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Workplace Safety and Health

NIOSH ALERT

Preventing Chronic Beryllium Disease and Beryllium Sensitization

DRAFT

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH

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Preventing Chronic Beryllium Disease and Beryllium Sensitization

WARNING!

Workers exposed to particles, fumes, or solutions from beryllium—containing materials may develop chronic beryllium disease, a potentially disabling or even fatal respiratory disease.

Workers

Workers exposed to particles, fumes, or solutions from beryllium-containing materials should take the following steps to protect themselves:

- Understand the risks and follow all proper procedures for working with beryllium—including participation in safety training.
- Keep beryllium out of the lungs:
  - Make sure that beryllium dusts, fumes, and beryllium-containing solutions and suspensions are controlled at their sources.
  - Participate in respiratory protection programs when advised to do so.
- Keep beryllium-containing dusts and solutions off the skin:
  - Keep work surfaces and work areas clean.
  - Participate in skin protection programs. These programs may include wearing gloves and company-issued clothing (with long sleeves and long pants) and showering at the end of the workday.
- Avoid the use of cleaning methods that may cause dust to become resuspended in air (dry sweeping, compressed air, and other dust-generating methods, for example).
- Prevent beryllium dusts and other contaminants from leaving beryllium work areas on your skin, clothing, shoes, and tools.
- Participate in medical surveillance so that risks related to job tasks can be identified and prevented.
- Seek medical attention for any chronic cough or shortness of breath, which may indicate chronic beryllium disease.

- Do not store or consume food, drinks, tobacco products, or cosmetics in beryllium work areas.

Employers

Employers of workers exposed to particles, fumes, or solutions from beryllium--containing materials should take the following steps to protect workers:

- Know the beryllium content of all materials in the workplace. The manufacturers or suppliers of materials containing greater than 0.1% beryllium are required to provide this information on material safety data sheets.

- Substitute less hazardous materials for those containing beryllium whenever feasible.

- Minimize the number of workers exposed to beryllium dusts, fumes, and beryllium-containing solutions and suspensions.

- Install, use, and maintain effective engineering controls for processes that create beryllium dusts, fumes, and beryllium-containing solutions and suspensions.

- Keep airborne concentrations of beryllium as low as possible, since no safe exposure limit for beryllium is known.

- Monitor airborne beryllium concentrations to document the effectiveness of efforts to reduce airborne exposures.

- Inform workers about the risks of beryllium sensitization, chronic beryllium disease, and lung cancer, and the proper procedures for working with beryllium-containing materials.

- Keep beryllium dusts, fumes, and beryllium-containing solutions and suspensions confined to the immediate work area.

- Avoid the use of cleaning methods that may cause dust to become resuspended in air (dry sweeping, compressed air, and other dust-generating methods, for example).

- Prevent beryllium dusts and other contamination from leaving beryllium work areas on workers' skin, clothing, shoes, and tools.

- Identify and clean areas outside the beryllium work zone that may have become contaminated before these recommendations were implemented.

- Establish and maintain an appropriate respiratory protection program as needed.

- Establish and maintain a skin protection program to protect workers' skin from contamination with beryllium dusts and solutions:

  — Keep work surfaces and work areas clean.

  — Provide work gloves, long-sleeved shirts, long pants, and shoes that remain at the workplace.

  — Provide showering and changing facilities.

- Conduct medical surveillance for sensitization using the beryllium lymphocyte proliferation test (BeLPT) for workers who come in contact with beryllium dusts, fumes, and beryllium-containing solutions and suspensions:

  — Identify higher-risk jobs and processes to prioritize prevention efforts and to evaluate their effectiveness in decreasing the risk of sensitization.

  — Ensure that sensitized workers identified through surveillance are referred for medical testing to (1) determine whether they have chronic beryllium disease, (2) establish radiographic and lung function baselines for followup testing, and (3) receive counseling about measures that may prevent progression to clinical chronic beryllium disease.

