sarcoidosis, etc. To diagnose a case of cancer or chronic beryllium disease requires supportive evidence of x-ray findings, immunological tests, pulmonary function tests, and the establishment of beryllium exposure by finding beryllium in urine or tissue or by strong epidemiological evidence of exposure. To differentiate beryllium disease from other respiratory ailments, the physician must evaluate the entire clinical picture.[19]

For beryllium workers, evidence of beryllium in the urine or tissues would not automatically indicate that they are suffering from beryllium disease, unless other evidence such as x-rays or pulmonary function tests indicate that such findings are probably an indication of the disease. For this reason, employees who work with beryllium should undergo medical screening so that indications of overexposure are detected as early as possible. OSHA has proposed medical surveillance requirements for employers having employees exposed to airborne

concentrations of beryllium above the TWA or ceiling limit. The purpose of the requirements is to ensure, to the extent possible, that early symptoms of cancer or beryllium disease are properly diagnosed and appropriate measures taken.

The proposed standard requires that a comprehensive medical and work history be taken at the time of initial assignment or upon institution of medical surveillance for any employee assigned to a regulated area. A medical examination including at least a 14 X 17 posterior-anterior chest x-ray; pulmonary function tests, including forced vital capacity; a baseline weight determination and a skin examination, must also be made available to employees.

In a June 5, 1974, letter to OSHA, Dr. Homayoun Kazemi,[21] Chief, Pulmonary Unit, Massachusetts General Hospital, recommended that tests of arterial blood gas or carbon monoxide diffusing capacity of the lung be made at least every three to five years for individuals working with beryllium. Dr. Kazemi stated that early interstitial lung disease may not appear as an abnormality on the chest x-ray or by measurements of forced vital capacity until the disease is in an advanced stage. Other experts agree that measurements of arterial blood gas or carbon monoxide diffusing capacity are more sensitive detectors of lung disease, but feel that it is technically infeasible for employers to have this test administered on a large scale. For this reason, OSHA has not included this test as part of the proposed medical surveillance requirements. However, the test is suggested in the Appendix C medical guidelines when tests of forced vital capacity are abnormal or the physician feels such an examination would be necessary.

Although the proposal specifies the types of medical tests and examinations to be given affected employees, the employer may allow the examining physician to use other types of medical examinations, provided they can give at least equal assurance of detecting the medical conditions pertinent to protecting employees from the health hazards associated with beryllium exposure. The employer may accept such alternative medical examinations if the employer obtains a statement from the physician setting forth the alternative medical examinations and the rationale for their substitution.

The employer must provide the examining physician with a copy of the standard for beryllium, including appendices; a description of the employee's duties; a description of any personal protective equipment used by the employee; the results of the employee's exposure measurement; and an estimate of the levels to which the employee will be exposed. The employer must also provide any available employee medical history information requested by the physician.

Following the medical examination, the employer must obtain a written opinion from the examining physician stating whether the employee has any medical condition that would place him at increased risk to his health, or that would be aggravated by exposure to beryllium. The physician's opinion must state any recommended limitations upon the employee's exposure or upon the employee's use of protective equipment and respirators. Also, the opinion must state that the employee has been informed of any medical conditions which require further examination or treatment, although the written opinion must not contain specific findings or diagnoses unrelated to the employee's exposure to beryllium. The employer must provide a copy of the physician's written opinion to each employee.

If, based on the physician's opinion, the employer determines that exposure of an employee to beryllium would materially impair the employee's health, it is the responsibility of the employer to remove the employee from exposure.

The employer must inform each employee who refuses required medical examinations of the possible health consequences of such refusal and the employee must sign a statement indicating an understanding of the risk involved in the refusal to be examined. The intent of this requirement is to encourage employees to take medical examinations. It is felt that a clear understanding of the necessity of medical examinations to minimize potential health consequences will encourage employees to accept the medical surveillance program.

J. *Employee Information and Training.* Information and training are essential for the protection of employees because an employee can do much to protect himself if he is informed of the nature of the hazards in his work place. To be effective, an employee education system must apprise the employee of the specific hazards associated with his work environment. For this reason, the employer would be required to inform each employee assigned to regulated areas of the nature of beryllium-related health problems, the necessity for exposure control and the medical and industrial hygiene monitoring programs. Further the employee must be instructed to report promptly the development of symptoms or conditions which could be attributed to overexposure to beryllium.

K. *Recordkeeping.* The proposed standard would require the employer to keep written records of the following: measurements of employee exposure; tests of mechanical ventilation system efficiency (where such systems are used for engineering control); annual training and information sessions; authorized personnel rosters; medical examinations and pre-placement histories.

Since symptoms of chronic beryllium disease often do not appear for many years after the last exposure to beryllium, records of exposure measurements and medical examinations should be retained for a period of years, even after the employee ceases to work in the beryllium industry. For this reason, the recordkeeping provisions of the proposal require the employer to retain these records for at least 40 years, or for the duration of employment plus 20 years, whichever is longer.

OSHA is aware that certain provisions of this proposal, such as medical surveillance and the extended retention period for exposure measurement and medical monitoring records may pose special problems to some employers, especially those who have small numbers of employees, operate with non-fixed places of employment, or use workforces which are highly transient in nature.

This awareness has been expressed by the Department of Labor in a statement submitted to the House Sub-Committee on Environmental Problems Affecting Small Business on 26 June 1975, as follows:

> It has become increasingly evident that the combined body of Federal regulations imposes a substantial, and, to some extent, unnecessary burden upon employers, particularly those who run small businesses. While most of these requirements serve a necessary and useful purpose, a definite potential exists for duplication, conflicting standards, and inappropriate recordkeeping requirements. In an effort to eliminate problems where any exist in the Department of Labor, I have requested my agency heads to assess the small business impact of the laws they administer and determine what can be done to ease the burden on the small employer, while still assuring compliance with the law.

