

IMPLEMENTATION GUIDE

for use with

DOE NOTICE 440.1

INTERIM CHRONIC BERYLLIUM DISEASE PREVENTION PROGRAM



OFFICE OF WORKER HEALTH AND SAFETY

Disclaimer

This Implementation Guide references specific sections of several available guides that are not part of the DOE Directives System. DOE endorses these specific sections but has made no judgments about the usefulness of the other sections of these guides.

FOREWORD

1. This Department of Energy (DOE) guide is approved by the Office of Environment, Safety and Health (EH) and is available for use by all DOE components and their contractors.
2. Beneficial comments (recommendations, additions, and deletions) and any pertinent data that may improve this document should be sent to the Director, DOE Office for Worker Health and Safety (EH-5), U.S. Department of Energy, Washington, D.C. 20585, by letter or by sending the self-addressed Standardization Document Improvement Proposal (DOE F 1300.3).
3. This guide is intended to identify acceptable methods for implementing the provisions of DOE Notice 440.1.

ACRONYMS

ABIH	American Board of Industrial Hygiene
ACGIH	American Conference of Governmental Industrial Hygienists
ACL	Administrative Control Level
AEC	Atomic Energy Commission
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute
AWE	Atomic Weapons Establishment
Be	Beryllium
BEI	Biological Exposure Indices
Be-LPT	Beryllium-Induced Lymphocyte Proliferation Test
BWI	Brush Wellman, Incorporated
CBD	Chronic Beryllium Disease
CBDPP	Chronic Beryllium Disease Prevention Program
CFR	Code of Federal Regulations
CRD	Contractor Requirements Document
D&D	Deactivation and Decommissioning
DOE	Department of Energy
EH	Office of Environment, Safety and Health
EH-5	DOE Office for Worker Health and Safety
ELISA	Enzyme-Linked Immunosorbent Assay
EPA	Environmental Protection Agency
FEOSH	Federal Employee Occupational Safety and Health Program
FEV	Forced Expiratory Volume
FVC	Forced Vital Capacity
HEPA	High-Efficiency Particulate Air
IARC	International Agency for Research on Cancer

ICP	Inductively Coupled Plasma
ISM	Integrated Safety Management
LANL	Los Alamos National Laboratory
LIBS	Laser Induced Breakdown Spectroscopy
LTT	Lymphocyte Transformation Test
MSDS	Material Safety Data Sheet
NIOSH	National Institute for Occupational Safety & Health
NPE	Negative Pressure Enclosures
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
STEL	Short-term Exposure Limit
TLV	Threshold Limit Value
TRADE	Training Resources and Data Exchange
TWA	Time Weighted Average

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I. INTRODUCTION

DOE Notice 440.1 (DOE N 440.1) establishes a chronic beryllium disease prevention program (CBDPP) that enhances, supplements, and is integrated into the worker protection program requirements of DOE Order 440.1 (DOE O 440.1), “Worker Protection Management for DOE Federal and Contractor Employees.” Appendix E contains specific citations from DOE O 440.1 that identify requirements that are relevant to a CBDPP. This program is designed to reduce the number of current workers exposed, minimize the levels of beryllium exposure and the potential for exposure to beryllium, and establish medical surveillance protocols to ensure early detection of disease.

DOE’s CBDPP is part of the Department’s efforts to establish the framework for an effective worker protection program that will reduce or prevent accidental losses, injuries, and illnesses by providing DOE Federal and contractor workers with a safe and healthful workplace.

DOE N 440.1 requires DOE elements and contractors to develop a specific CBDPP for their site. This non-mandatory Implementation Guide (DOE G 440.1-7) for use with DOE N 440.1 was developed to assist sites by describing DOE’s expectations for these site-specific CBDPPs.

DOE G 440.1-7 presents suggestions and various approaches that DOE elements and contractors may wish to consider for use in the risk-based implementation of DOE N 440.1 as an integral part of their worker protection programs. The goal of DOE G 440.1-7 is to make accessible to the user a detailed presentation of how a site might wish to implement DOE N 440.1. It accomplishes this goal by providing information concerning lessons learned and best practices for controlling beryllium exposure and disease as well as references to other sources of information.

II. APPLICATION

DOE N 440.1 applies to all activities (including design, construction, operation, maintenance, deactivation and decommissioning [D&D], research and development, and environmental restoration activities) performed by DOE, its contractors, and their subcontractors.

Activities conducted under the authority of the Director, Naval Nuclear Propulsion Programs, described in Public Law 98-525, are exempt from the provisions of DOE N 440.1.

DOE N 440.1 does not apply to DOE laboratory operations involving beryllium that are subject to the requirements of 29 CFR (Code of Federal Regulations) 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories." The Occupational Safety and Health Administration (OSHA) describes laboratory operations for the purposes of 29 CFR 1910.1450 (b) by the following definitions:

- "Laboratory" means a facility where the "laboratory use of hazardous chemicals" occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.
- "Laboratory scale" means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. Laboratory scale excludes those workplaces whose function is to produce commercial quantities of materials.
- "Laboratory use of hazardous chemicals" means handling or use of such chemicals in which all of the following conditions are met:
 - Chemical manipulations are carried out on a "laboratory scale";
 - Multiple chemical procedures or chemicals are used;

- The procedures involved are not part of a production process, nor in any way simulate a production process; and
 - “Protective laboratory practices and equipment” are available and in common use to minimize the potential for worker exposure to hazardous chemicals.
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- “Protective laboratory practices and equipment” means those laboratory procedures, practices, and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for worker exposure to hazardous chemicals.
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- Furthermore, 29 CFR 1910.1450 does not apply to quality control or quality assurance laboratories, or pilot plants, that support production processes.

Most of DOE's operations involving beryllium, including operations in DOE's national laboratories, would not be considered laboratory operations by OSHA's definitions and therefore would not be exempt from DOE N 440.1.

The CBDPP addresses current DOE and DOE contractor workers. “Current workers” includes presently employed workers who are, or potentially are, being exposed at DOE-owned or -leased facilities at this time and presently employed workers who may have been exposed to beryllium at DOE-owned or -leased facilities in the past. Presently employed workers include workers who left and returned to employment. Former DOE and DOE contractor workers who may have been exposed to beryllium at DOE-owned or -leased facilities are not addressed in DOE N 440.1. (See Appendix A, Section 1.7 for further discussion on former workers.)

The Contractor Requirements Document (CRD) (Attachment 2 to DOE N 440.1) delineates requirements that are to be applied to contractors that have been awarded contracts for

performing work for DOE on DOE-owned or -leased facilities. Contractor compliance with the CRD will be required to the extent set forth in a contract.

DOE G 440.1-7 provides general information and methodologies that DOE finds acceptable in meeting the Department's requirements defined in DOE N 440.1. Other worker protection-related Implementation Guides are:

- G 440.1-3, "Occupational Exposure Assessment"
- G 440.1-4, "Contractor Occupational Medical Program"

The Federal Employee Occupational Safety and Health (FEOSH) Program is established in 29 CFR 1960, "Basic Program Elements for Federal Employee Occupational Safety and Health (FEOSH) Programs and Related Matters." Requirements for FEOSH flow down into DOE O 440.1 and are reflected in G 440.1-7.

In addition, other DOE Rules, Orders, and their Implementation Guides will have an impact on the CBDPP. Those documents contain requirements and non-mandatory guidance that must be integrated with the CBDPP to be complete and effective. The additional Orders and Rules include but are not limited to:

- DOE O 440.1, "Worker Protection Management for DOE Federal and Contractor Employees"
- DOE O 210.1, "Performance Measures and Data Analysis"
- DOE O 225.1, "Accident Investigation"

- DOE O 231.1, “Safety and Health Reporting Requirements”
- DOE O 232.1, “Occurrence Reporting”
- DOE O 361.1, “Federal Employee Training”
- DOE O 5480.29, “Employee Concerns”
- 10 CFR 830.330, “Training and Qualification”

Additional non-mandatory guidance (Implementation Guides, technical standards, and handbooks) is available to assist DOE elements and contractors in developing a successful site-specific CBDPP. This additional guidance includes but is not limited to:

- DOE G 120.1-5, June 1996, Guidelines for Performance Measurement
- Functional Area Qualification Standards for Defense Nuclear Facilities Technical Personnel

These additional non-mandatory guidance documents describe acceptable means of satisfying the requirements established in DOE N 440.1. DOE elements and contractors are free to use the guidance provided in DOE G 440.1-7 and the additional non-mandatory guidance listed above, or develop their own unique methods, provided that these alternative methods afford workers a level of protection equal to or greater than that required by DOE N 440.1.

Additional guidance that was not published for DOE-wide use also has been used in DOE G 440.1-7 and is referenced at its point of use in the text. Disclaimer: This Implementation Guide references specific sections of several available guides that are not part of the DOE

Directives System. DOE endorses these specific sections but has made no judgments about the usefulness of the other sections of these guides.

III. GENERAL INFORMATION

1. PROGRAM ELEMENTS

The CBDPP elements consist of conducting a baseline inventory and sampling, conducting hazard assessments, conducting exposure monitoring, reducing and minimizing exposures, conducting medical surveillance, providing training, keeping records, and providing performance feedback. Detailed information about each of these subjects is provided in Section IV.

2. STRATEGY FOR REDUCING AND MINIMIZING EXPOSURES

Exposure reduction and minimization includes reducing airborne levels of beryllium as-low-as-practical, minimizing the number of current workers exposed and potentially exposed to beryllium, minimizing the number of opportunities to be exposed, and setting reasonable exposure reduction and minimization goals using a risk-based (tailored) approach. Section IV.4.3.3 provides detailed information on actions that reduce and minimize exposures. There is not yet an accepted technical basis to define reduction and minimization in terms of an exposure limit that would adequately prevent chronic beryllium disease (CBD) in DOE workers who are predisposed to developing CBD (see Appendix A, Section 1.3, and Attachment A-1, Section 2). Each DOE site is expected to consider social, technical, economic, practical, and public policy considerations in implementing exposure reduction and minimization that is appropriate for their site. Each DOE site is expected to apply a graded approach to minimizing beryllium exposures based on the level of risk of incurring CBD.

3. MINIMIZING DISABILITY

The disability associated with CBD should be minimized by early detection of the disease. Current workers who are sensitized to beryllium or have CBD should be offered placement in positions without beryllium exposure to maintain employment, and be assured of continued medical screening. Section IV.5 provides detailed information on early detection through medical surveillance. Although DOE currently funds medical surveillance programs, state workers' compensation programs provide benefits to workers who need medical treatment as a result of CBD. It is important to involve Contractor Benefits Administrators and Loss Control Managers in developing a CBDPP to assure that benefit programs address unique CBD issues.

The presentation and progression of CBD are highly variable. A percentage of individuals with positive results in their peripheral blood beryllium-induced lymphocyte proliferation tests (Be-LPT) probably will require treatment for CBD symptoms even though those symptoms and other signs of CBD may not be present at the time of the test. Close medical monitoring of those workers who are positive on the Be-LPT but are presently without loss of lung function or other symptoms will allow for the consideration of early treatment options, if symptoms appear, that may slow progression of the disease and reduce both morbidity and mortality (ref. III.3.1).

4. PROGRAMMATIC CONSIDERATIONS

The strategy of the DOE CBDPP is to "look" for beryllium in order to identify where it exists in the work site; establish its hazard significance to set priorities for actions; minimize, within reason, instances where exposure may occur and reduce exposure levels to as low as practical in order to prevent disease from occurring; detect disease that has occurred at the earliest stages to allow early treatment; and evaluate program effectiveness to promote its continuous improvement.

4.1 Written Program

The site-specific CBDPP should be incorporated and integrated into a site's written worker protection program and should outline specific goals and objectives for the CBDPP (see Appendix E for relevant citations from DOE O 440.1). The written program should describe, in detail, the responsibilities and accountability of program personnel and the specific procedures to be used to implement the required DOE CBDPP elements (see Section III.1). The written program should address integrating line management, workers, maintenance, and worker protection and other support functions.