For additional information, see ***NIOSH Alert: Preventing Chronic Beryllium Disease and Beryllium Sensitization*** [DHHS (NIOSH) Publication No. 2008–xxx]. Single copies of the Alert are available free from the following:

Telephone: **1–800–CDC–INFO** (1–800–232–4636)
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DEPARTMENT OF HEALTH AND HUMAN SERVICES
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Preventing Chronic Beryllium Disease and Beryllium Sensitization

WARNING!

Workers exposed to particles, fumes, or solutions from beryllium—containing materials may develop chronic beryllium disease, a potentially disabling or even fatal respiratory disease.

The National Institute for Occupational Safety and Health (NIOSH) requests assistance in preventing chronic beryllium disease and beryllium sensitization. Development of these conditions requires exposure to beryllium and is affected by both ***job tasks*** and ***genetic factors***. Some jobs or tasks involve exposures that increase the risk of sensitization and disease. Some people have inherited genes that make them more likely to become sensitized or develop chronic beryllium disease when exposed.

NIOSH requests that the information in this Alert be brought to the attention of workers and employers by the following: trade associations, editors of trade journals, safety and health officials, labor organizations, members of the academic and public health communities, advocacy groups, workers' compensation insurance companies, distributors of materials that contain beryllium, and the mass media.

BACKGROUND

Risks may be associated with *all* beryllium-containing materials (including alloys of beryllium as well as beryllium metal and oxide materials) when these materials are heated or worked to create particles or fumes.

Beryllium may be encountered as any of the following:

- Compounds extracted from beryl and bertrandite minerals
- A refined metal with unique physical properties including high strength, lightness (low density), stiffness, dimensional stability, fidelity of vibration transmission, high thermal and electrical conductivity, neutron-moderating properties, and X-ray transparency
- A ceramic with electrical resistivity, a high melting point, and excellent thermal conductivity
- An alloy or mixture of metals having special properties including antigalling behavior, castability, corrosion resistance, electrical conductivity, durability, flexibility, nonsparking behavior, springiness (elasticity), and wear resistance*

* Copper-beryllium alloys are the most widely used form of beryllium.

- A byproduct of recycling materials that contain beryllium, such as alloys

See the Appendix for examples of industries that use beryllium and products that may contain beryllium.

Material safety data sheets (MSDSs) provide information about the beryllium content of products that contain more than 0.1% beryllium. At lower concentrations, employers and workers may not be aware of the presence of beryllium; but health risks exist if the beryllium-containing material is dispersed as a dust, fume, or beryllium-containing solution that can be inhaled or come into contact with unprotected skin.

Cases of beryllium sensitization and chronic beryllium disease have been reported in which exposures were below the current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) of 2.0 µg/m^3 and the current NIOSH recommended exposure limit (REL) of 0.5 µg/m^3.

HEALTH EFFECTS

Sensitization

A worker's immune system determines whether he or she will develop health problems from working with beryllium. Some workers become sensitized to beryllium, which means that beryllium has triggered the immune system to recognize and respond to this metal as a foreign substance. The risk of sensitization is determined by beryllium exposure, but it may be increased by certain genes that have been inherited from each parent.

A blood test—the beryllium lymphocyte proliferation test (BeLPT)—can detect sensitization by measuring how blood cells react to beryllium. However, the BeLPT is not foolproof: *false positive* results (a nonsensitized person's test result indicates sensitization) and *false negative* results (a sensitized person's test result indicates no sensitization) may occur. Despite its limitations, the BeLPT is the best available tool to identify sensitization until a more precise test becomes available.

No health symptoms are associated with beryllium sensitization. However, it is believed that a person must first be sensitized before beryllium in the lungs can cause the lung scars (called granulomas) of chronic beryllium disease [Kreiss et al. 1993a].

To determine whether chronic beryllium disease is present, a worker with abnormal BeLPT results must have further medical testing. A lung biopsy may be performed to remove small samples of lung tissue. In chronic beryllium disease, granulomas can be seen with a microscope in the biopsy samples. The biopsy test can detect disease before a worker has any symptoms. Other tests such as chest X-rays, computed axial tomography (CAT) scans of the chest, or pulmonary function tests can also help make the diagnosis of advanced disease.