Although it is clear that OSHA's first and primary responsibility is to assure employees safe and healthful places of employment, the Act and its legislative history recognize that economic and technological feasibility are legitimate factors to be considered in the setting of occupational safety and health standards.

In addition, the Act explicitly takes cognizance of its impact upon affected small business, specifically with respect to any recordkeeping requirements which are imposed.

Pursuant to section 8(d) of the Act, OSHA is exploring methods of reducing, to the maximum extent possible, the administrative and economic burdens of the proposal's various recordkeeping requirements.

While the proposal does not address itself to specific alternatives, OSHA invites comments concerning options which would both provide full protection to affected employees and at the same time minimize the administrative and economic burden on affected employers—especially those with small numbers of employees, non-fixed workplaces, or highly transient workforces.

A record of the tests of mechanical ventilation system efficiency is required to be maintained so that the employer can ensure that tests of the system are being made at the required time intervals. Further, the record is useful to the employer since the evaluation of the data obtained in any individual test is needed to compare the most recent test with previous tests to detect any trends that may be occurring.

L. *Observation of Monitoring.* Section 8(c)(3) of the Act requires that em-

ployers provide employees or their representatives with the opportunity to observe monitoring of employee exposures to toxic materials or harmful physical agents. In accordance with this section, the proposed standard contains provisions for such observation. To ensure that the right to observe is meaningful, observers would be entitled to receive an explanation of the measurement procedure, to observe all steps related to the measurement procedure, and to record the results obtained.

The observer, whether an employee or designated representative, must be provided with and is required to use any personal protective devices required to be worn by employees working in the area that is being monitored, and must comply with all other applicable safety procedures.

M. *Appendixes.* Three appendixes have been included in this proposal: Appendix A, "Substance Safety Data Sheet;" Appendix B, "Substance Technical Guidelines;" and Appendix C, "Medical Surveillance Guidelines." It should be noted that the appendixes have been included for informational purposes only. None of the statements contained therein should be construed as imposing a mandatory requirement which is not otherwise imposed or as negating any requirement which is imposed by the standard.

The information contained in Appendixes A and B is intended to aid the employer in complying with requirements of the standard. This information is also to be provided to employees as part of the annual training and education program.

Appendix C gives the employer a means of providing the examining physician with an explanation of the potential health effects of beryllium exposure and provides information needed by the physician to make an accurate results. Apof the medical examination results. Appendix C also lists other types of examinations, not required by the standard, which may help the physician in making an accurate determination of whether an employee should be exposed or should continue to be exposed to beryllium.

VI. Environmental Impact Assessment

The National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321–4347), requires, among other things, that Federal agencies assess their proposed major actions, including rulemaking, to determine whether a significant impact on the quality of the human environment may result. Furthermore, 29 CFR 1999.3(d) requires that where OSHA determines that an environmental impact statement should be prepared, the determination to do so must be published in the Federal Register. Accordingly, it is hereby noticed that OSHA intends to prepare an environmental impact statement on the proposed standard for occupational exposure to beryllium in accordance with the requirements of 29 CFR Part 1999.

Once the draft environmental impact statement has been prepared, a copy of it will be made available by OSHA to any member of the public who requests an opportunity to comment on it. Any person or agency submitting comments on it to OSHA must at the same time forward five copies of the comments to the Council on Environmental Quality (CEQ), 722 Jackson Place NW., Washington, D.C. A 45-day period will be allowed for the submission of comments after the publication of the notice of availability of the draft environmental impact statement. The draft statement will be available, where practicable, at least 15 days prior to a public hearing on the proposed standard. The environmental impact of the proposal would be an appropriate issue at such hearing.

It appears at present that the preceding preamble to the proposed standard for occupational exposure to beryllium adequately assesses the impact of the proposal on the workplace environment. It further appears that the proposed standard for occupational exposure to beryllium will have no significant effects on the quality of the human environment external to the workplace. The proposal does not increase the amount of beryllium permitted to be released into the ambient air, nor does the proposal call for changes of industry practice in disposal of beryllium wastes. For these reasons, OSHA does not anticipate any increased impact on the community contiguous to establishments in which beryllium is used or produced.

Interested persons may submit comments that may be helpful in preparing the draft environmental impact statement on the proposed standard. A person having revelant information or data not readily available in the open literature is invited to submit it to David R. Bell, Office of Standards Development, Occupational Safety and Health Administration, U.S. Department of Labor, 200 Constitution Avenue NW., Room N3669, Washington, D.C. 20210, by November 17, 1975. Comments submitted in regard to the proposed standard need not be resubmitted. All material received on environmental impact will be available for public inspection and copying at the above address.

VII. Notes and References

The studies discussed herein represent the primary sources upon which the proposed beryllium standard is based. The discussion does not include all studies and source materials which OSHA has considered in the development of this proposal. A complete list of references is available for inspection and copying at the OSHA Technical Data Center, Room N3620, U.S. Department of Labor, 200 Constitution Avenue, N.W., Washington, D.C. 20210.

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VIII. Public Participation

Interested persons are invited to comment on the proposed standard on or before December 16, 1975. Written data, views and arguments must be submitted in quadruplicate to the Docket Officer, OSHA Technical Data Center, Docket No. H005, Room N3620, 200 Constitution Avenue, N.W., U.S. Department of Labor, Washington, D.C. 20210. Written submissions must clearly identify the provisions of the proposed standard addressed and the position taken with respect to each such provision. The data, views and arguments will be available for public inspection and copying at the above address and will be made a part of the record.