The written program also should reflect the nature of beryllium activities performed and the level of potential beryllium exposure at the site.

4.2 Occupational Exposure Limits

See Appendix E for citations in DOE directives relevant to occupational exposure limits (OEL). See Appendix A, Section 1.3 for a discussion on the efficacy of the OELs. Also in Appendix E are citations relevant to administrative action levels. Section IV.4.3.2 describes administrative action levels.

OSHA

29 CFR 1910.1000, the OSHA General Industry Standard, establishes the following permissible exposure limits (PEL) for beryllium:

- 8-Hour Time Weighted Average (TWA) - 2 micrograms/m³ (A worker's exposure to beryllium and its compounds in any 8-hour work shift of a 40-hour work week shall not exceed 2 micrograms/m³);

- Acceptable Ceiling Concentration - 5 micrograms/m³ (A worker's exposure to beryllium and its compounds shall not exceed at any time during an 8-hour shift the 5 micrograms/m³ acceptable ceiling concentration limit);
- Acceptable Maximum Peak Concentration - 25 micrograms/m³ (A worker's exposure to beryllium and its compounds shall not exceed 25 micrograms/m³, the acceptable maximum peak above the acceptable ceiling concentration, for a maximum duration of 30 minutes).

The 8-hour TWA exposure limit of 2 micrograms/m³ is repeated in 29 CFR 1926.55 for construction. Also, 29 CFR 1926.55 adopts the 1970 ACGIH TLVs for beryllium, and OSHA recommends using the latest version of a consensus standard which, in this case, are the ACGIH TLVs provided later on in this section.

OSHA has specific beryllium requirements for welding and cutting on beryllium-containing base or filler metals in 29 CFR 1910.252(c)(8):

Welding or cutting indoors, outdoors, or in confined spaces involving beryllium-containing base or filler metals shall be done using local exhaust ventilation and airline respirators unless atmospheric tests under the most adverse conditions have established that the workers' exposure is within the acceptable concentrations defined by 1910.1000. In all cases, workers in the immediate vicinity of the welding or cutting operations shall be protected as necessary by local exhaust ventilation or airline respirators.

These above requirements are repeated in 29 CFR 1926 for construction. In addition, OSHA Technical Manual - CPL 2-2.20B references beryllium in Chapter 1, "Personal Sampling for Air Contaminants," Appendix 1-E, "Sampling for Special Analyses," under

“Samples Analyzed by Inductively Coupled Plasma (ICP)” and in Chapter 2, “Sampling for Surface Contamination,” which suggests swipe sampling of surfaces since accumulated toxic materials such as beryllium “may become suspended in air, and may contribute to airborne exposures. Bulk and wipe samples may aid in determining this possibility.” (ref. III.4.1)

NIOSH (National Institute for Occupational Safety & Health)

Recommended Exposure Level (Ceiling) - 0.5 microgram/m³

NIOSH also identifies beryllium as an occupational carcinogen. In making the carcinogen determination, NIOSH uses the following definition:

Potential occupational carcinogen means any substance, or combination or mixture of substances, which causes an increased incidence of benign and/or malignant neoplasms, or a substantial decrease in the latency period between exposure and onset of neoplasms in humans or in one or more experimental mammalian species as the result of any oral, respiratory or dermal exposure, or any other exposure which results in the induction of tumors at a site other than the site of administration. This definition also includes any substance which is metabolized into one or more potential occupational carcinogens by mammals. (Section 3.1.2 of ref. III.4.1)

American Conference of Governmental Industrial Hygienists (ACGIH)

The ACGIH has established the following Threshold Limit Value (TLV) for beryllium and beryllium compounds:

- 8-Hour TWA - 2 micrograms/m³;
- Short-term Exposure Limit (STEL) - 10 micrograms/m³ (15-minute TWA exposure which should not be exceeded at any time during a workday even if the 8-hour TWA is within the TLV TWA.)

The ACGIH lists beryllium and beryllium compounds as an A1 carcinogen, a known human carcinogen. ACGIH explains this classification in their Documentation of TLVs by indicating that the weight of evidence supports the view that beryllium is a confirmed human carcinogen but is of such low potency that only persons exposed to airborne levels above 100 micrograms/m³ would be at significant risk of developing lung cancer (Section 3.1.3 of ref. III.4.1).

4.3 Program Integration

The DOE CBDPP is an integral part of DOE's worker protection program and should be an integral part of the worker protection program at sites where beryllium exposure is reasonably possible. Sites with Integrated Safety Management (ISM) plans should include the CBDPP therein. Sites with a Work Smart set of standards should consider DOE N 440.1 requirements for relevance. Work that involves beryllium should be planned by interdisciplinary teams including workers assembled to perform enhanced work planning. The CBDPP should be integrated into all other current and future worker protection initiatives for which beryllium exposure is reasonably possible.

4.4 Teaming

The site-specific CBDPP should be implemented by interdisciplinary teams that integrate line management, workers, maintenance, and worker protection and other support

functions. Workers should be included when planning work, identifying hazards, or during other activities where the worker may provide valuable insights into local beryllium hazards and effective controls. DOE O 440.1 requires that the written site worker protection program (which should include the CBDPP) outline a method for encouraging worker involvement in the development of program goals, objectives, and performance measures and in the identification and control of hazards in the workplace. (See Appendix E for a citation on teaming.)

4.5 Goals

The DOE CBDPP includes setting reasonable goals using a risk-based (tailored) approach that reflects the level of risk of incurring CBD. Goals that reflect expectations for each of the CBDPP program elements (see Section III.1) would be useful tools for improving program performance. In general, goals are targets, or achievements that one works toward accomplishing. Goals define what is important, provide focus, establish direction, and provide a basis for measuring performance. Examples of site-specific CBDPP goals include:

- Complete the sitewide baseline inventory and sampling by the end of FYXX.
- Complete hazard assessments for all known beryllium activities/processes by the end of FYXX.
- Enroll all workers who are exposed or potentially exposed to airborne or potentially airborne beryllium in a medical surveillance program by the end of FYXX.
- Review job and exposure history of all beryllium sensitized workers by FYXX.

- Provide beryllium hazard communication training to all workers who are exposed or potentially exposed to beryllium by the end of FYXX, and general employee awareness training on beryllium to all other workers by the end of FYXX.
- Provide performance feedback reports on a quarterly basis beginning in FYXX.

4.5.1 Goals for Exposure Reduction and Minimization

Exposure reduction and minimization goals are essential and are explicitly required by DOE N 440.1 (see Appendix E). Goals for exposure reduction and minimization should be established and reestablished periodically using a risk-based approach. Reestablishing goals does not require a continuous reduction in exposures, but instead ensures that goals are current with the site's mission and management is actively engaged in the implementation and continuous improvement of the site's CBDPP. In some cases, goals may be modified to allow higher exposures consistent with mission changes requiring increased workloads or activities that emit greater amounts of airborne beryllium so long as these goals never exceed OELs. For sites conducting extensive nonroutine activities, such as D&D, goals reflecting the intrinsically higher level of risk and limited availability of engineering controls may be appropriate. When establishing exposure reduction and minimization goals, the following factors should be considered:

- Existing exposure levels,
- Reductions in exposures needed to reach an OEL or administrative action level,
- Impact on workers,

- Effectiveness of control options,
- Impact on operations, and
- Social, technical, economic, practical, and public policy considerations in determining the practicability of various control options for reducing and minimizing worker exposure to beryllium.

Examples of goals reflecting exposure reduction and minimization efforts include:

- No more than xx (determined by site management) percent of all measured exposures for FYXX will exceed the site's administrative action level.
- No measured exposures for FYXX will exceed the 8-hour TWA PEL at work sites where engineering and administrative controls are available to maintain exposures below that level. It is recognized that a small percentage of exposure values are likely to exceed the PEL. Site management should consider those exceedences to be violations of the DOE Order that adopted the OSHA standard and a failure to achieve this goal.
- There will be no incidents of uncontrolled exposures during FYXX. It is recognized that incidents of uncontrolled exposures may occur. Site management should consider those incidents to be a failure to achieve this goal.
- The total number of beryllium-exposed workers for FYXX will decrease by xx (determined by site management) percent of the current number of beryllium-exposed workers after normalizing for any change in the potential for beryllium

exposure that is expected due to changes in mission work with beryllium and the scope of work to be performed.

- The total number of workers entering restricted-access areas for FYXX will decrease by xx (determined by site management) percent from the current number of workers entering restricted-access areas after normalizing for any change to the amount of work taking place in these areas that is expected due to changes in mission work with beryllium and the scope of work to be performed.

Additional information specific to exposure reduction and minimization goals and performance measures is provided in Section IV.4.3.1. Additional information provided by DOE's Training Resources and Data Exchange (TRADE) organization on goals and performance measures in general can be found in ref. III.4.2. A source of information for specific safety and health performance measures that could be modified for the site-specific CBDPP is Kodak's "Safety Performance Indexing: Metrics for Safety Performance Improvement Projects" (ref. III.4.3).

4.6 Documentation

Two types of documentation are essential to the DOE CBDPP. One type are the records that provide sufficient information about the site's exposure and health conditions to understand the causes of any CBD that occurs. Documenting and posting the locations where beryllium hazards exist fall into this category. The other type of documentation provides a description of the site-specific CBDPP, including the goals that are set and the site's performance against those goals. This programmatic documentation is critically important because the DOE CBDPP uses the performance-based strategy of requiring performance toward reducing and minimizing exposures rather than selecting DOE-wide OELs. Documentation of site-specific CBDPP rationales, plans, and performance is an

important factor in demonstrating adherence to the requirements of DOE N 440.1. See Section IV.7 for more details about documentation and recordkeeping.

4.7 Labor Relations Requirements

An application of reduction and minimization principles with regard to the protection of workers from the hazards of exposure to beryllium at DOE work sites constitutes a mandatory subject of bargaining under Section 8(a)(5) of the National Labor Relations Act. Where workers are represented for purposes of collective bargaining, in the absence of a waiver of the union's rights, an employer violates that duty to bargain by either (1) unilaterally changing conditions pertaining to workplace exposure to beryllium without notice and bargaining to a good-faith impasse with the collective-bargaining representative of its workers or (2) substantially and materially modifying any collective-bargaining agreement regarding workplace beryllium practices without the agreement of the labor organization. Therefore, DOE N 440.1 provides for an exception consistent with the requirements of the National Labor Relations Act. See Appendix E for the relevant citation in DOE N 440.1.

Sites should include the collective bargaining representatives of workers in the development of a site CBDPP to help ensure that labor relations issues are resolved before the plan is submitted to DOE for approval.

4.8 Qualified Personnel

DOE N 440.1, 3.a. calls for the use of qualified personnel (see Appendix E for the citation). Worker protection personnel who are responsible for implementing a site-specific CBDPP should be qualified in their discipline and specifically qualified in the subject of beryllium within their discipline.

An effective worker protection program must have access to competent industrial hygienists. Management should ensure that its industrial hygiene staff:

- Is adequately trained in the anticipation, recognition, evaluation, and control of hazardous and potentially hazardous occupational exposures, and
- Has the support necessary to maintain and enhance the staff's proficiency in industrial hygiene through continued training, professional education, and professional activities (e.g., the professional certification process).
- Because industrial hygienists have widely varying backgrounds, experience, talent, and education, their development programs should be individualized. Within the worker protection field, opportunities exist for cross-training among the various disciplines. For example, an industrial hygienist may benefit from cross-training in health physics, environmental protection, occupational safety, and waste management, as well as from management training in administration, budgeting, and strategic planning.