The exact number of sensitized workers who will eventually develop chronic beryllium disease is unknown. However, many workers who are sensitized already have chronic beryllium disease or will develop it later. Among workers who did not have chronic beryllium disease when they were first determined to be sensitized to beryllium, approximately 8% were diagnosed with chronic beryllium disease each year over an average followup period of 4½ years [Newman et al. 2005].

Screening beryllium-exposed workers for sensitization may not prevent chronic beryllium disease in those with abnormal test results. Screening can be used to prevent chronic beryllium disease in other workers only if it is part of a medical surveillance program. Medical surveillance of a workforce looks at medical test results over time in relation to information about jobs and processes. The aims are to see whether some jobs or processes are higher risk than others, to set priorities for making changes to protect workers, and to evaluate the success of efforts to prevent disease. Screening for beryllium sensitization documents failures to prevent it and is not a substitute for prevention of beryllium exposure. Chest X-rays, CAT scans, and pulmonary function tests are not effective screening tools, as these tests identify advanced chronic beryllium disease.

Chronic Beryllium Disease

Chronic beryllium disease occurs when a sensitized worker's lungs react with beryllium that has been inhaled, producing lung granulomas and scarring.

Chronic beryllium disease has been observed among workers with a variety of exposure histories—long and short duration, high and low air concentrations of beryllium, and any form of beryllium. In many cases, chronic beryllium disease develops while workers are still being exposed to beryllium, occasionally within months of first exposure. In other instances, the disease may not be diagnosed until years after a person has stopped working in the beryllium industry.

Chronic beryllium disease usually has a slow onset of symptoms. It can be so mild at the time of diagnosis that the affected worker has no suspicion that he or she has a lung disease. However, when chronic beryllium disease progresses, the widespread granulomas cause chronic chest symptoms such as coughing and shortness of breath on exertion. Other symptoms that may develop in some persons with chronic beryllium disease are unusual fatigue and weight loss.

The symptoms and lung function abnormalities usually respond to corticosteroid medication such as prednisone or other medications that suppress the immune system response to beryllium. However, these medications do not cure the disease; they have side effects and must usually be taken indefinitely to prevent progressive lung damage or slow the rate of clinical deterioration. Some people with chronic beryllium disease eventually require supplemental oxygen, become severely disabled, and even die because of respiratory failure or insufficiency.

Certain genes appear to cause beryllium-exposed workers to be more susceptible to beryllium sensitization and chronic beryllium disease. Continuing *genetic research* may contribute to a better understanding of why some are more susceptible. This research may also lead to prevention of sensitization and disease and the exploration of new treatments for sensitization and disease in affected workers. However, with our current knowledge, *genetic testing* is not useful in predicting who will develop chronic beryllium disease because (1) the genes linked to sensitization and disease are found in a large percentage of the population and (2) sensitization and chronic beryllium disease have developed in some people who do not have these genes. The future usefulness of genetic testing remains to be determined, but it may someday have a role in helping workers make informed decisions about working with beryllium.

Acute Beryllium Disease

Acute beryllium disease has been diagnosed in the past, but it is rare today. The disease typically has a quick onset with symptoms resembling those of pneumonia or bronchitis. It occurs after exposure to high concentrations of soluble beryllium salts, which are used in the making of beryllium metal. Acute beryllium disease usually resolves within months of stopping beryllium work, but some affected workers later develop chronic beryllium disease.

Cancer

Significantly elevated risks of lung cancer have been reported for workers exposed to beryllium; the International Agency for Research on Cancer [IARC 1993] and the National Toxicology Program [NTP 2002] list it as a known carcinogen. Controlling beryllium exposures to prevent chronic beryllium disease should also reduce the risk for lung cancer.