In addition to the comments and objections invited above, OSHA hereby solicits comments from interested persons regarding the potential inflationary impact of the proposed standard. Comments may be directed toward any or all of the following subjects:

(1) Cost impact on consumers, businesses, markets or Federal, state, or local government;

(2) Effect on productivity of wage-earners, businesses or government;

(3) Effect on competition;

(4) Effect on supplies of important materials, products, or services;

(5) Effect on employment; and

(6) Effect on energy supply or demand.

It is OSHA's intention to prepare an inflationary impact statement and analysis, if appropriate, or a certification that the proposal has no substantial inflationary impact, at least 30 days prior to any public hearings on the proposed standard. The potential inflationary impact of the proposed standard will be an appropriate issue at the hearings.

This procedure has been concurred in by the Council on Wage and Price Stability in accordance with the Office of Management and Budget Circular A-107 (January 28, 1975), issued pursuant to Executive Order 11821 (39 FR 41501, November 27, 1974).

Pursuant to 29 CFR 1911.11 (b) and (c), interested persons may, in addition to filing written matter as provided above, file objections to the proposal requesting an informal hearing with respect thereto in accordance with the following conditions:

(1) The objections must include the name and address of the objector;

(2) The objections must be postmarked on or before December 16, 1975.

(3) The objections must specify with particularity the provision of the proposed rule to which objection is taken, and must state the grounds therefor;

(4) Each objection must be separately stated and numbered; and

(5) The objections must be accompanied by a summary of the evidence proposed to be adduced at the requested hearing.

The proposed standard will be reviewed after consideration of the entire record of this proceeding, including any oral and written data, views or arguments will be modified appropriately if the submissions so warrant.

Accordingly, pursuant to sections 6(b) and 8(c) of the Occupational Safety and Health Act of 1970 (84 Stat. 1593, 1599; 29 U.S.C. 655, 657), and 29 CFR Part 1911, it is hereby proposed to amend Part 1910 of Title 29 of the Code of Federal Regulations as set forth below.

Signed in Washington, D.C. this 10th day of October, 1975.

JOHN T. DUNLOP,
Secretary of Labor.

1. Table Z–2 in § 1910.1000 is proposed to be amended by deleting the following:

§ 1910.1000 [Amended]

* * * * *

Beryllium and beryllium compounds . . .	2μg./m³ . . .	5μg/m³ . . .	25μg/m³ . . . 30 minutes (Z37.29–1970)

* * * * *

2. A new § 1910.1026 is proposed to be added to Part 1910 of Title 29 of the Code of Federal Regulations, reading as follows:

§ 1910.1026 Beryllium.

(a) *Scope and application.* This section applies to the transportation, production, release, packaging, repackaging, storage, handling, or use of beryllium ex-

cept that this section will not apply to working conditions with respect to which any other Federal agency has exercised statutory authority to prescribe or enforce standards or regulations affecting occupational safety or health hazards.

(b) *Definitions.* "Authorized persons" means any person authorized by the employer to enter a regulated area, or any person entering such an area as a designated representative of employees for the purpose of exercising the opportunity to observe monitoring and measuring procedures under paragraph (d) of this section.

"Beryllium" means elemental beryllium and compounds and alloys of beryllium (as elemental beryllium) that may be released into the place of employment as particulate matter or that may be present in the place of employment in bulk forms.

"Bulk forms" means beryllium which is not airborne but which poses a dermal hazard to employees upon contact with, of penetration of the skin. Such forms include soluble beryllium compounds or solid forms (i.e. crystals, chips, shavings, etc.) of soluble or insoluble beryllium which could penetrate the skin.

"Director" means the Director, National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, or his designee.

"Emergency" means any occurrence such as, but not limited to equipment failure, rupture of containers, or failure of control equipment which is likely to, or does, result in the unexpected release of beryllium in excess of the ceiling limit.

"Secretary" means the Secretary of Labor, U.S. Department of Labor, or his designee.

(c) *Exposure limits*—(1) *Permissible exposure limits*—(i) *Time-weighted average limit (TWA).* No employee may be exposed to an 8-hour time-weighted average airborne concentration of beryllium in excess of 1.0 per cubic meter of air (1.0 ug/m^3), based on a 40-hour work week.

(ii) *Ceiling limit.* No employee may be exposed to an airborne concentration of beryllium in excess of 5 micrograms per cubic meter of air (5 μg/m^3) as averaged over a maximum sampling time of 15 minutes.

(2) *Dermal and eye exposure limit.* No employee may be exposed by skin or eye contact to bulk forms of beryllium.

(d) *Exposure monitoring and measurement*—(1) *Initial monitoring.* Each employer who has a place of employment in which beryllium, is present shall monitor each such workplace and work operation to accurately measure if any employee may be exposed to beryllium above the permissible exposure limits, and determine if any employee is exposed by skin contact with bulk forms of beryllium. Such a determination shall be made by monitoring which is representative of each employee's exposure to beryllium over an 8-hour period.

(2) *Measurements below the permissible limit.* If the measurements under paragraph (d)(1) of this section reveal employee exposure, to be below the permissible exposure limits the employer shall repeat the measurements for each employee at least quarterly.

(3) *Measurements above the Permissible Limits.* (i) Where the measurements reveal employee exposures to be in excess of the permissible exposure limits, the measurements required under paragraph (d)(1) of this section shall be repeated for each employee at least monthly. The employer shall continue measurements under this paragraph (d)(3) until at least two consecutive measurements are below the permissible exposure limits and thereafter the employer shall comply with paragraph (d)(2) of this section.

(ii) If exposure measurements reveal employee exposure to be above the TWA or the ceiling limit, the employer shall, in addition to the requirement in paragraph (d)(3)(i):

(*a*) Inform the employee of the exposure as required by paragraph (d)(5) of this section;

(*b*) Institute control measures as required by paragraph (f) of this section; and

(c) Provide personal protective equipment and clothing as required by paragraphs (g) and (i) of this section.