The industrial hygiene aspects of the worker protection program should be directed by a senior industrial hygienist with appropriate experience, who should report directly to a senior member of management. A senior industrial hygienist is a person who is certified in the practice of industrial hygiene or who meets the American Board of Industrial Hygiene's (ABIH) requirements for certification. At a minimum, such individuals must have a college or university degree in industrial hygiene or a related scientific, engineering, or technical degree; special studies and training; and 5 years of full-time employment in the professional practice of industrial hygiene. An industrial hygiene technician should have, at a minimum, a high school diploma, special studies and training in the field of industrial hygiene, and five years of experience under a senior industrial hygienist. Appropriate

introductory-level college courses can serve as the equivalent of one year of experience, and an appropriate associate's degree can serve as the equivalent of two years of experience. [See the ABIH *Bulletin* (ref. III.4.4) for detailed requirements for certification or eligibility for certification.]

DOE G 440.1-4 describes professional qualifications for medical staff (see Appendix E for relevant citations). In addition, the DOE Department-wide Functional Area Qualification Standard: Industrial Hygiene Qualification Standard can be used to establish the qualifications of industrial hygienists and the Office Specific Standards called for in the Department-wide Technical Qualifications Program can be used to address specific knowledge, skills, and abilities concerning beryllium. A directory of DOE Qualification Standards is available on the World Wide Web at <http://cted.inel.gov/cted/qualstd/> and the industrial hygiene standard is at <http://cted.inel.gov/cted/qualstd/ih.html>.

III. References

- III.3.1 Rossman, M.D., et al., Beryllium: Biomedical and Environmental Aspects.
Williams & Wilkins, Baltimore, MD, 1990
- III.4.1 Defense Programs Beryllium Good Practice Guide, University of California
Publication Number UCRL-ID-127871, July 1997
- III.4.2 Training Resources and Data Exchange (TRADE). How To Measure
Performance: A Handbook of Techniques and Tools, October 1995
- III.4.3 Kodak Corporate Safety, Eastman Kodak Company (716-722-6955): Safety
Performance Indexing: Metrics for Safety Performance Improvement
Projects, 1994
- III.4.4 American Board of Industrial Hygiene, *Bulletin*, April 13, 1997

IV. GUIDELINES

1. BASELINE INVENTORY AND SAMPLING

1.1 Baseline Inventory and Sampling Requirements

See Appendix E for the requirements to characterize the workplace and identify activities that may contribute to potential workplace exposures.

1.2 General Implementing Guidance for Baseline Inventory and Sampling

Baseline inventory and sampling are the first steps in determining potential beryllium exposures. The desired outcome is a complete inventory of available information on workers, tasks, materials, and locations that can be reviewed to identify the potential beryllium hazards. The baseline inventory and sampling should provide an inventory of activities that may generate hazardous exposures and a list of the potentially exposed workers, preliminary exposure monitoring data, and preliminary exposure profiles of each similarly exposed group of workers. Included in the inventory is a comprehensive listing of locations where beryllium is located or suspected. This information is vital in determining locations for posting areas, establishing beryllium restricted areas, and in the conduct of work planning that results in adequate and appropriate worker protection from beryllium hazards. Appendix E identifies DOE's Exposure Assessment Implementation Guide, (DOE G 440.1-3), which provides information on initial hazard identification and conducting qualitative exposure monitoring, including development of exposure profiles, identification of exposure groups, and use of administrative controls limits.

1.3 Specific Implementing Guidance for Baseline Inventory and Sampling

1.3.1 Inventory

All sources of information about the current and former presence and use of beryllium on site should be considered for review to ascertain the locations of beryllium and the potential for beryllium exposures. Sites should use a risk-based approach to determine which of these sources to review. See Appendix E for requirements to conduct an inventory of beryllium hazards and DOE G 440.1-3, Section 4.4.1, for a list of sources of information to review in conducting a hazard inventory.

1.3.2 Sampling

Once the potential presence of beryllium is established, sampling should be conducted to verify the locations and actual and potential exposure levels. (See Appendix E for the DOE N 440.1 requirement for sampling.) DOE N 440.1 does not intend that sites sample locations that are not likely to present a reasonable risk of beryllium exposure based on the inventory. Standard survey sampling techniques for air sampling (breathing zone and fixed location or “area”) and available survey sampling techniques for surface sampling should be used to determine the extent of possible contamination and exposure. A site’s beryllium sampling strategy should use a combination of sampling techniques that are appropriate to the site’s conditions and should document the controls, including personal protective equipment (PPE) in use, and the amount and form of beryllium used in the area for the period for which the sampling results are representative. (See Section IV.3.3 for details on sampling.)

Appendix B, Numbers 1 and 2 provides specific examples of sampling plans and hazard assessments conducted at facilities at Los Alamos National Laboratory (LANL) and

Rocky Flats Environmental Technology Site (RFETS) that had potential beryllium hazards. Appendix B, Number 3, provides examples of typical sampling field data and results.

2. HAZARD ASSESSMENT

2.1 Hazard Assessment Requirements

See Appendix E for requirements when conducting hazard assessments.

2.2 General Implementing Guidance for Hazard Assessments

Hazard assessment is the activity of determining and documenting the likelihood that individuals will contract CBD from exposure to beryllium that has been identified in the results of the baseline inventory and sampling.

2.3 Specific Implementing Guidance for Hazard Assessments

The higher the toxicity (different forms of beryllium have different levels of toxicity) and the greater the frequency and magnitude of beryllium exposure, the greater the hazard. Other determinants of hazards are the physical and chemical form of the beryllium; the likelihood that the beryllium will become airborne; the frequency, magnitude, and variability of exposure; and the routes of exposure. The hazard assessment should also consider the adequacy and potential for failure of engineering and work practice controls. Sections IV.1 and IV.3 provide information about characterizing workers' exposures. Section III.4.2 and Appendix A, Attachment A-1, Section 2, provide information about beryllium OELs and other measures of toxicity. The hazard assessment should be based on this exposure and toxicity information and be performed as a collaboration among line management, workers, maintenance, and worker protection and other support functions.

Early integration of exposure assessment with work planning activities ensures that assessments of potential exposures during the work are addressed in the work plan. The

use of a work planning team will help facilitate this integration. A multidisciplinary team, convened at the earliest stage of a job or project, can help plan the work and include the hazard characterization and exposure assessment as part of the job. Team members may include planners, engineers, managers, health and safety professionals, professionals from other technical disciplines, technicians, and representative workers.

3. EXPOSURE MONITORING

3.1 Exposure Monitoring Requirements

See Appendix E for exposure monitoring requirements.

DOE N 440.1 requires the exposure monitoring of workers in beryllium areas or engaged in beryllium operations in order to collect accurate exposure data on individual workers. DOE N 440.1 also allows a subset of workers to be monitored as long as the rationale for using a subset is provided. Situations for which monitoring a subset of workers is allowed are further described in section IV.3.3 below.

The terms “assessment” and “monitoring” often are used to convey the same general meaning. The Environmental Protection Agency (EPA) and the American Industrial Hygiene Association (AIHA) both provide the following definition of exposure assessment:

- Exposure Assessment is the determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, and route of exposure (ref. IV.3.1, EPA “Guidelines for Exposure Assessment; Notice,” May 29, 1992; ref. IV.3.2, AIHA “A Strategy for Occupational Exposure Assessment,” 1991).

Exposure monitoring for DOE G 440.1-7 more narrowly refers only to the ongoing determination or estimation (quantitative) of the magnitude, frequency, duration, and route of actual beryllium exposure to workers.

3.2 General Implementing Guidance for Exposure Monitoring

For operations having potential beryllium exposure, surveys should include:

- Personal monitoring for airborne contaminants using breathing zone samples that reflect the 8-hour TWA exposures, TWA excursions, short-term exposures, or ceiling exposure of the worker, as indicated by the appropriate occupational exposure limit. Area monitoring results should not be used for estimating personnel exposures.
- Sampling and analysis, using methods specified by OSHA or NIOSH or by other methods documented to be at least as accurate as the OSHA or NIOSH methods.
- Interpretation of personal monitoring results by industrial hygienist(s) in a manner that is consistent with procedures in OSHA's *Field Inspection Reference Manual* (ref. IV.3.5) and *Technical Manual* (ref. IV.3.6).

3.3 Specific Implementing Guidance for Beryllium Monitoring

Much of the following information is based on the Defense Programs Beryllium Good Practice Guide (ref. IV.3.3). Other good practices can be found in the procedures of the Brush Wellman Company, Inc. (BWI), (Appendix B, Number 4), and the Atomic Weapons Establishment (AWE), Cardiff Facility (Appendix B, Numbers 5-8).

A beryllium exposure assessment plan should be developed for activities with beryllium exposure or potential for exposure. Ref. IV.3.3 provides additional guidance on developing such a plan. Appendix B, Numbers 1 and 2, identify examples of plans. The suggested plan would be a component of the written worker protection program

addressed in Section III.4.1. The relevant elements of the suggested plan are the following:

- identifying all potential exposures to beryllium;
- ranking exposure hazard potential;
- identifying potentially exposed workers;
- monitoring to characterize exposures;
- documenting, communicating, and keeping records of monitoring results;
- determining the frequency of monitoring; and
- developing and establishing mechanisms to initiate additional monitoring following changes in processes, production, materials, controls, work practices, or personnel (ref. IV.3.3, Section 4).

A useful tool for communicating ranking of exposure potential is to develop an exposure matrix for all beryllium activities and different forms of beryllium in use at the site that is similar to Table 2 in DOE G 440.1-3 (see Appendix E).

The suggested plan would be updated along with the written worker protection program that addresses beryllium (covered in Section III.4.1) periodically and when significant operation, process, or procedure changes are made.

An effective exposure assessment plan uses statistical principles to determine the most meaningful monitoring to conduct and the most meaningful presentation of the monitoring results. Presentation of results should use statistical tools to describe the uncertainty, variability, and level of confidence of the results to avoid misunderstandings and inappropriate actions in response to the results. The NIOSH Occupational Exposure Sampling Strategy Manual (ref. IV.3.4) is a good reference to consult to obtain techniques for applying statistical principles to monitoring beryllium at a site. DOE's Exposure Assessment Implementation Guide, DOE G 440.1-3 (see Appendix E) describes exposure assessment in terms of the three types of monitoring relevant to the workplace:

- personal air monitoring;
- area air monitoring; and
- surface monitoring.

Monitoring serves one or both of the following two fundamental purposes:

- determining personal exposure, and
- diagnosing the sources of exposure.

Appendix B, Numbers 1 and 2, are examples of actual sampling plans for personal air, area air, and surface sampling. Appendix B, Number 3, provides examples of typical sampling field data and results.

3.3.1 Personal Air Monitoring

Personal air monitoring is used primarily to estimate or measure individual worker exposure. The major personal air monitoring issues that must be addressed in the exposure assessment plan are whom, when, and how often to monitor, what to measure, and by what methods.

Breathing zone is recommended for personal monitoring because samples of breathing zone air provide the best estimate of worker exposure. Breathing zone samples should be obtained for every worker for every shift until sufficient data are collected that demonstrate that worker exposures are fully characterized and uniformly low. Breathing zone samples are the only samples that can be used to represent personal exposure. Breathing zone sample results should not be reported as adjusted by protection factors for samples taken while the worker was using respiratory protection. This approach of reporting unadjusted breathing zone sample results is required by OSHA to demonstrate compliance and allows worker protection professionals to compare and aggregate different sets of breathing zone results. The type of respiratory protection and its protection factor should be noted with the sample results. Results both unadjusted and adjusted by protection factors should be provided to the monitored workers with an explanation of the meaning of these results. Sampling results should include the actual concentration and sampling time in addition to any TWAs that may be calculated.

Monitoring every worker for every shift is recommended but less monitoring may be appropriate under limited circumstances. Both representative monitoring and reduced frequency of monitoring for specific operations may be appropriate once the operations and their controls are stable and monitoring data demonstrate that exposure levels are stable and consistently below an administrative action level. No, or occasional, monitoring

may be appropriate for highly controlled operations, e.g., operations conducted in fully enclosed systems.