WORKFORCE SURVEYS

Since the late 1980s, beryllium-exposed workforces have been surveyed for sensitization to beryllium and chronic beryllium disease. Workers typically complete a questionnaire about their health and work history and submit blood samples that are tested for sensitization to beryllium. Sensitized workers are then further evaluated for chronic beryllium disease. Scientists look for jobs and work tasks in which sensitization and chronic beryllium disease are most common. They may also estimate workers' beryllium exposure to determine whether risk increases as estimated exposure increases.

Researchers have studied various beryllium workplaces, including those in the primary beryllium industry [Kreiss et al. 1996; Kreiss et al. 1997; Henneberger et al. 2001; Rosenman et al. 2005; Schuler et al. 2005], nuclear weapons facilities [Kreiss et al. 1993a; Stange et al. 2001; Stange et al. 2004], the ceramics industry [Kreiss et al. 1993b], mining and ore milling facilities [Deubner et al. 2001],

precision machining plants [Newman et al. 2001], beryllium-contaminated buildings undergoing decontamination and decommissioning [Sackett et al. 2004], and workplaces with construction trades workers [Welch et al. 2004]. Workers in these studies were exposed to different forms of beryllium, such as beryllium oxide ceramic, pure beryllium metal, and beryllium alloys (primarily copper alloys); they may have been current or former workers.

Workers who refine, prepare, and process beryllium and beryllium-containing materials are at the greatest risk for sensitization and chronic beryllium disease. Sensitization has been found in 1% to 14% of workers studied, with chronic beryllium disease diagnosed in 10% to 100% of sensitized workers. The risk for workers in other industries depends on their potential exposure to dust particles, fumes, and beryllium-containing solutions and suspensions.

Exposure-Related Risks

Some production jobs have higher rates of chronic beryllium disease. Specific jobs or work processes that have been shown to carry a higher risk include machining of ceramics or beryllium metal [Kreiss et al. 1993a; Kreiss et al. 1996; Henneberger et al. 2001; Stange et al. 2001], ceramics production [Kreiss et al. 1997], work with copper-beryllium rod and wire materials [Schuler et al. 2005], and engineering, laboratory, and technical jobs [Kreiss et al. 1993b; Kreiss et al. 1997; Stange et al. 2001].

Risk is not limited to production workers. In many studies, additional cases of sensitization or chronic beryllium disease were identified among nonproduction workers or workers whose exposure appeared to be minimal, such as secretaries, other clerical workers, and security guards [Kreiss et al. 1993a; Kreiss et al. 1993b; Kreiss et al. 1996; Kreiss et al. 1997; Stange et al. 2001].

When estimates of beryllium exposure (based on mass concentration of airborne beryllium) were calculated for study participants, no consistent relationship was found between airborne exposure and risk of either sensitization or chronic beryllium disease. In other words, workers with the highest estimated beryllium exposures were not necessarily at the highest risk for sensitization or chronic beryllium disease, and higher risk jobs or processes did not always have the highest beryllium exposure.

Skin Exposure

Recent research at NIOSH suggests that sensitization may result from skin contact with beryllium dusts, fumes, and beryllium-containing solutions and suspensions. NIOSH researchers observed that tight control of airborne beryllium exposure did not prevent sensitization of new workers in the first year or two of their employment. NIOSH laboratory researchers demonstrated that (1) mice could become sensitized to beryllium if beryllium was placed on their skin, and (2) tiny particles (dextran beads less than 1 μm in diameter) could penetrate human skin

tissue samples when the skin was flexed, thereby allowing them to reach the layers of the skin where the immune system cells are located and where the sensitization process can begin [Tinkle et al. 2003]. Particles larger than 1 µm could penetrate only cuts or abrasions. Although research is continuing, NIOSH recommends that employers and workers prevent skin contact with tiny beryllium particles or solutions containing beryllium.