(4) *Additional monitoring.* Whenever there has been a production process control change which may result in new or additional exposures, or whenever the employer has any other reason to suspect a change which may result in new or additional exposures, or whenever the employer has any other reason to suspect a change in exposure conditions, additional measurements in accordance with this paragraph shall be made.

(5) *Employee notification.* The employer shall individually notify in writing, within 5 working days after the receipt of measurement results, every employee who is found to be exposed to beryllium above the TWA or the ceiling limit. Such notification need not be given more frequently than once a month. The employee shall also be notified of the corrective action being taken, to reduce exposure to or below the permissible limits.

(6) *Accuracy of measurement.* The method of measurement shall have an accuracy (with a confidence limit of 95%) of not less than plus or minus 25% for concentrations of beryllium greater than or equal to 1.0 ug/m^3. Sampling of airborne concentrations of beryllium to determine employee exposure, shall be performed by methods which collect all airborne particles (i.e. respirable and nonrespirable).

(7) *Employee exposure.* For the purposes of this section, employee exposure is that exposure which would occur if the employee were not using a respirator.

(e) *Regulated Areas.* (1) A regulated area shall be established where concentrations are in excess of the permissible exposure limits,

(2) Access to regulated areas shall be limited to authorized persons.

(3) A weekly roster shall be made of all persons who enter a regulated area.

(f) *Methods of compliance.*—(1) *Engineering controls.* (i) Engineering controls shall be instituted immediately to reduce exposures to or below the permissible exposure limits, except to the extent that such controls are not feasible.

(ii) A program shall be established as soon as practicable, and implemented to reduce exposures to or below the permissible exposure limits or to the greatest extent feasible, solely by means of engineering controls.

(iii) Written plans for such a program shall be developed and furnished upon request for examination and copying to the Secretary and the Director. Such plans shall be reviewed and revised at least every 6 months to reflect the current status of the program.

(iv) When mechanical ventilation is used to control exposure, measurements which demonstrate the effectiveness of the system to control the exposure, such as capture velocity, duct velocity, or static pressure, shall be made at least every three months. Measurements of the system's effectiveness to control exposure shall also be made within 5 days of any change in production, process, or control which might result in any change in airborne concentrations of beryllium.

(2) *Work practice controls.* Wherever feasible engineering controls which can be instituted immediately are not sufficient to reduce exposures to or below the permissible exposure limits, they shall nonetheless be used to reduce exposures to the lowest practicable level, and shall be supplemented by work practice controls.

(3) *Respirators.* Where feasible engineering controls and supplemental work practice controls are insufficient to reduce exposures to or below permissible exposure limits, they shall nonetheless be used to reduce exposures to the lowest practicable level and shall be supplemented by the use of respirators in accordance with paragraph (g) of this section as required.

(g) *Respiratory protection*—(1) *Permitted use.* Where respirators are required under this section, compliance with the permissible exposure limit may not be achieved by the use of respirators except:

(i) During the time period necessary to install engineering controls; or

(ii) In work situations such as maintenance and repair activities in which engineering controls are not feasible; or

(iii) In work situations in which engineering controls and supplemental work practice controls are insufficient to reduce exposure to or below the permissible exposure limits; or

(iv) In emergencies.

(2) *Respirator selection.* (i) Where respirators are required under this section the employer shall select and provide the appropriate respirator from Table 1 and shall ensure the employee uses the respirator provided.

TABLE 1

RESPIRATORY PROTECTION FOR BERYLLIUM

Concentration of Beryllium (ug/m)[3]	*Required Respirator*
Equal to or less than 10.	(a) Air-purifying respirator equipped with high-efficiency filters[1] and quarter-mask or half-mask facepiece; or (b) Supplied air respirator equipped with half mask facepiece.
Equal to or less than 50.	(a) Air-purifying respirator equipped with high-efficiency filters[1] and full facepiece; or (b) Supplied-air respirator equipped with full facepiece; or (c) Self-contained breathing apparatus equipped with full facepiece.
Equal to or less than 1,000.	(a) Supplied-air respirator equipped with half-mask facepiece and operated in continuous flow mode; or (b) Powered air purifying respirator equipped with high efficiency filters[1] and equipped with half-mask or full facepiece or hood.
Equal to or less than 2,000.	(a) Supplied-air respirator equipped with full facepiece, helmet, or hood and operated in continuous flow or pressure-demand mode.
Greater than 2,000 or unknown.	(a) Self-contained breathing apparatus equipped with full facepiece and operated in pressure-demand mode.

[1] NOTE: High efficiency filter—99.97 percent efficient against 0.3 micron size particles.

(ii) Respirators shall be selected from those approved by the Mining Enforcement and Safety Administration (formerly called the Bureau of Mines) or by the National Institute for Occupational Safety and Health under the provisions of 30 CFR Part 11.

(iii) Respirators prescribed for higher concentrations may be used for any lower concentration.

(3) *Respirator program.* (i) The employer shall institute a respiratory program in accordance with § 1910.134 (b), (d), (e), and (f).

(ii) Employees who wear respirators shall be allowed to leave work areas to wash the face and respirator facepiece to prevent potential skin irritation associated with respirator use.

(h) *Emergency situations*—(1) *Written plan.* (i) A written plan for emergency situations shall be developed for each facility involved in a beryllium operation in which there is a possibility of an emergency. Appropriate portions of the plan shall be implemented in the event of an emergency.

(ii) The plan shall specifically provide that employees engaged in correcting emergency conditions shall be equipped as required in paragraphs (g) and (i) of this section until the emergency is abated.