Groups that are selected to be characterized by representative monitoring should be selected based on actual tasks performed and their individual histories of exposures, not on job title. For a given representative group, the individuals with the highest expected exposure should be monitored. Ref. IV.3.3, Section 4.2.1 recommends the minimum percentage of workers in each representative group that should be monitored and provides a table, (Table 4-1), that recommends the frequency of personal air monitoring needed as a function of the reasonable potential level of beryllium exposure. Ref. IV.3.3 further suggests that sometimes an increase in sampling frequency helps to make positive changes to local culture, e.g., by providing performance measures that motivate workers to actively trend and reduce their own exposures. The representative and reduced frequency monitoring still should allow continued demonstration that workers' exposures are adequately characterized and consistently below an administrative action level. The exposure matrix shown as Table 2 in DOE G 440.1-3 can be a convenient tool for linking the individuals or groups to tasks and the exposures anticipated from those tasks.

Additional recommendations for personal air monitoring include the following:

- Characterization of all operations and job tasks for both full shift and potential peak exposures. New operations, or those recently modified or previously uncharacterized, require the most intensive initial exposure evaluation. Personal monitoring and sample analysis should be conducted in accordance with procedures in the OSHA Technical Manual (ref. IV.3.6) and NIOSH methods 7102 (ref. IV.3.7) and 7300 (ref. IV.3.8) or equivalent. Comparability of equivalent methods should be documented.

- In operations where it can be reasonably expected that brief high concentrations of beryllium may be possible, the initial monitoring should include short-term breathing zone samples. These exposure samples should be taken during those portions of operations expected to produce high-level exposures. Such sampling would be taken in addition to full shift monitoring.
- Rapid analysis and feedback. Rapid analysis and feedback of worker exposure data allows early identification of problems. Analysis of samples at the end of each shift would provide the opportunity to correct problems before work continued. Also, this would allow validation of individual worker's clean work practices.
- Frequent monitoring. For example, in the United Kingdom, the AWE has successfully monitored every beryllium worker during every shift (ref. IV.3.3, Section 4.2.1). The AWE Cardiff facility monitored every worker (approximately 300) for every shift for 37 years of operation (see Appendix B, Numbers 5 and 8).

Frequent personal monitoring allows the site to validate its specific CBDPP. Section 4.2.1 of ref. IV.3.3 provides the following additional reasons for frequent personal air monitoring:

- It provides greater assurance that workers are not overexposed.
- The variability of exposures in the workplace can be characterized.
- Individual work practices contributing to high exposures can be identified.
- It acts as a continuing check on the efficacy of workplace controls.

The added value of frequent monitoring should be considered when developing an exposure assessment plan. The cost of frequent monitoring may be relatively small compared to that of a worker over-exposure or the shutdown of an operation due to control failure (ref. IV.3.3, Section 4.2.1).

Non-routine operations such as maintenance, repair, cleaning, D&D, and special projects have some of the highest potential exposures to beryllium (ref. IV.3.3., Section 4.2.1).

Personal air monitoring should be conducted where respirators are used to confirm that the level of respiratory protection is adequate (see Section IV.4.3.3.3.2. for more information about respiratory protection).

D&D operations at former beryllium facilities may result in unexpected exposures to beryllium. Monitoring every worker for every shift is recommended but less monitoring may be appropriate under limited circumstances. Both representative monitoring and reduced frequency of monitoring for specific operations may be appropriate once the operations and their controls are stable, and monitoring data demonstrate that exposure levels are stable and consistently below the OELs set by the site for these activities. D&D operations tend to be highly variable so attaining consistently stable operations and controls may be rare. As a minimum for each task or work group, daily personal air monitoring should be conducted where respirators are used to confirm that the level of respiratory protection is adequate.

Periodic personal air monitoring still may be necessary to validate that conditions have not changed even in situations where a beryllium hazard is present but there is no reasonable potential for beryllium exposure. The exposure assessment plan should document how it was determined that there is no reasonable potential for exposure with that specific

operation or process, and the rationale for the monitoring schedule that validates the presumption of no beryllium exposure.

3.3.2 Area Air Monitoring

Area air monitoring is used primarily as a diagnostic tool in characterizing sources of beryllium exposure, checking the effectiveness of beryllium control systems, making an initial determination of the level of respiratory protection needed, and confirming acceptable air quality in general work areas.

Sample analysis should be conducted according to procedures in the NIOSH Methods 7102 and 7300 (refs. IV.3.7 and IV.3.8) or equivalent. Comparability of equivalent methods should be documented.

Routine area air monitoring should be conducted at locations of all potential sources of airborne beryllium and in all areas that have the potential for containing airborne beryllium.

It is encouraged that area air monitoring be used periodically as a general beryllium air quality measure in both beryllium operations areas and in adjacent non-beryllium operations areas. This type of monitoring may require high flow rates and/or long sampling times to achieve the sensitivity required. Frequency and location of such air quality measurements should be identified in the facility's beryllium exposure assessment plan.

New, recently modified, or previously uncharacterized operations initially will require the most frequent area air monitoring. Non-routine operations such as maintenance, repair, cleaning, reconfiguration, special projects, and D&D operations often require frequent area monitoring for the duration of the activity. As a minimum for each task or work

group, representative area air monitoring should be conducted to fully characterize potential sources of worker exposures.

Routine area air monitoring should focus on reducing exposure. AWE, Cardiff, obtained area air samples at potential beryllium emission points and in general room air every shift. They analyzed the samples and posted the results daily. They discontinued operations and investigated the cause any time elevated levels were measured. In addition, they identified a number of “core” samples taken at operations that were the most difficult to control. AWE, Cardiff, collected and analyzed the core samples at the middle and end of each shift so that they could stop personal exposures from occurring within a few hours of when a release began. (Consult Numbers 4, 6, and 9 of Appendix B for additional examples of area air monitoring frequency.)

DOE has developed Laser Induced Breakdown Spectroscopy (LIBS) as a new technology that will greatly enhance the ability to diagnose emissions from beryllium operations. LIBS will provide results within minutes of when the sample was taken, which will allow pinpointing the specific tasks and locations that are responsible for the release of beryllium. DOE plans to have LIBS commercially available.

Area air monitoring may be useful in conjunction with personal air monitoring when characterizing potential worker exposures. When used to characterize potential worker exposures, area monitors should be placed along the expected path of the exposure where the beryllium concentration is expected to be equal to or greater than the worker's potential exposure. When interpreting area air monitoring results, keep in mind the difficulty of anticipating the actual path of exposure and that area air monitoring may help to understand the source of potential exposures, but is not a substitute for personal air monitoring to determine actual exposures.

3.3.3 Surface Monitoring

Surface monitoring is most often used to monitor the effectiveness of housekeeping efforts in a workplace and to help diagnose the sources of beryllium contamination. The location and pattern of surface levels can help to pinpoint the source of airborne beryllium.

Beryllium contamination on surfaces may become resuspended and contribute to airborne levels if aggressively agitated.

Facilities should strive to keep surfaces in the workplace at or below the levels of accumulations of beryllium dust that could become airborne that have been established in the site's CBDPP. The appropriate use of surface monitoring should be covered in the beryllium exposure assessment plan. The frequency of monitoring should be determined using a risk-based approach and can vary from occasional to every shift. Occasional monitoring may be adequate for activities that are not likely to increase surface contamination levels. Examples include activities conducted in administrative areas that are adjacent to, but not within, an active beryllium work area and small scale tasks that are conducted in ventilated enclosures. On the other hand, frequent monitoring may be appropriate for activities that have a high potential for increasing surface contamination levels. For example, both the AWE at Cardiff (Appendix B, Number 8) and the LANL Beryllium Technology Facility (Appendix B, Number 9) procedures call for surface monitoring every shift. Surface monitoring should be conducted according to procedures in the OSHA Technical Manual (ref. IV.3.6) or equivalent. Appendix B, Numbers 4 and 7 provide specific examples of surface monitoring methods. Comparability of equivalent methods should be documented.

Sites should establish surface contamination administrative action levels that trigger control actions that get more aggressive as the levels increase. See Section IV.4.3.2 for a discussion of administrative action levels.

Surface wipes are a useful tool for monitoring the effectiveness of housekeeping efforts or to help identify the presence of potential beryllium hazards, but they should not be used in an attempt to measure worker exposure or demonstrate regulatory compliance.

Surface wipes will not detect beryllium that is difficult to remove, sealed beneath paint, or imbedded in building materials. Such beryllium that is not detectable by surface wipes could potentially become airborne during D&D or remodeling operations. Methods suitable for difficult to remove beryllium should be used in addition to surface wipes when identifying potential beryllium hazards for operations that will involve demolition, resurfacing, remodeling, or other procedures that will significantly disturb structures or building materials. Section 4.4.1 of DOE G 440.1-3 provides guidance in using other sources of information (such as worker interviews and records reviews) to identify locations where beryllium may be present on surfaces from prior beryllium activities.

IV.3. References

- IV.3.1 Environmental Protection Agency, "Guidelines for Exposure Assessment; Notice," Federal Register Vol. 57, No. 104, May 29, 1992
- IV.3.2 American Industrial Hygiene Association, "A Strategy for Occupational Exposure Assessment," 1991
- IV.3.3 Defense Programs Beryllium Good Practice Guide, University of California Publication Number UCRL-ID-127871, July 1997
- IV.3.4 NIOSH, Occupational Exposure Sampling Strategy Manual, DHEW (NIOSH) Publication Number 77-173, 1977
- IV.3.5 U.S. Department of Labor. OSHA Field Inspection Reference Manual
- IV.3.6 U.S. Department of Labor. OSHA Technical Manual, Fourth Edition. Washington, DC: Government Institutes, Inc. 1996
- IV.3.7 National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. Method 7102, "Beryllium and compounds, as Be," U.S Department of Health and Human Services/National Institute for Occupational Safety and Health. Cincinnati, OH: 1987
- IV.3.8 National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. Method 7300, "Elements by ICP," U.S Department of Health and Human Services/ National Institute for Occupational Safety and Health. Cincinnati, OH: 1987

4. EXPOSURE REDUCTION AND MINIMIZATION

4.1 Exposure Reduction and Minimization Requirements

Appendix E contains specific citations from DOE O 440.1 and DOE N 440.1 that address implementation of a hazard prevention and abatement process to ensure that all identified hazards are managed through abatement or control.

4.2 General Implementing Guidance for Exposure Reduction and Minimization

Appendix E contains specific citations from guides and standards in the DOE directives system that address minimizing and reducing exposures.

4.3 Specific Implementing Guidance for Exposure Reduction and Minimization

Although OELs for chemicals in general are airborne concentrations to which nearly all workers may be repeatedly exposed without adverse effect, some workers will still experience discomfort or disease at airborne concentrations below these limits because of variations in individual susceptibility. Some of these individuals may be hypersusceptible or unusually responsive for various reasons, such as genetic factors, age, and personal habits. Consequently, OELs should be viewed as guidelines for good practice, and controls should be implemented to maintain airborne concentrations as low as practical. This approach is recommended by the ACGIH, 1996 TLVs and Biological Exposure Indices (ref. IV.4.10) and is the approach recommended for controlling beryllium exposures within DOE.

Because information is not available to determine if individuals with positive Be-LPT results or CBD were exposed above the OEL or are hypersusceptible, it is prudent to

control beryllium exposures at DOE sites to as low as practical using strategies of exposure reduction and minimization. The objectives of an exposure control program based on exposure reduction and minimization are (see Appendix E for relevant citations):

- reduce airborne levels of beryllium to levels that are as-low-as-practical,
- minimize the number of current workers exposed and potentially exposed to beryllium,
- minimize the number of opportunities to be exposed, and
- set reasonable exposure reduction and minimization goals using a risk-based (tailored) approach.