Prevention

One study at a beryllium oxide ceramics plant has shown that a comprehensive preventive program can reduce the development of sensitization in new workers not previously exposed to beryllium [Cummings et al, 2007]. The program placed special emphasis on preventing the migration of dust and fluids away from work processes and on protection of skin, in addition to engineering controls and respiratory protection. The facility used medical surveillance with the BeLPT to monitor the effectiveness of the program in preventing sensitization. Beryllium sensitization was significantly reduced among workers hired between 2000 and 2004 (1%), after the program was implemented, when compared to workers hired between 1993 and 1998 (9%) [Henneberger et al, 2001]. Air levels of beryllium were similar for the two time periods. Since these prevention results are from a single plant and cover a relatively short period of time, the results should be considered encouraging but preliminary. Additional follow-up over longer periods and at other beryllium workplaces should be performed.

Case Studies

Case 1: Two years after starting work at a beryllium-using facility, a secretary was moved to an area in which beryllium laboratory analyses had been done years earlier. The following year, her work area was renovated, including opening the ventilation duct work. She developed skin problems, including itching and raised lesions, which she believed were due to the dust from renovation. Five months after renovation, she had her first positive BeLPT blood test which was confirmed the following month. She was then evaluated for chronic beryllium disease: no granulomas or other pathologic abnormalities were found in lung biopsy samples; her lung lymphocytes were elevated (22%); and her lung lavage cells did not indicate lung sensitization. She left work the following year. A second clinical evaluation, 16 months after the first, then found granulomas in the biopsy samples and increased elevation of lung lymphocytes (36%), and she was diagnosed with chronic beryllium disease.

Case 2: A beryllium worker took part in medical surveillance, after he had spent more than 20 years in different production jobs and as a foreman. He did not wear a respirator. He reported no cough, wheeze or shortness or breath. His first blood samples were sent to two laboratories, and one BeLPT was positive. The following month, a second set of samples was sent to two laboratories, and both were positive, confirming that he was sensitized. His clinical evaluation showed granulomas in his lung biopsy samples, elevated lung lymphocytes (27%), and a positive lung lavage BeLPT, all of which supported the diagnosis of chronic beryllium disease.

What do these cases illustrate? Case 1 shows us that sometimes those who don't work directly with beryllium, but who are exposed to beryllium-containing dust, can develop chronic beryllium disease. It also demonstrates that continued monitoring of the health of sensitized workers is important; this person's chronic beryllium disease was not diagnosed until her second clinical evaluation and after she left employment. Case 2 shows us the value of participating in workplace medical surveillance. This person had no symptoms and would not have known he had chronic beryllium disease if he had not participated in the medical surveillance that was offered to him.

CURRENT EXPOSURE LIMITS

Current beryllium exposure limits from various agencies and groups are provided below.

NIOSH

In 1977, NIOSH suggested an REL of 0.5 µg/m^3 to reduce the risk of beryllium-related lung cancer [NIOSH 1977]. This REL does not prevent beryllium sensitization or chronic beryllium disease. Since no safe exposure limit has been established for beryllium, NIOSH recommends that employers keep airborne concentrations of beryllium as low as possible.

OSHA

The current OSHA PEL for beryllium is 2.0 µg/m^3 as an 8-hour time-weighted average (TWA) [29 CFR† 1910.1000]. OSHA has stated that the current PEL does not adequately protect beryllium-exposed workers from developing chronic beryllium disease [OSHA 1998; OSHA 1999]. Other OSHA exposure limits for beryllium are a ceiling concentration of 5.0 µg/m^3, and a maximum peak concentration of 25.0 µg/m^3 for a maximum duration of 30 minutes [29 CFR 1910.1000].

DOE

The U.S. Department of Energy (DOE) requires various actions to limit exposures to beryllium (including engineering and administrative controls and the use of respiratory protection). The DOE also requires medical surveillance using the BeLPT when airborne concentrations of beryllium exceed an action limit. In 1999, the DOE set a beryllium exposure action limit (8-hour TWA) to 0.2 µg/m^3 [10 CFR 850]. In addition, the DOE building-surface contamination limit for beryllium in work areas during nonoperational periods is 3.0 µg/100 cm^2 of surface area. The concentration of beryllium on items released to the public must not exceed 0.2 µg/100 cm^2 [10 CFR 850]. These surface contamination limits are based on technical feasibility rather than on documented risk for sensitization and disease.