(iii) Employees not engaged in correcting the emergency shall be restricted from the area and normal operations in the affected area(s) shall not be resumed until the emergency is abated.

(2) *Alerting employees.* Where there is the possibility of employee exposure to beryllium in excess of the ceiling limit due to the occurrence of an emergency, a general alarm shall be installed and maintained to promptly alert employees of such occurrences.

(i) *Skin protection and work clothing.*—(1) *Work clothing.* Where employees are exposed to airborne concentrations of beryllium in excess of the permissible exposure limits, or are subject to skin contact with bulk forms of beryllium the employer shall provide and ensure that employees wear work clothing and other appropriate protective equipment in accordance with this paragraph.

(i) The employer shall provide each employee with coveralls or similar full-body work clothing, headcoverings, and work shoes or shoe coverings. Resin-impregnated paper or similar disposable work clothing may be substituted for fabric-type clothing.

(ii) New or laundered work clothing shall be provided at least daily to each affected employee.

(2) *Skin and eye protection.* (i) Wherever employees are subject to skin contact with bulk forms of beryllium, the employer shall provide and ensure that employees wear protective gloves impermeable to the material handled.

(ii) Additional protection such as face shields, goggles, and gauntlets, which provide protection for eyes, face, neck, arms and other exposed skin areas, shall be provided if the operation could result in such areas having contact with bulk forms of beryllium.

(iii) Protective clothing and equipment required by this paragraph shall be supplied to each employee daily, and shall be maintained in accordance with paragraph (j) of this section.

(j) *Equipment and clothing laundering and maintenance.*—(1) *Laundering.* (i) The employer shall launder, maintain, or dispose of skin protective devices and work clothing required by paragraph (i) of this section.

(ii) The employer shall inform any person who launders or cleans beryllium contaminated protective devices or work clothing of the potentially harmful effects of exposure to beryllium.

(2) *Removal and storage.* (i) the employer shall ensure that employees remove contaminated work clothing only in change rooms as required by paragraph (m)(1) of this section.

(ii) The employer shall ensure that no employee removes contaminated protective devices and work clothing from the change room except for those employees authorized to do so for the purpose of laundering, maintenance, or disposal.

(iii) Beryllium-contaminated protective devices and work clothing shall be placed and stored in closed containers which prevent dispersion of the beryllium outside the container.

(iv) Containers of contaminated protective devices or work clothing which are to be removed from change rooms or from the work place for laundering or disposal, or for any other reason, shall bear labels in accordance with paragraph (p)(2) of this section.

(v) Dust removal by blowing or shaking of work clothing is prohibited.

(k) *Housekeeping*—(1) *Work surfaces.* (i) All external work surfaces shall be maintained free of accumulations of beryllium dust.

(ii) Dry sweeping and the use of compressed air for the cleaning of floors and other surfaces where beryllium dust is found is prohibited.

(iii) Where vacuuming methods are selected, either portable units or permanent systems may be used.

(*a*) If a portable unit is selected, the exhaust shall be attached to the general workplace exhaust ventilation system or collected within the vacuum unit, equipped with high efficiency filters, so that beryllium is not reintroduced into the work place air; and

(*b*) Portable vacuum units used to collect beryllium, may not be used for other cleaning purposes and shall be labeled as prescribed by paragraph (p)(2) of this section.

(iv) Cleaning of floors and other contaminated surfaces may not be performed by washing down with a hose, unless a fine spray has first been laid down.

(2) *Dust collection systems.* Periodic cleaning of dust collection systems, i.e. ducts, filters, etc. shall be performed to reduce beryllium dust buildups.

(l) *Waste disposal.* Beryllium waste, scrap, debris, bags, containers or equipment, consigned for disposal, shall be collected and disposed of in sealed bags or other closed containers which prevent dispersion of beryllium outside the container.

(m) *Hygiene facilities and practices.* Where employees are exposed to airborne concentrations of beryllium in excess of the permissible exposure limits, the facilities described by this paragraph shall be provided by the employer for the use of those employees and employees shall be required to use the facilities provided.

(1) *Change rooms.* The employer shall provide change rooms in accordance with § 1910.141(e).

(2) *Showers.* Showers shall be provided in accordance with § 1910.141(d)(3).

(3) *Locker-shower arrangements.* Clothes locker and shower facilities shall be so arranged that the showers serve to demarcate between potentially contaminated and uncontaminated areas.

(4) *Lavatory-toilet arrangements.* Lavatory and toilet facilities which are located in beryllium contaminated areas shall be so arranged that no access is available to an uncontaminated area.

(n) *Medical surveillance*—(1) *General requirements.* (i) Each employer who has a place of employment in which employees are, have been, or will be exposed to

beryllium above the permissible exposure limit or ceiling limit shall institute a medical surveillance program.

(ii) The program shall provide each affected employee with an opportunity for medical examinations in accordance with this paragraph.

(iii) If any employee refuses any required medical examination, the employer shall inform the employee of the possible health consequences of such refusal and obtain a signed statement from the employee indicating that the employee understands the risk involved by the refusal to be examined.

(iv) All medical examinations and procedures shall be performed by or under the supervision of a licensed physician, and shall be provided during the employee's normal working hours, without cost to the employee.

(2) *Initial examinations.* At the time of initial assignment, or upon institution of medical surveillance, the following shall be performed by the physician:

(i) A work history and a medical history which shall include the presence and degree of respiratory symptoms, i.e., breathlessness, cough, sputum production and wheezing; and

(ii) A medical examination which must include as a minimum the following:

(*a*) A 14 x 17 posterior-anterior chest X-ray;

(*b*) Pulmonary function tests to include forced vital capacity (FVC);

(*c*) Baseline weight; and

(*d*) A skin examination.