Sites can determine their reduction and minimization strategies to control their beryllium hazards after they have characterized their beryllium by conducting baseline inventory and sampling (Section IV.1), hazard assessment (Section IV.2), and exposure monitoring (Section IV.3). Sites may wish to evaluate control strategies used for other hazards (e.g., radiation and asbestos) for application to beryllium. Also, sites may wish to determine the value of consolidating beryllium operations as much as possible. Activities that are limited in number and not expected to generate airborne beryllium may be adequately addressed by implementing a few simple controls aimed at contamination control. These controls, even if basic, should be formally adopted to ensure that the beryllium does not inadvertently become a more significant hazard at a later time. Sources that may generate airborne beryllium sufficient to impact workers' health should be fully evaluated from a reduction/minimization standpoint to identify appropriate control strategies for preventing beryllium exposure.

Appendix B, Numbers 9, 13, and 14 provide examples of exposure reduction and minimization procedures used by LANL, RFETS, and AWE, Cardiff, U.K.

4.3.1 Goals, Plans, and Performance Measures

Goals should be established that represent a reasonable and practical effort to achieve exposure reduction and minimization. Because exposure reduction and minimization strategies focus on reducing exposure levels, minimizing the number of exposures per worker, and minimizing the total number of exposed workers, it may be appropriate to establish goals based on these control strategies. Goals may focus on each control strategy, or just one, depending on the types of activities and the current exposure levels. For example, new facilities offer the opportunity to include cost-effective engineering controls that can achieve aggressive goals for the reduction or prevention of routine exposures. For facilities or operations involving small or localized beryllium sources, goals for exposure minimization, rather than exposure reduction via engineering controls, would be graded to fit those unique circumstances. Also, if exposure levels are below the site's administrative action level, further reduction may not be needed, and emphasis would be placed on minimization strategies. Exposure reduction and minimization performance measures corresponding to the above goals should be established. See Section III.4.5.1 for suggestions for exposure reduction and minimization goals and performance measures.

Once goals and performance measures have been established, it is important to follow through with an implementation plan that identifies the necessary steps in achieving the goals. The implementation plan should establish accountability by identifying responsible organizations and setting due dates for completing actions. Adherence to the plan should be monitored by management.

4.3.2 Administrative Action Levels

Administrative action levels are established as the levels at which controls are implemented or actions taken to prevent the occurrence of exposures above the OEL that has been established by the site. For many substance-specific OSHA standards, the administrative action level is one-half the PEL. Applying this approach to beryllium, the administrative action level would be 1 microgram/m³. However, it is also possible and sometimes practical to set administrative action levels at exposures less than half of the PEL. Many sites already have action levels less than half the PEL. For example, RFETS subcontractors follow administrative action levels of 0.2 and 0.5 microgram/m³ to initiate wearing respiratory protection. These levels are below half of the PEL and reflect the risk-resource balance that they have determined for their different tasks. Administrative action levels may differ for differing conditions but the rationales used to determine these levels should be consistent and documented. DOE G 440.1-3, Section 4.4.6.2, describes an approach for setting administrative action levels (called administrative control limits in DOE G 440.1-3).

Administrative action levels may also differ depending on the control strategy. For example, one administrative action level may be used to initiate establishing a restricted-access area, while another may be used to initiate using PPE. An administrative action level may also be used to trigger cleanup of surface contamination. Sites should establish surface contamination levels that trigger control actions that get more aggressive as the levels increase. These levels should be facility and operation specific and kept as low as is reasonable and practical. At some sites, a surface contamination of 25 micrograms/ft² will initiate cleanup; other sites use 10 micrograms/ft². Reference IV.4.1 and Appendix B, Numbers 4, 7, 10 and 11, provide examples of recommended actions to take at various levels of surface contamination. It is important to keep in mind when setting administrative action levels and interpreting the results of surface sampling that the

sampling techniques (often referred to as surface wipes or swipes) are not standardized and are subject to a number of hard-to-control variables that could affect the results. Although it is not possible to relate specific surface contamination levels to specific airborne levels, it is possible for surface contamination to become airborne if sufficiently agitated and result in exposures. Establishing housekeeping administrative action levels will help control and minimize potential exposure to airborne beryllium that may be resuspended from surface contamination. (See Section IV.3.3.3 for information on surface sampling.)

Administrative action levels should be selected to provide confidence that exposures are below the site's OEL and will meet site exposure reduction and minimization goals. The rationales for selecting administrative action levels should be documented in the site-specific CBDPP.

4.3.3 Exposure and Contamination Controls

To determine appropriate controls for exposure reduction and minimization, a multidisciplinary team including line management, workers, maintenance, and worker protection and other support functions, who are familiar with beryllium operations, hazards, and control methods, should review existing engineering and administrative controls and PPE. A typical review may include, but not be limited to, the following:

- The general configuration of the facility and impacts of beryllium control strategies on operations; including traffic patterns, location of beryllium sources, need for changerooms, personnel, decontamination facilities, personnel monitoring, adequacy of space for proposed modifications, and the impact on maintenance, production, research, and decommissioning activities;

- Verification that the design criteria are consistent with applicable regulations and reduction and minimization goals;
- Verification that beryllium controls provide the required level of protection from airborne beryllium. Any releases of beryllium to the workplace atmosphere should be avoided under normal operating conditions and inhalation by workers should be avoided to the greatest extent practical;
- Evaluation and confirmation of the adequacy of specific control devices for reducing the opportunity for worker exposures, including local ventilation, containment systems, and PPE;
- Verification that the facility design is able to maintain personnel entry control for each beryllium restricted-access area to prevent the spread of contamination, and that the design is commensurate with the existing or potential beryllium hazard within the restricted-access area; and
- Assessment of the adequacy of the monitoring planned for activities and spaces that involve potential beryllium exposure to characterize worker exposures, provide measurements needed to implement the reduction and minimization control strategies, and identify elevated or unplanned beryllium exposures.

Planning efforts should incorporate exposure reduction and minimization strategies. To ensure appropriate control strategies are selected for the planned activities, fundamental principles of enhanced work planning, or other similar collaborative planning process, should be followed. At the completion of short-term beryllium activities such as maintenance, post-job reviews should be conducted to identify lessons learned and best practices to control beryllium exposures during future work. Conduct of operations

reviews that are conducted of long-term operations should include reviews of beryllium activities.

Much of the following information on controls has been obtained from the Defense Programs Beryllium Good Practice Guide (ref. IV.4.1). Additional design specifications for controls at the LANL Beryllium Technology Facility are provided in Appendix B, Number 9.

4.3.3.1 Engineering Controls

Primary reliance should be placed on engineering controls for maintaining airborne concentrations below the administrative action level established in the site-specific CBDPP. Engineering controls normally include local exhaust ventilation, gloveboxes, and other enclosures. For non-routine operations, temporary enclosures such as glovebags or negative pressure enclosures (NPEs) can be used to control exposures and contamination. Engineering controls also include wet methods for cutting, grinding, machining, sanding, or processing of solid beryllium. Caution still must be exercised since any airborne contaminated liquid that is generated would be a potential source of exposure.

4.3.3.1.1 Ventilation

The design and air-flow specifications of local ventilation systems should be reviewed to ensure they at least meet the design criteria of the ACGIH's current "Industrial Ventilation, A Manual for Recommended Practice" (ref. IV.4.2). Section 10.40 (Low-Volume/High Velocity Exhaust Systems) of this manual includes applications for beryllium operations. Even better control of airborne beryllium can be obtained by using state-of-the-art ventilation systems such as the High-Volume/High Velocity Exhaust System and other systems that LANL will use for their new beryllium facility (see Appendix B,

Number 9). Hood configuration and air-flow rates are critical design features for adequate face or capture velocity. Insufficient face velocity allows toxic materials to remain airborne around the hood and to be potentially drawn into the breathing zones of workers. Hood designs need to be specific to the actual operation. Exhaust from routine beryllium-processing operations that could produce airborne particulates should be vented to the environment through an approved high-efficiency particulate air (HEPA) filter. Where air is removed from an area, make-up air must be supplied. Make-up air systems should be constructed so they do not draw in contaminated exhaust air, create turbulence that disperses beryllium contamination, and do not contaminate the workspace with toxic or irritating materials originating from some other location.

Ventilation systems should be evaluated periodically under actual operating conditions to ensure continued operation at design specifications. For work areas that routinely process beryllium (i.e., at least monthly), visual indicators, audible alarms, telltale power lights, or flow indicators should be installed at appropriate work stations to show that the ventilation is operating properly. Workers should perform daily operational checks of their engineering controls before beginning work. These are initial tests to ensure that the systems are on and that air is circulating through them. Ventilation systems should be scheduled for preventive maintenance.

Engineering controls should also be checked after any change in work operations or equipment that might affect the controls to ensure that changes do not impair or overwhelm the system's efficacy and that all design specifications continue to be met. Normal beryllium operations should not be resumed until the system is shown to be operating properly.

4.3.3.1.2 Glovebags and Negative Pressure Enclosures

For non-routine operations such as maintenance or D&D activities, temporary enclosures provide an adequate approach to controlling exposures and contamination. Because exposure levels may be difficult to predict for non-routine activities, it is recommended that temporary enclosures be used when practical to keep exposures below the site-specific administrative action level. Glovebags can provide a flexible, easily installed, and quickly removed temporary work enclosure ideal for small-scale maintenance or D&D activities. When properly installed and used, glovebags permit workers to remain completely isolated from beryllium dust. Glovebags with support frames can be used as NPEs when connected to a HEPA-filtered vacuum system. Additional information on the use of glovebags can be found in 29 CFR 1926.1101 (ref. IV.4.3). Although this standard is concerned with controlling exposures to asbestos, much of the information provided is directly applicable to controlling exposures to beryllium dust.

For larger scale maintenance and D&D activities, NPEs may be an appropriate control method for preventing contamination outside the enclosure. This control method does not necessarily reduce exposures of workers within the NPE but exposures can be minimized within the enclosure by directing air movement away from the workers and toward a HEPA filtration system. NPEs usually are constructed of 6-mil plastic and maintained under a negative pressure of at least 0.02 inch of water pressure differential, relative to outside pressure. Additional information on NPEs can be found in 29 CFR 1926.1101 (ref. IV.4.3).

4.3.3.2 Administrative Controls

Administrative controls can be an effective means for reducing and minimizing worker exposures to below the site-specific administrative action level. Administrative controls

involve changing work conditions or operations to lower exposure. Examples of appropriate administrative controls include:

- Establishing restricted-access areas;
- Scheduling maintenance activities that generate airborne beryllium during times when most workers are elsewhere;
- Arranging operations, schedules, or equipment such that fewer persons are potentially exposed, or persons are exposed for shorter periods or to lower concentrations of beryllium;
- Developing site-specific exposure reduction and minimization procedures; and
- Posting warning signs.

Administrative control through worker rotation is not recommended because this practice does not minimize the number of workers exposed to beryllium. Additionally, tours should not be permitted in areas where there is a potential for beryllium exposure above the site-specific administrative action levels. Instead, alternative methods of viewing the activities and processes, such as closed-circuit TV, videotapes, or adjacent viewing rooms with windows, should be used.

4.3.3.2.1 Restricted-access Areas

Beryllium restricted-access areas should be established for any location where there is airborne beryllium, a potential for airborne beryllium, or when there is a concern for the spread of beryllium contamination. Restricted-access areas are established to limit the

number of individuals exposed and potentially exposed, to provide formality of operations for personnel who enter the location, and to limit the spread of contamination to uncontrolled areas.

Because operations and activities with beryllium exposures vary throughout the complex, as well as at an individual site, a single type of restricted-access area would not be appropriate for all possible situations. Restricted-access areas may vary from a simple barricade around the designated area with a small contamination reduction zone for doffing of contaminated PPE, to a facility where access is gained only through a change room. An industrial hygienist should play a major role in determining whether an area needs to be classified as a restricted-access area, and the type of restricted-access area should be based on risk for exposure.