† ***Code of Federal Regulations***. See CFR in references.

Other Limits

The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) for beryllium is 2.0 µg/m^3 as an 8-hour TWA [ACGIH 2006]. In 2006, ACGIH published a notice of intended change to lower the TLV to 0.05 µg/m^3 and a short-term exposure limit (STEL) of 0.2 µg/m^3 as a 15-minute TWA that should not be exceeded at any time during a workday [ACGIH 2006]. A number of other countries also use 2.0 µg/m^3 as an 8-hour TWA for their current standard, including Canada (TLV) and the United Kingdom (recommended limit) [IPCS 1990].

OTHER RESOURCES

More information about beryllium is available through the following resources:

NIOSH

Respirators: www.cdc.gov/niosh/npptl/topics/respirators/

Searchable database: www2a.cdc.gov/nioshtic-2/nioshtic2.htm

Pocket guide to chemical hazards: www.cdc.gov/niosh/npg/pgintrod.html

International chemical safety cards: www.cdc.gov/niosh/ipcs/nicstart.html

Sampling/analytical method for beryllium:
www.cdc.gov/niosh/nmam/pdfs/7102.pdf

OSHA

Hazard Information Bulletin—*Preventing Adverse Health Effects from Exposure to Beryllium on the Job* [OSHA 1999]:
www.osha.gov/dts/hib/hib_data/hib19990902.html

Hazard Information Bulletin—*Preventing Adverse Health Effects from Exposure to Beryllium in Dental Laboratories* [OSHA 2002]:
www.osha.gov/dts/hib/hib_data/hib020419.html

Other

Department of Energy—Title 10 CFR Part 850 Chronic Beryllium Disease Pre-vention Program: www.eh.doe.gov/be/docs/berule.pdf

Department of Labor—Energy Employees Occupational Illness Compensation Pro-gram: www.dol.gov/esa/regs/compliance/owcp/eeoicp/main.htm

Lawrence Livermore National Laboratory's implementation of the DOE Chronic Beryllium Disease Prevention Program:
www.llnl.gov/es_and_h/hsm/doc_14.04/doc14-04.html

CONCLUSIONS

Workers in various sectors of the beryllium industry are at risk of developing serious respiratory disease following exposure to beryllium. More action is needed to (1) improve protective measures for exposed workers, (2) reduce/minimize both overall exposures and, when possible, the number of exposed workers, (3) educate workers about the hazards of working with beryllium, (4) determine the characteristics of exposures (*e.g.*, particle size, shape, surface area, and chemical form) that are associated with increased risk, and (5) identify industrial and occupational sectors that use beryllium and target them for prevention efforts.

RECOMMENDATIONS

Workers exposed to particles, fumes, or solutions from beryllium-containing materials should take the following steps to protect themselves:

- Understand the risks and follow all proper procedures for working with beryllium—including participation in safety training.
- Keep beryllium out of the lungs:
  - Make sure that beryllium dusts, fumes, and beryllium-containing solutions and suspensions are controlled at their sources.
  - Participate in respiratory protection programs when advised to do so.
- Keep beryllium-containing dusts and solutions off the skin:
  - Keep work surfaces and work areas clean.
  - Participate in skin protection programs. These programs may include wearing gloves and company-issued clothing (with long sleeves and long pants) and showering at the end of the workday.
- Avoid the use of cleaning methods that may cause dust to become resuspended in air (dry sweeping, compressed air, and other dust-generating methods, for example).
- Prevent beryllium dusts and other contaminants from leaving beryllium work areas on your skin, clothing, shoes, and tools.
- Participate in medical surveillance so that risks related to job tasks can be identified and prevented.
- Seek medical attention for any chronic cough or shortness of breath, which may indicate chronic beryllium disease.
- Do not store or consume food, drinks, tobacco products, or cosmetics in beryllium work areas.