(3) *Periodic examinations.* (i) Examinations specified in this paragraph shall be performed at least annually for all employees specified in paragraph (n)(1) of this section.

(ii) If an employee has not had the examinations prescribed in paragraph (n)(2) of this section within 3 months of his termination of employment, the employer shall make such examination available to the employee.

(4) *Alternative medical examinations.* If the examining physician determines that alternative medical examinations to those specified in paragraph (n)(2) of this section will provide at least equal assurance of detecting medical conditions pertinent to protecting the employee from the health hazards associated with exposure to beryllium, the employer may accept such alternative medical surveillance examinations as meeting the requirements of this section provided that the employer:

(i) Obtains a statement from the examining physician setting forth the alternative medical examinations and the rationale for their substitution; and

(ii) Informs each exposed employee of the fact that alternative medical examinations to those required in paragraph (n)(2) of this section are to be made available.

(5) *Interim examinations.* Each employee exposed to beryllium due to the occurrence of an emergency shall be provided the medical examinations prescribed in paragraph (n)(2) of this section.

(6) *Information provided to the physician.* The employer shall provide the following information to the examining physician:

(i) A copy of this regulation for beryllium including Appendixes A, B, and C;

(ii) A description of the affected employee's duties as they relate to his exposure;

(iii) The results of the employee's exposure measurement;

(iv) A description of any personal protective equipment used;

(v) The employee's anticipated or estimated exposure level (for preplacement examinations or in cases of exposure due to an emergency); and

(vi) Upon request of the physician, information from previous medical examinations of the affected employee.

(7) *Physician's written opinion.* (i) The employer shall obtain a written opinion from the examining physician, containing the following:

(*a*) The physician's opinion as to whether the employee has any detected medical condition which would place the employee at increased risk of material impairment of the employee's health from exposure to beryllium, or which would directly or indirectly aggravate any detected medical condition; and

(*b*) Any recommended limitations upon the employee's exposure to beryllium and upon the use of protective equipment and respirators; and

(*c*) A statement that the employee has been informed by the physician of any medical conditions which require further examination or treatment.

(ii) The written opinion shall not reveal specific findings or diagnoses unrelated to exposure to beryllium.

(iii) A copy of the written opinion shall be provided to the affected employee.

(iv) If the employer determines, on the basis of the physician's written opinion, that any employee's health would be materially impaired by continued exposure to beryllium, such employee shall be withdrawn from possible exposure to beryllium.

(o) *Employee information and training.*—(1) *Training program.* (i) The employer shall provide a training program for all employees assigned to workplace areas where any beryllium is produced, released, packaged, repackaged, stored, handled, or used.

(ii) The training program shall be provided at the time of initial assignment, and at least annually thereafter, and shall include informing each employee of:

(*a*) The information contained in the substance data sheets for beryllium, which are contained in Appendixes A and B;

(*b*) The quantity, location, manner of use, release or storage of beryllium and the specific nature of operations which could result in exposure to beryllium at or above the permissible limits as well as any necessary protective steps;

(*c*) The purpose, proper use, and limitations of respiratory devices as specified in § 1910.134 (b), (d), (e), and (f);

(*d*) The purpose and a description of the medical surveillance program as required by paragraph (n) of this section and the information contained in Appendix C;

(*e*) Emergency procedures as required by paragraph (h) of this section; and

(*f*) A review of this standard.

(2) *Access to training materials.* (i) A copy of this standard and its appendices shall be readily available to all employees exposed to beryllium.

(ii) All materials relating to the employee information and training program shall be provided upon request to the Assistant Secretary and the Director.

(p) *Precautionary labels and signs.* (1) *General.* (i) Labels or signs required by this paragraph may be in addition to or in combination with labels required by other statutes, regulations or ordinances.

(ii) No statement shall appear on or near any required sign, label or instruction which contradicts or detracts from the effect of any such required sign, label or instruction.

(2) *Labels.* Precautionary labels shall be applied to all containers, packages or equipment containing beryllium. The label shall provide at least the following information:

(i) The word "WARNING" or "DANGER"

(ii) The word "Beryllium" (may include additional words such as alloy, powder, product, etc.)

(iii) A warning statement against breathing dusts or fumes,

(iv) A warning statement to avoid skin or eye contact where such hazards are present and to wash thoroughly after handling.

(3) *Signs.* Entrances or access ways to regulated areas shall be posted with legible signs bearing the legend:

WARNING (OR DANGER)

AUTHORIZED PERSONNEL ONLY

Respirators and Protective Clothing Required to be Worn in this Area

(q) *Recordkeeping* — (1) *Exposure measurement.* The employer shall keep an accurate record of all measurements taken to monitor employee exposure to beryllium as prescribed in paragraph (d) of this section.

(i) This record shall include:

(*a*) The date of measurements;

(*b*) The operation involving exposure to beryllium which is being monitored;

(*c*) Sampling and analytical methods used and evidence of their accuracy;

(*d*) Number, duration, and results of samples taken;

(*e*) Type of protective devices worn, if any; and

(*f*) Name and social security number and exposure of the employee monitored.

(ii) This record shall be maintained for at least 40 years, or for the duration of the employee's employment plus 20 years, whichever is longer.

(2) *Mechanical ventilation measurements.* When mechanical ventilation is used as an engineering control, the employer shall maintain a record of the measurements demonstrating the effectiveness of such ventilation as required by paragraph (f)(1)(iv) of this section.

(i) This record shall include:
(a) Date of measurement;
(b) Type of measurement taken; and
(c) Result of measurement.
(ii) This record shall be maintained for at least two years.

(3) *Employee training.* The employer shall keep an accurate record of all employee training required by paragraph (o) of this section.
(i) This record shall include:
(a) Date of training;
(b) Name and social security number of employee trained; and
(c) Content or scope of training provided;
(ii) This record shall be maintained for at least 2 years.