The controls necessary for a restricted-access area vary to reflect the actual or potential level of airborne concentration or surface contamination. The basic restricted-access area should be demarcated from the rest of the workplace by appropriate physical barriers and signs. There should be storage outside the area for clean PPE. A contamination reduction zone should be established that has containers for booties, outer garments, respirators, and other equipment. Temporary restricted-access areas are needed to cover maintenance, intermittent operations, or unforeseen situations. For permanent activities where site-specific administrative action levels are likely to be exceeded, restricted-access areas should be wholly separate rooms maintained at a negative pressure with respect to adjacent areas to prevent the migration of contamination. All potential sources of contamination need to be identified to ensure the integrity of the restricted-access area when moving people and items out of restricted-access areas. For example, it may be appropriate to assume that papers inside the beryllium area are contaminated. The AWE at Cardiff (Appendix B, Number 8), under this assumption, photocopied all papers on a machine at the area barrier. The copies came out of the clean side of the barrier, and the

originals were retained in the beryllium area until disposed as beryllium waste. Additional information on configurations of restricted-access areas can be found in 29 CFR 1926.1101 (ref. IV.4.3).

A record of all individuals who enter restricted-access areas should be kept since entry indicates potential exposure. (See Section IV.7.3.2 for more information about exposure control records). Such a record ensures that employers are knowledgeable about all individuals who work in a restricted-access area and, in addition, serves to relate any health events to possible exposures. Access records are particularly important when exposure monitoring results indicate an unforeseen elevated exposure had occurred. The record might include the following information:

- Date and time that the restricted area was entered and left;
- Location of the restricted area;
- Names of workers;
- PPE worn; and
- Type of activity performed.

4.3.3.2.2 Decontamination Facilities

For workers who work in restricted-access areas, provision of decontamination facilities consisting of a change room where contaminated clothing is removed, a shower, and a clean room where workers may store and don street clothing is important. The proximity of the decontamination facility to the restricted-access area depends on the beryllium

hazards and local conditions. The change room and clean room should be separate, and the change room should be maintained at negative pressure to the clean room. If circumstances require, the restricted-access area or parts thereof may be used as the change room if it meets all the criteria in this section.

Workers should be required to shower after leaving a restricted-access area, but the location of the change room and shower, and how soon a shower is taken after leaving a restricted-access area depend on local conditions. For example, change rooms may not necessarily be located adjacent to restricted-access areas. Where operations are changing, of short-term duration, or of small scale and low hazard (site-specific administrative action level not likely to be exceeded), it is often impractical to have change rooms and showers adjacent to the operations. However, it is important that soiled work clothing be removed in a change room that is separate from the room where street clothing is stored, and that this change room be maintained under negative pressure to all adjacent rooms outside the restricted-access areas. In some cases, soiled overclothes and equipment may be removed in the restricted-access area, thus combining the change and restricted-access area if the restricted-access area meets the requirements of negative pressure with respect to surrounding areas and can be physically separated (i.e., enclosed with a door, etc.) Conversely, where high-hazard (site-specific administrative action level likely to be exceeded) operations are involved, a contiguous decontamination facility is recommended.

4.3.3.2.3 Personal Hygiene

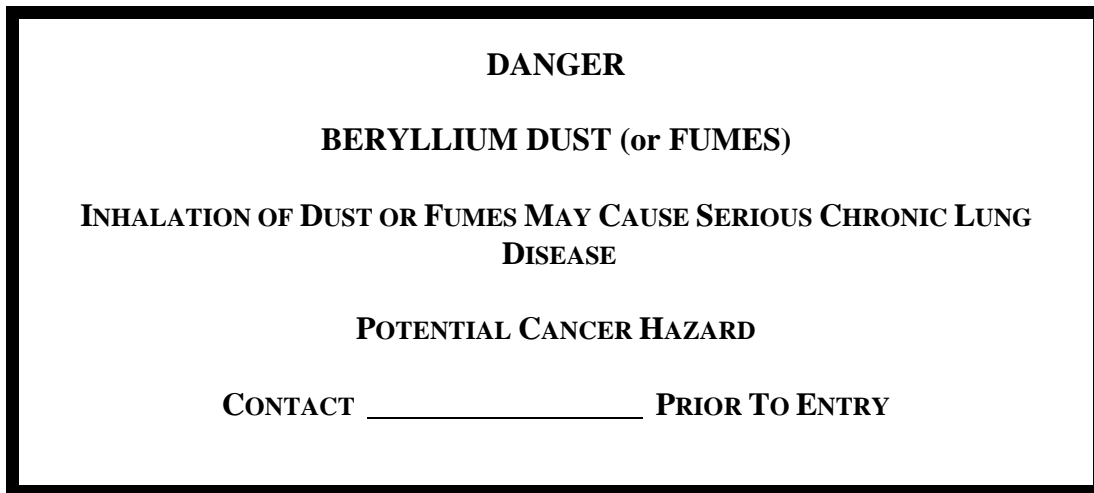
Although ingestion is not the primary occupational hazard of beryllium, good personal hygiene, including frequent hand washing, is necessary to control the spread of contamination and to control personal exposure to airborne beryllium. Some restricted-access areas do not require personal hygiene facilities, whereas other areas will have the need for full showers, lockers for street clothing, and handwashing facilities. The need is

based on risk. While personal exposure does have some role in the decision, in general the spread of contamination should be the basic factor for deciding when to require this type of rigor. For instance, if one is concerned that personnel may take contamination home through contaminated hair, shoes, or undergarments, then shower facilities should be required.

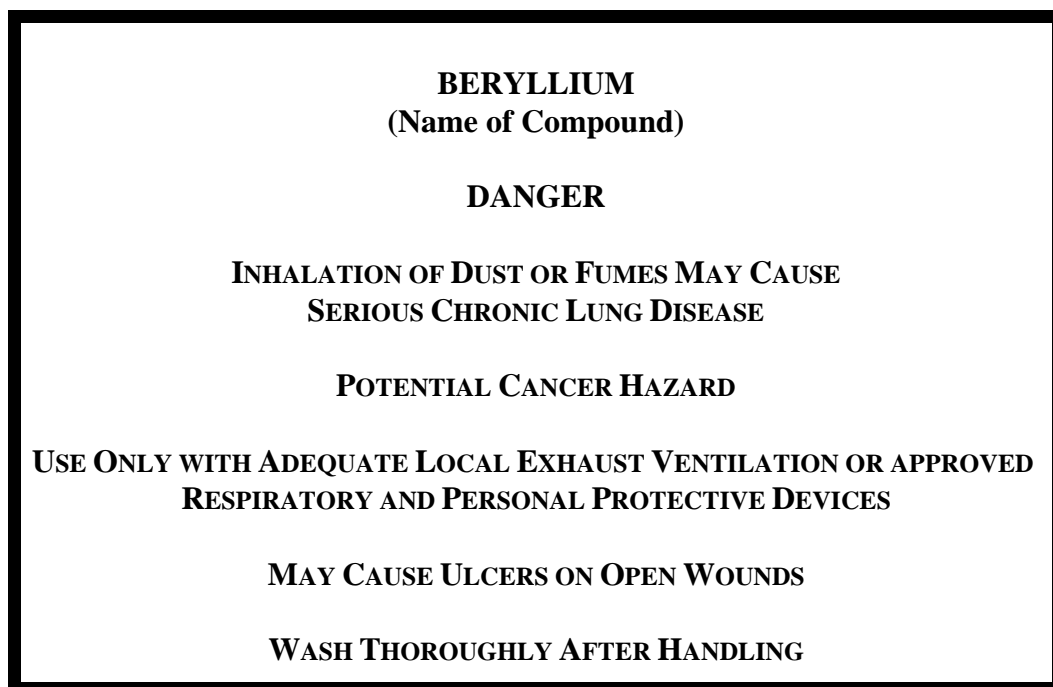
Smoking, drinking, or eating should not be allowed in a beryllium restricted-access area. Storing tobacco, beverages, and food in beryllium restricted-access areas should also be prohibited.

4.3.3.2.4 Warning Signs and Labels

Proper exposure control of beryllium requires that its presence be clearly identified to all who might possibly be exposed. The purpose of the warning label is to ensure that all affected individuals, not only those previously identified as potentially exposed to beryllium, are appraised of the potential hazards of beryllium exposures. The posting of signs serves as a warning to workers who may otherwise not know they are entering a restricted-access area where beryllium exposure may occur. Restricted-access areas, as discussed above, may often exist on a temporary basis such as during maintenance, D&D operations, or in emergency situations. The use of warning signs under these circumstances is of particular importance because a maintenance or D&D operation, or an emergency may present new or unexpected potential for exposure to workers who are regularly expected to conduct work unrelated to beryllium at these sites. Distinctive warning signs for restricted-access areas where only authorized personnel are allowed access are recommended. All restricted-access areas should be clearly identified with warning signs containing the following information:



All containers of beryllium, beryllium compounds, beryllium parts, or beryllium-contaminated clothing, waste, scrap, or debris should have a prominent warning label. These provisions should conform to OSHA's Hazard Communication Standard (29 CFR 1910.1200) (ref. IV.4.4). The warning may convey the following information:



Equipment with beryllium contamination or potential contamination should also be labeled. All equipment inside a permanent beryllium restricted area may not need to be labeled until the item is removed from the area. Examples of labels include:

CAUTION

BERYLLIUM CONTAMINATION

**INHALATION OF DUST OR FUMES MAY CAUSE
SERIOUS CHRONIC LUNG DISEASE**

This equipment was known to have been used for beryllium operations, and may be internally contaminated. If the internal compartments of this equipment are breached, workers must be protected in accordance with applicable OSHA standards. Surveys were performed to determine levels of external surface contamination. Survey results are packaged with the equipment.

CAUTION

POSSIBLE BERYLLIUM CONTAMINATION

**INHALATION OF DUST OR FUMES MAY CAUSE
SERIOUS CHRONIC LUNG DISEASE**

This equipment was in a building where beryllium manufacturing operations were performed. This equipment was not used in beryllium operations but may be internally contaminated. If the internal compartments of this equipment are breached, workers must be protected in accordance with applicable OSHA standards. Surveys were performed to determine the presence of external surface contamination. Survey results are packaged with the equipment.

Detailed specifications for warning signs and labels, such as size, color, or other physical attributes, should conform to the requirements of 29 CFR 1910.145 (ref. IV.4.5). It is the responsibility of the contractor to design, produce, and use signs and labels of appropriate size, color, contrast, and the like, so that warning signs are easily visible to the workers. Emphasis is on visibility and effectiveness in informing workers of beryllium's potential to cause serious disease.

4.3.3.2.5 Industrial Hygiene Procedures

Site-specific industrial hygiene procedures are another example of an administrative control for the protection of workers from the hazards of beryllium. All beryllium processes and activities that are capable of generating airborne beryllium should have a site-specific industrial hygiene procedure to address the hazards and identify appropriate controls. Examples of such processes are cutting, machining, welding, maintenance, and D&D activities. For non-routine work, an industrial hygienist familiar with beryllium controls should participate in the planning phase and review all work control documents to ensure minimization of exposure levels.

4.3.3.2.6 Work Practices

Procedures should ensure housekeeping practices are performed regularly and thoroughly to reduce beryllium contamination to the extent practical. All surfaces should be maintained at or below the site-specific administrative action levels that have been established for accumulations of beryllium dust that could become airborne. Following this practice will minimize the amount of beryllium dust that may be entrained into the air (and the worker's breathing zone) from contaminated surfaces such as floors, work surfaces, ventilation system components, equipment and furnishings, windows and window sills, doors and door frames, rafters, and other supporting structures.

Cleaning methods should minimize the generation of airborne beryllium dust. In contrast to dry cleaning methods such as dusting and dry sweeping, wet cleaning methods are likely to capture and retain beryllium particles before they can be dispersed into the air from dusty surfaces. Floors and other surfaces should be cleaned using HEPA vacuum cleaning, wet cleaning, or both. Acceptable methods of wet cleaning include the use of low-pressure water mists (rather than high-pressure streams that will disperse beryllium particles), mobile wet scrubber units, wet floor mops, and wet wipes, sponges, and cloths.