Employers of workers exposed to particles, fumes, or solutions from beryllium-containing materials should take the following steps to protect workers:

- Know the beryllium content of all materials in the workplace. The manufacturers or suppliers of materials containing greater than 0.1% beryllium are required to provide this information on material safety data sheets.
- Substitute less hazardous materials for those containing beryllium whenever feasible.
- Minimize the number of workers exposed to beryllium dusts, fumes, and beryllium-containing solutions and suspensions.
- Install, use, and maintain effective engineering controls for processes that create beryllium dusts, fumes, and beryllium-containing solutions and suspensions.
- Keep airborne concentrations of beryllium as low as possible, since no safe exposure limit for beryllium is known.
- Monitor airborne beryllium concentrations to document the effectiveness of efforts to reduce airborne exposures.
- Inform workers about the risks of beryllium sensitization, chronic beryllium disease, and lung cancer, and the proper procedures for working with beryllium-containing materials.
- Keep beryllium dusts, fumes, and beryllium-containing solutions and suspensions confined to the immediate work area.
- Avoid the use of cleaning methods that may cause dust to become resuspended in air (dry sweeping, compressed air, and other dust-generating methods, for example).
- Prevent beryllium dusts and other contamination from leaving beryllium work areas on workers' skin, clothing, shoes, and tools.
- Identify and clean areas outside the beryllium work zone that may have become contaminated before these recommendations were implemented.
- Establish and maintain an appropriate respiratory protection program as needed.
- Establish and maintain a skin protection program to protect workers' skin from contamination with beryllium dusts and solutions:
  - Keep work surfaces and work areas clean.
  - Provide work gloves, long-sleeved shirts, long pants, and shoes that remain at the workplace.

  - Provide showering and changing facilities.

- Conduct medical surveillance for sensitization using the beryllium lymphocyte proliferation test (BeLPT) for workers who come in contact with beryllium dusts, fumes, and beryllium-containing solutions and suspensions:
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We greatly appreciate your assistance in protecting the health of U.S. workers.

John Howard, M.D.
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APPENDIX. BERYLLIUM INDUSTRIES AND PRODUCTS

Note: Health risks exist if beryllium-containing materials are dispersed as a dust, fume, or beryllium-containing solution or suspension that can be inhaled or come into contact with unprotected skin.

Aerospace: Altimeters, braking systems, bushings and bearings for landing gear, electronic and electrical connectors, engines, gyroscopes, mirrors (*e.g.*, space telescopes), precision tools, rockets, satellites, structural components, and missile guidance systems.

Automotive: Air-bag triggers, antilock brake system terminals, electronic and electrical connectors, steering wheel connecting springs, and valve seats for drag racer engines.

Biomedical: Dental bridges, partials, and other prostheses, medical laser and scanning electron microscope components, and X-ray windows.

Decommissioning and decontamination of worksites: Various beryllium-containing materials.

Defense: Heat shields, mast-mounted sights, missile guidance systems, nuclear weapon components, submarine hatch springs, and tank mirrors.

Energy and electrical: Heat exchanger tubes, microelectronics, microwave devices, nuclear reactor components, oil field drilling and exploring devices, and relays and switches.

Fire prevention: Nonsparking tools and sprinkler system springs.

Instruments, equipment, and objects: Bellows, camera shutters, clock and watch gears and springs, commercial speaker domes, computer disk drives, musical instrument valve springs, pen clips, and commercial phonograph styluses.

Manufacturing: Injection molds for plastics, and bearings.

Sporting goods and jewelry items: Golf clubs, fishing rods, beryl and chrysoberyl gemstones (including aquamarine, emerald, and alexandrite), and manmade emerald and other gemstones with distinctive colors.

Scrap recovery and recycling: Various beryllium-containing products.

Telecommunications: Cellular telephone components, electromagnetic shields, electronic and electrical connectors, personal computer components, rotary telephone springs and connectors, and undersea repeater housings.

NOTES

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