(4) *Medical surveillance.* The employer shall keep an accurate medical record for each employee subject to medical surveillance required by paragraph (n) of this section.
(i) The record shall include:
(a) Physician's written opinion;
(b) Any employee medical complaints related to exposure to beryllium;
(c) A copy of the information provided to the physician as required by paragraph (n)(6) of this section; and
(d) A signed statement of any refusal to be examined.
(ii) This record shall be maintained for at least 40 years, or for the duration of employment plus 20 years, whichever is longer.

(5) *Rosters.* Rosters required by paragraph (e)(3) of this section shall be maintained for at least 40 years.

(6) *Availability.* (i) All records required to be maintained by this section shall be made available upon request to the Secretary and the Director for examination and copying.
(ii) Employee exposure measurement records as required by paragraph (q)(1) of this section shall be made available for examination and copying to employees, former employees, and their designated representatives.
(iii) Employee medical records required to be maintained by this section shall be made available upon request for examination and copying to a physician designated by the employee or former employee.

(7) *Transfer of records.* (i) In the event the employer ceases to do business, the successor shall receive and retain all records required to be maintained by this section.
(ii) In the event the employer ceases to do business and there is no successor to receive and retain his records, these records shall be transmitted by mail to the Director, and each employee and former employee shall be individually notified in writing of this transfer.

(r) *Observation of monitoring.* (1) *Employee observation.* The employer shall give his employees or their representatives, an opportunity to observe any measuring of their exposure to beryllium which is conducted pursuant to this section.

(2) *Observation procedures.* (i) When observation of the monitoring of employee exposure to beryllium requires entry into an area where the use of personal protective devices is required, the observer shall be provided with and required to use such equipment and shall comply with all other applicable safety and health procedures.
(ii) Without interfering with the measurement, observers shall be entitled to:
(a) Receive an explanation of the measurement procedures;
(b) Observe all steps related to the measurement of airborne concentration of beryllium performed at the place of exposure; and
(c) Record the results obtained.

(s) *Effective date.* This standard shall become effective 30 days following publication of the final standard in the FEDERAL REGISTER.

(t) *Startup dates.* (1) *Employee measurement.* Measurements prescribed in paragraph (d) of this section shall be instituted within 3 months of the effective date of the final standard, except that for new production areas or operations such measurements shall be instituted within 30 days of startup of operation.

(2) *Medical surveillance.* Medical surveillance prescribed in paragraph (n) of this section shall be instituted within 3 months of the promulgation of the final standard.

(u) *Appendixes.* The information contained in the appendixes to § 1910.1026 is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.

APPENDIX A

SUBSTANCE SAFETY DATA SHEET

Beryllium

I. SUBSTANCE IDENTIFICATION

A. Substance Beryllium
B. Permissible exposure:
1. *Airborne.* 1.0 microgram of beryllium per cubic meter of air (1.0$\mu g/m^3$), time-weighted-average (TWA) for an 8-hour workday, with a ceiling concentration limit of 5$\mu g/m^3$ as averaged over a maximum sampling time of 15 minutes.
2. *Dermal.* Skin contact with bulk forms of beryllium is prohibited.
C. Appearance: Steel-gray-solid (metal)

II. HEALTH HAZARD DATA

A. Ways in which beryllium affects your body: Beryllium can affect your body when you breathe in airborne beryllium particles. Certain forms of beryllium can also cause diseases of the skin and eyes if they contact such areas.
B. Effects of overexposure:
1. *Short-term overexposure:* Breathing airborne concentrations of beryllium materials may cause damage to your respiratory system. Symptoms of overexposure may include spasmodic cough, substernal discomfort and burning, tightness of the chest, difficulty in breathing upon exertion, mild nose bleeds and irritation of nasal and bronchial passages.

Skin contact with certain forms of beryllium may cause skin disease. Symptoms of skin disease include itching and reddened, elevated, or fluid accumulated lesions which appear on the body, especially the face, neck, arms and hands. Ulcers can result from implantation of beryllium substances in skin areas previously injured as a result of abrasions, cuts, etc. Abscess and ulceration frequently result from such exposure.

Eye effects may occur as inflammation of the conjunctiva in "splash burn" or in association with contact dermatitis. Splashes may also cause corneal burns closely resembling those produced by acids and alkalies. Fluid accumulation and reddening around the eye socket are frequently observed.

2. *Long-term (chronic) overexposure:* If you are overexposed to beryllium for long periods of time you may develop serious respiratory disease. This disease may not develop until many years after exposure. Early symptoms and signs may include weakness, easy fatigability, weight loss, cough and chest pain.

III. EMERGENCY AND FIRST AID PROCEDURES

1. *Skin exposure:* If powders or liquids containing beryllium contact skin areas, immediately wash the affected skin areas with soap and water to remove the beryllium.
2. *Eye exposure:* If a beryllium is splashed into the eyes, the eyes should be flushed immediately with water for at least 5 minutes. The individual should then be referred to a physician.
3. *Breathing:* Individuals who accidentally inhale large amounts of beryllium dust or fumes should be removed from contact with beryllium and immediately referred to a physician.

IV. PROTECTIVE CLOTHING AND EQUIPMENT

A. *Respirators:* Respirators can only be required for routine use if your employer is in the process of installing engineering controls and in situations where these controls are insufficient or cannot feasibly reduce exposure levels to permissible limits. You may be required to wear respirators for nonroutine activities or in emergencies if you are likely to be exposed in excess of permissible exposure limits. If respirators are worn, they must have a Mining Enforcement and Safety Administration or National Institute for Occupational Safety and Health (NIOSH) seal of approval. (Older respirators may have a Bureau of Mines approval label). If you experience difficulty breathing while wearing a respirator, tell your employer.