Beryllium-contaminated dust and debris collected by portable or mobile vacuum systems should not be released into the workplace atmosphere. Either dedicated central vacuum cleaners or HEPA-type portable vacuum cleaners should be the only types used in the cleanup of beryllium. The same dedicated system may be used for beryllium and other toxic contaminants as long as all hazards are considered in the maintenance of the system and disposal of contaminated filters. Vacuuming systems should be equipped with HEPA filters because these filters have a high degree of capture efficiency for particulates. Periodic monitoring should be conducted to demonstrate the efficacy of the filters. Dedicated central vacuuming systems that discharge outside after filtration will normally be permitted by the local authority for enforcement of the Clean Air Act. The filtration system and maintenance schedule may be specified by the local authority in the permit.

Filter maintenance is critical for vacuum systems. Partially or completely blocked filters can substantially compromise system function. HEPA filters on portable or mobile vacuum units should be changed as often as necessary to maintain the design flow rate. To ensure this, periodic maintenance of portable HEPA filter vacuum cleaners should be required. It is recommended that such maintenance be conducted on fixed systems as well. Such maintenance normally includes pressure drop testing to determine when a filter is clogged and needs to be cleaned or replaced, and aerosol penetration testing to determine that no leaks have developed in the HEPA filters. Aerosol penetration testing

of HEPA filters is also normally done when a new filter is installed to ensure that the unit is correctly positioned and dust is not leaking around the filter. Filter testing and maintenance personnel should be considered for inclusion in the CBDPP.

Mobile or portable vacuum units used in beryllium work areas should not be used in workplace areas that are not identified as potentially contaminated with toxic material. Cleaning equipment used in restricted-access areas should not be used in non-restricted areas. This prevents equipment such as vacuum cleaners from being emptied or handled outside of beryllium restricted-access areas; such equipment is often a major source of beryllium-contaminated dust and debris. Adequate facilities should be available to prevent personnel exposure and dust dispersion during emptying of vacuum cleaners and changing of HEPA filters. Mobile or portable vacuum cleaners used in a beryllium operation should be labeled accordingly. The maintenance personnel should be included in the CBDPP.

Dry methods of cleaning should be prohibited; these methods entrain previously settled dust into the workplace air, where it may subsequently enter the workers' breathing zones. Examples of prohibited dry cleaning methods include shoveling, sweeping, or brushing. The use of these methods is acceptable only in completely closed systems such as a glovebox. Another prohibited work practice includes the use of compressed air to remove dust containing particles of beryllium unless the compressed air is used in conjunction with an enclosed ventilation system designed to capture the disturbed dust.

When a spill has occurred and it is possible to transport the beryllium-contaminated item, it is best to determine if it would be preferable to conduct the cleanup where the spill has occurred, or to isolate and transport the item to another site for decontamination. Reasons to transport the item may include lower risk to workers performing the cleanup or better technology resulting in a more effective cleanup process.

4.3.3.3 Personal Protective Equipment

4.3.3.3.1 Protective Clothing

The use of protective clothing for beryllium operations should be specified in the site-specific CBDPP and industrial hygiene procedures. Employers should provide protective clothing for all workers working in areas where they may be exposed to airborne beryllium and who enter areas where there is a potential of surface contamination. The type and variety of protective clothing (e.g., coveralls, lab coats, or shoe covers) should be based on the work conditions and expected contamination levels. Typically, a lab coat, gloves, and booties are the minimum protection needed. Gloves should be worn by workers who may get high levels of contamination on their hands so that the gloves can be removed close to the point of use rather than allowing the hands to spread contamination. Open wounds must be sealed because beryllium contamination causes ulcers which seriously aggravate the wound (see Appendix B, Number 8 for information about a beryllium contaminated wound that occurred at the U.K. Cardiff facility). Impermeable gloves should be worn when working with soluble forms of beryllium to avoid skin contamination. Upon leaving the restricted-access area, workers should remove protective clothing and discard it as hazardous waste or segregate it with other beryllium-contaminated clothing. Workers should carefully remove and place soiled clothing in laundry containers to avoid generating airborne beryllium and unnecessarily contaminating the change room with the beryllium-bearing dust on the clothing. Beryllium-contaminated clothing should be appropriately labeled.

Clean protective clothing should be provided at least daily. Employers may choose reusable or disposable clothing. Each choice has its benefits and drawbacks. Reusable clothing is more comfortable to wear but presents the problem of potential exposure of laundry personnel. Laundry containers should have lids that automatically close behind the

deposited clothing. Additional protective equipment (face-shields, goggles, gloves, etc.) may be required when the danger of skin or eye exposure to soluble forms of beryllium exists. Laundry bags are available that dissolve during the washing process so that laundry workers can avoid the potential exposure that could result from opening the bags and handling the contaminated clothing. Laundry operation workers should be included in the CBDPP. Contractors who provide laundry services should be notified of the beryllium contamination, the hazards associated with the contamination, and appropriate protective measures related to beryllium exposure.

4.3.3.3.2 Respiratory Protection

When employers have implemented all practical engineering and administrative controls and the site-specific administrative action level continues to be exceeded, the employer must implement a respiratory protection program in accordance with DOE O 440.1, which references OSHA's respirator standards, 29 CFR 1910.134 (ref. IV.4.6) and 29 CFR 1926.103 (ref. IV.4.7), as well as ANSI Z88.2, *Practices for Respiratory Protection* (ref. IV.4.8). Contractors may elect to use more stringent requirements when implementing a respiratory protection program. Additional information on respiratory protection can be obtained from the AIHA Manual, *Respiratory Protection: A Manual and Guideline* (ref. IV.4.9).

ANSI Z88.2, *Practices for Respiratory Protection* (ref. IV.4.8) provides protection factors in section 4.5.4 (Table 1 - Assigned Protection Factors). The actual protection provided by respirators may vary from this table for individuals depending on the fit of the respirator and the conditions of use. Respirators accepted for use at higher concentrations may be used at lower concentrations; respirators must not, however, be used at concentrations higher than those for which they are approved. Full-facepiece respirators

should be worn during the operations where airborne soluble forms of beryllium have the potential to cause irritation to eyes or skin.

Respirator protection factor technology and standards are undergoing major changes at this time. NIOSH, in 1995, replaced the Mine Safety and Health Administration regulations at 30 CFR 11 with NIOSH regulations at 42 CFR 84. This action included a revision to their respirator certification standards. NIOSH's significant revisions were for their non-powered particulate filter standards and the designations of these filters. For example, filters formally designated as High Efficiency Particulate Air filters now are designated as N-100, R-100, or P-100 (N = not resistant to degradation by oil, R = resistant to degradation by oil, and P = most resistant to degradation by oil). See web site <http://www.cdc.gov/niosh/pt84abs2.html> for a summary or 42 CFR 84 for details. OSHA, on January 8, 1998, promulgated a revised respiratory protection standard. OSHA reserved section 29 CFR 1910.134(d)(3)(A) for assignment of protection factors. OSHA's new protection factors may supercede the factors in the ANSI Z88.2 table. Site CBDPPs regularly should be updated to reflect these changes in respirator protection factor technology and standards.

4.3.3.4 Waste Management

A waste management program designed to minimize the generation of beryllium waste should be implemented. Because beryllium waste may or may not be interpreted to be a hazardous waste under the Resource Conservation and Recovery Act (RCRA), and discharges to air and water may require permits, each site should involve environmental personnel who are familiar with applicable regulations in establishing the beryllium waste management program. Certainly it is necessary to dispose of beryllium-contaminated waste in such a manner as to ensure both that workers are not additionally exposed to airborne beryllium generated by the handling of such wastes, and that downstream

handlers of waste are also protected. The activities of containment and labeling of beryllium waste should be considered a beryllium activity and included in the CBDPP.

In some situations, disposing of beryllium-contaminated items may be more protective of workers than performing cleanup operations prior to disposal. In such a situation, worker protection should have a higher priority than waste minimization programs.

Release or disposal of equipment or materials used for beryllium operations or used in beryllium areas needs to be reviewed with regard to the intended end use to minimize exposure and potential exposure to beryllium by the subsequent users.

Documents transferring ownership of items with actual or potential beryllium contamination should inform the new owner or user of the contamination, steps taken or not taken to clean both internal and external surfaces, surface contamination levels, hazards associated with beryllium exposure, and appropriate protective measures related to beryllium exposure.

The AWE at Cardiff (Appendix B, Number 8) has established three release criteria, depending on the end use. For items that will be disposed of in a landfill, the accessible surfaces are cleaned before disposal. For items released to the Aldermaston facility, accessible surfaces were cleaned to 5 micrograms/ft². For items released for other uses within the Cardiff facility, accessible surfaces are cleaned to 1 microgram/ft².

IV.4. References

- IV.4.1 Defense Programs Beryllium Good Practice Guide, University of California
Publication Number UCRL-ID-127871, July 1997
- IV.4.2 American Conference of Governmental Industrial Hygienists. Industrial
Ventilation, A Manual for Recommended Practice, 22nd Edition, 1995
- IV.4.3 Title 29 CFR Part 1926.1101 (Asbestos), October 11, 1994
- IV.4.4 Title 29 CFR Part 1910.1200 (Hazard Communication), March 11, 1994
- IV.4.5 Title 29 CFR Part 1910.145 (Specifications for Accident Prevention Signs and
Tags), September 19, 1986
- IV.4.6 Title 29 CFR Part 1910.134 (Respiratory Protection), latest revision
- IV.4.7 Title 29 CFR Part 1926.103 (Respiratory Protection), March 7, 1996
- IV.4.8 American National Standard Institute. American National Standard Practices for
Respiratory Protection, Z88.2
- IV.4.9 American Industrial Hygiene Association. Respiratory Protection: A Manual and
Guideline, 2nd Edition, 1991
- IV.4.10 American Conference of Governmental Industrial Hygienists. Threshold Limit
Values for Chemical Substances and Physical Agents Biological Exposure Indices,
latest edition

5. MEDICAL SURVEILLANCE

5.1 Occupational Medicine Requirements

See Appendix E for medical surveillance requirements and additional information on medical surveillance and coordination with industrial hygiene that is relevant to the CBDPP.

5.2 General Implementing Guidance for Medical Surveillance

Medical surveillance should be offered to all current workers at risk for CBD due to either current or past exposures (see Appendix A, Section 2.3 for a discussion of beryllium exposure groups). Table 1 provides a recommended schedule of medical surveillance. At most sites, records identify some workers known to have been exposed to beryllium. In the past, however, incidentally exposed workers were often not considered to be at risk for CBD and were not included. If records are known to be incomplete, workers should be given an opportunity to self-identify as having been exposed to beryllium in the past. At some sites, beryllium projects had a limited duration, and when asked, some workers may recall that they worked on those projects rather than that they worked with beryllium.

Table 1. Recommended Schedule of Medical Surveillance

	Complete Medical and Occupational History	Physical Examination	Chest x- ray (Postero- anterior view)	Spirometry	Blood Be- LPT
Preplacement	ND ¹ Include emphasis on prior respiratory disease	ND	D ² Offered if spirometry and history warrant	ND	D Offered if history of exposure to Be
Periodic (1-3 yrs)	ND Updated	ND Directed (Lungs and Skin)	D Offered only if medically indicated	ND	D Offered as voluntary
Termination or Transfer	ND Updated	ND Directed (Lungs and Skin)	D Offered only if medically indicated	ND	D Offered as voluntary

¹ ND = Non-discretionary component of surveillance.

² D = Discretionary component of surveillance to allow individual decisions on the risk versus benefits and because surveillance can be conducted without this procedure.

Medical surveillance using traditional screening tests has proven ineffective in detecting CBD in its early stages. The Be-LPT demonstrates immune system sensitivity to beryllium, which is usually a pre-indicator of CBD. Many sensitized individuals, as identified by positive results on the Be-LPT, have developed CBD at a future date.

Participants should be offered other screening tests considered appropriate by a qualified occupational medicine physician. Spirometry and respiratory medical histories are recommended as part of preplacement examination to rule out other lung diseases and to establish a baseline. If the result of spirometry and the medical history justifies the provision of a chest x-ray, it should be offered by the physician on a voluntary basis. A standardized questionnaire is often used as part of periodic examinations to elicit signs or symptoms of respiratory disease.