B. *Protective clothing.* Protective clothing must be provided for you and you must wear such clothing to prevent beryllium from being carried outside the workplace on your own clothing and to protect your skin from contact with beryllium.

C. *Eye and face protection:* Your employer is required to provide and you must wear safety goggles if beryllium dust or solutions could be splashed in your eyes, and a face shield if solutions could be splashed on your face.

V. PRECAUTIONS FOR SAFE USE, HANDLING AND STORAGE

Beryllium should be cleaned up by vacuuming or by wet methods. Where you are subject to airborne beryllium particles in excess of the permissible limits, you must wear clean work clothes every day and shower at the end of each work day. You may not wear your work clothes home. Containers of beryllium substances should be safely handled and stored to prevent breakage and possible dispersion of beryllium into the air. Ask your supervisor where beryllium is used in your work area and for any additional plant safety rules.

VI. REGULATED AREAS

Only employees authorized by your employer should enter a regulated area.

APPENDIX B

SUBSTANCE TECHNICAL GUIDELINES

Beryllium

I. PHYSICAL AND CHEMICAL DATA

A. Substance Identification
1. Synonyms: Glucinium
2. Formula: Be
3. Be containing materials (examples):

Be carbonate, Be fluoride, Be silicate, Be hydroxide, Be sulfate, Be chloride, Be oxide, Be oxyfluoride, Be copper alloys, Be nickel alloys, Beryl (BeO·Al203·6Si02), Bertrandite (Be4Si1207(OH12), Chrysoberyl (Be Al1204). Phenacite (BeSi04).

B. Physical Data (Beryllium Metal)
1. Boiling Point (760 mm Hg): 2970 C
2. Specific gravity @ 25 C: 1.85
3. Melting Point: 1283 C
4. Solubility in water: Insoluble
5. Vapor Pressure @ 1910 C: 7.6 mm Hg
6. Appearance (Metal): Steel-gray-solid

II. FIRE, EXPLOSION, AND REACTIVITY DATA

Locations where very fine dusts or powders of Beryllium may be present are considered Class II Group E for the purpose of conforming to the requirements of 29 CFR 1910.309.

III. SPILL OR LEAK PROCEDURES

A. *Steps to be taken if substance is released or spilled:* Clean-up crews are required to wear protective clothing and appropriate respiratory protection. Vacuum clean-up procedures are recommended although wet methods are acceptable. B. Persons not wearing protective equipment and not involved in clean-up operations should be restricted from areas of spills until clean-up has been completed. C. *Waste Disposal Method:* Beryllium waste and scrap should be recycled or buried.

IV. MONITORING AND MEASUREMENT PROCEDURE

Measurements taken for the purpose of determining exposure under this section are best taken such that the average 8-hour exposure may be determined from a single sample or two (2) 4-hour samples. Short time interval samples (up to 30 minutes) may also be used to determine average exposure level if a minimum of five (5) measurements are taken in a random manner over the work shift. Random sampling means that any portion of the work shift has the same chance of being sampled as any other. The arithmetic average of all such random samples taken on one (1) work shift is an estimate of an work shift. The short-term interval samples should also be used to ensure that no exposures above 5$\mu g/m^3$ are occurring. Samples of the work environment may be taken on filters or other media that are capable of trapping all suspended dusts, mists, or fumes that contain beryllium.

V. MISCELLANEOUS PRECAUTIONS

A. Employees exposed above permissible limits must wear clean clothes each day and shower at the end of each day's work. Work clothes may not be worn home.

B. All contaminated clothing including impervious protective clothing should be washed under controlled conditions. The employer must inform the launderer of work clothing contaminated with beryllium, of the hazardous properties of beryllium.

C. Employers are required to advise affected employees of all plant areas and operations where exposure to beryllium could occur.

APPENDIX C

MEDICAL SURVEILLANCE GUIDELINES

Beryllium

I. Route of entry. Inhalation.

II. Toxicology. The health hazard is high. Breathing beryllium can bring about acute and chronic diseases of the respiratory tract. Skin contact with some forms of beryllium may cause dermatitis. Implantation of beryllium metal or contamination of an abrasion, superficial laceration, or dermatitic area with crystals of soluble beryllium salts may result in ulceration. Conjunctivitis and associated periorbital edema may accompany contact dermatitis or may occur separately. Also beryllium is suspected of having carcinogenic potential in humans.

III. Symptoms and signs. Symptoms of skin disease include itching and reddened, elevated, or fluid accumulated lesions. Implantation of beryllium in the skin can cause abscess and ulceration. Eye effects include fluid accumulation and reddening around the eye socket.

Respiratory symptoms include spasmodic cough, substernal discomfort and burning, tightness of the chest, difficulty in breathing upon exertion, weakness, easy fatigability, weight loss, mild nose bleeds and irritation of nasal and bronchial passages.

IV. Surveillance and preventive examinations. A. Preplacement. Routine medical histories and physical examinations are required for each employee exposed to beryllium. In addition to the medical history, a complete physical examination shall be given that shall include as a minimum the following:

a. 14 x 17 posterior-anterior chest X-ray;

b. Pulmonary function tests to include forced vital capacity (FVC);**

c. Weight determination; and

d. Examination of the skin.

B. Periodic Examinations: The above examinations are to be given at least annually, to each employee subject to exposure to beryllium.

(Secs. 4, 6, 8, 84 Stat. 1592, 1593, 1599 (29 U.S.C. 653, 655, 657) and 29 CFR Part 1911)

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**If pulmonary function tests show a decrease in forced vital capacity (FVC), a determination of the arterial blood gas or carbon monoxide diffusing capacity of the lung should be made.