Workers with signs or symptoms of CBD are usually referred to an occupational medicine or pulmonary medicine clinic familiar with CBD and the protocols for establishing a diagnosis. The reports on diagnoses provide health effects information. The medical surveillance program should include periodic and systematic review and analysis of beryllium worker health and exposure data, with the aim of providing early recognition of work-related health effects. The program should periodically present summary data on the incidence of CBD and sensitization by risk factor (such as tasks and location where exposure occurred, job title, and exposure level). The goal is to provide workers and managers a better understanding of the risks associated with beryllium operations so that they can take actions to improve health protection programs when needed.

All beryllium workers and employees who have been exposed to beryllium incidentally in the past (incidentally exposed workers) should be included in the occupational medicine surveillance program. (See Appendix A, Section 2.3, for a discussion of exposed and incidentally exposed workers.)

5.3 Specific Implementing Guidance for Occupational Medicine Monitoring

The disability associated with CBD should be minimized through early detection of the disease. Current workers sensitized to beryllium or diagnosed with CBD should be offered placement to maintain employment, and be assured of continued screening. DOE G 440.1-7 further on in this section provides information on various screening tests to assist in the diagnosis of CBD, including the Be-LPT, and spirometry. Although DOE currently funds medical surveillance programs, state workers' compensation programs provide benefits to workers who need medical treatment as a result of CBD. It is important to involve Contractor Benefits Administrators and Loss Control Managers in developing a CBDPP to assure that benefit programs address unique CBD issues.

Much of the following information has been adapted from the Defense Programs Beryllium Good Practice Guide (ref. IV.5.1). Also, the BWI Medical Surveillance Program (Appendix B, Number 12) provides useful information on specific tests and procedures to follow on current workers who work, or have worked, in facilities where the potential exists for exposure to environments with air levels of beryllium greater than 0.1 microgram/m³. BWI also provides specific medical protocols to follow for former employees who think they may have CBD as well as employees and former employees who have sub-clinical and clinical CBD.

Medical surveillance should be conducted on a periodic basis of at least 1 to 3 years, with a preplacement and a termination or transfer examination. Medical evaluations are recommended a minimum of every 3 years because of the delay between first exposure and first indication of disease. Frequent medical examinations ensure less concern about false negatives, particularly when diagnosing CBD in the very early stages. Medical surveillance should be offered to persons who have had only brief exposure to beryllium levels that were presumed minimal because there is insufficient information to know for

certain that these individuals did not have a brief high-level exposure that went undetected, and the possibility exists that some of these individuals are highly sensitive to beryllium and may develop CBD. An exposed worker with any pulmonary symptoms should be evaluated immediately. Termination or transfer examinations will document the occupational health status of workers, and should be used to remind them of signs and symptoms that they and their private physician should look for that warrant future medical evaluation for CBD.

Medical examinations should include:

- complete medical and occupational history with special focus on history of respiratory disease;
- physical examination;
- spirometry;
- Chest x-ray may be offered if medically justified and approved by the occupational medicine physician on review of lung function tests or relevant medical history. Chest x-rays also are useful in documenting the absence of other diseases.
- The pulmonary function testing should include, as a minimum, the forced vital capacity (FVC) and the forced expiratory volume (FEV) at one second. These tests can show other pulmonary disease and, along with a chest x-ray, are important as a baseline.
- Be-LPT.

- Be-LPT should be offered to known or self-identified current beryllium workers and incidentally exposed workers (see Appendix A, Section 2.3 for a description of these workers).
- The Be-LPT is being used as a diagnostic test, as a screening test, and as a surveillance tool. The *in vitro* proliferation of beryllium-exposed lymphocytes has been shown to be an indicator of CBD. A positive Be-LPT in lung lymphocytes combined with granuloma is considered to provide definitive support for a diagnosis of CBD (see Appendix A, Section 2.2 for CBD diagnostic criteria). A positive Be-LPT in peripheral blood lymphocytes indicates sensitization and may be an early sign of CBD. The incidence of positive peripheral blood Be-LPT results in exposed workers is considered to be an indicator of the occupational health impacts of beryllium operations and a method for identifying populations at risk for CBD.
- Individuals' participation in Be-LPT screening for CBD should be voluntary. In addition, workers should understand that the Be-LPT can produce false positive and false negative results. Occupational medicine physicians are encouraged to make recommendations on participation within the context of the individual's overall health, employment, and life situation after discussing all these issues with the worker. Be-LPT screening should be offered every 1-3 years to those workers who choose to participate.

IV.5. References

- IV.5.1 Defense Programs Beryllium Good Practice Guide, University of California
Publication Number UCRL-ID-127871, July 1997.

6. TRAINING

6.1 Training Requirements

Appendix E contains specific citations from DOE O 440.1 and DOE N 440.1 that address training requirements.

6.2 General Implementing Guidance for Training

Appendix E contains a specific citation from DOE G 440.1-1 pertaining to training.

6.3 Specific Implementing Guidance for Training

Personnel who work directly with beryllium need to receive training specific to beryllium and the activities they perform. In addition to these workers, others who require training specific to their duties and risks for beryllium exposure include workers working in areas adjacent to beryllium restricted-access areas, maintenance and waste workers, laundry staff, emergency responders, procurement staff, planners, industrial hygiene and medical personnel, visitors, line supervisors, and management. For sites with widespread beryllium activities, it may be appropriate to provide training to all workers. Industrial hygienists with key CBDPP responsibilities should be qualified as described in section III.4.8.

Because not all of the above groups require the same level of training, a graded approach should be implemented. The highest level of training would be provided to workers with beryllium exposures and potential exposures, including maintenance workers, waste workers, laundry staff, and industrial hygienists. The lowest level of training would be provided to site workers not involved in beryllium activities. For these workers, a brief discussion during General Employee Training (awareness training) of basic information

about beryllium, the beryllium activities performed at the site, and familiarization with warning signs may be sufficient. A training matrix with suggested topics for the various groups is provided in Appendix C. All training should meet the requirements of 29 CFR 1910.1200 (ref. IV.6.1) and be presented by trainers who are technically qualified. A list of training resource materials is included in Appendix D.

Workers with actual and potential beryllium exposures should receive periodic training. A mentor program would be beneficial in the training of new workers who have actual and potential beryllium exposures. This training should provide information pertinent to the potential for beryllium exposure of their positions, and focus on lessons learned at the site to help reduce and minimize exposures. The periodic training should provide new information, trends, recent events, etc., and not be merely a repeat of the initial training. How often training is provided should be determined using a risk-based approach. Examples of when more frequent training would be required include when the risk for exceeding an administrative action level is high, the effectiveness of exposure reduction and minimization strategies is marginal or not proven, and activities and processes are highly variable.

IV.6 References

- IV.6.1 Title 29 CFR Part 1910.1200 (Hazard Communication), March 11, 1994.

7. RECORDKEEPING

7.1 Recordkeeping Requirements

See Appendix E for recordkeeping requirements relevant to the CBDPP.

7.2 General Implementing Guidance for Recordkeeping

Accurate and retrievable records are essential to the assessment of the adequacy of worker protection programs. All information that supports assessments of the compliance with OELs, the acceptability of exposures, the adequacy of exposure controls, and health effects due to exposure should be kept. Sites should link exposure data to the identity of exposed individuals to support communication of exposure information to workers and creation of an historical record that can be combined with medical surveillance data for epidemiologic analysis. Records of beryllium inventory, hazard assessment, medical surveillance, and exposure monitoring provide the basis for decisions on the implementation of an effective and efficient CBDPP.

Sites should take advantage of existing records systems for use by the site-specific CBDPP. Records kept for personnel, work control, and cost accounting often contain information relevant to a site's CBDPP. Multidisciplinary teams representing line management, workers, maintenance, and worker protection and other support functions such as personnel and accounting, should collaborate on the content and format of the records that each function needs and can provide. The ultimate objective is an efficient sitewide system, or linked systems, that minimize the resources needed for upkeep and maximize the ease of entry to, access to, and usefulness of the records.

7.3 Specific Implementing Guidance for Recordkeeping

7.3.1 Program Records

Records of all aspects of the site-specific CBDPP addressed in Sections III.1, III.4.1, III.4.2, and III.4.5 should be documented. Reduction and minimization documents: CBDPP policies, goals, implementation strategies, plans and schedules; job-specific plans; beryllium specific training; OELs and administrative action levels; lessons learned; and good practices are particularly important records to maintain.

7.3.2 Exposure and Medical Records

The data needed to answer frequently asked questions should be kept in an electronic format for easy retrieval. These should include:

- Baseline hazard information: beryllium and beryllium contamination inventory, facility and process descriptions including diagrams, cost codes that link workers to tasks that involve beryllium, and building and room numbers identified as having the presence or potential presence of beryllium. Include the strategy used in determining that the baseline is comprehensive and explanations of why the spaces and processes not shown in the baseline are unlikely to contain beryllium hazards.
- Exposure group information: personal identifiers, job, task, and location, whether the worker is current or former, whether the worker has had known exposures or potential incidental exposures, and other information that can be used to link beryllium exposure information to individuals and medical records.

- Records of individuals who enter restricted-access areas, since entry indicates potential exposure and can link workers to unexpected elevated exposures that are identified later when routine monitoring results are available. Records should include name, date, time entered and left, location, activities performed in the area location, and PPE worn.
- Hazard assessment and industrial hygiene reports: methods, assumptions, conclusions, and recommendations.
- Medical records: diagnoses and clinical results linked to exposure and work history data and exposure groups.
- Exposure monitoring: dates, locations, and chemical and physical characteristics of beryllium contaminants; methods; results; the type of respiratory protective equipment worn; the identity of workers monitored; and links to exposure groups, if appropriate. Records should indicate whether the purpose of the sample was to characterize personal exposure or characterize a process.
- Types of control methods in use including design and measured levels of control.
- Investigative reports of significant accidental releases.
- Worker concerns and occurrence reports that indicate breaches in the worker protection program.

The physician responsible for medical services should outline procedures for the creation and maintenance of a medical record for each worker who is identified as exposed or

potentially exposed to airborne beryllium. These medical records should be easily retrievable and protected against loss or destruction.

Employers are required to maintain medical monitoring records for all workers who are subject to the beryllium medical surveillance program (see Appendix E). Medical surveillance records should be retained permanently. Medical records should include the following:

- copies of the attending physician's written reports;
- a copy of the worker's occupational medicine history;
- results of all medical tests including additional tests recommended by the physician;
- a description of any worker medical complaints which may be related to beryllium exposure; and
- original x-ray films.

Cases of CBD are required to be investigated and reported in accordance with DOE O 231.1. One goal of this investigation report is to create CBD case descriptions that can be grouped for analysis. The narrative portion of the investigation reports should include: (1) a work history collected through a review of personnel records and an interview; (2) a summary of exposure records, which should include descriptive statistics such as range, mean, standard deviation, or alternatively, percent exceedance of detection limits and OELs; and (3) a characterization of the clinical stage of the disease such as alveolitis, granuloma, or fibrosis and whether treatment has been prescribed.

8. PERFORMANCE FEEDBACK

8.1 Performance Feedback Requirements

See Appendix E for performance feedback requirements relevant to the CBDPP.

8.2 General Implementing Guidance for Performance Feedback

Performance measurement to provide feedback is important to the management of safety and health risks. One of the principles stated in the DOE ISM guide is “Responsibility and accountability are demonstrated through performance measures and indicators specified in contracts.” Feedback is one of ISM's five core safety functions.

Performance measures can be selected to determine progress toward achieving the site-specific CBDPP goals discussed in Section III.4.5. Performance measures provide information that helps with understanding, managing, and improving program implementation as well as demonstrating performance to external customers and stakeholders. A performance measure is a quantitative or qualitative characteristic of performance, usually consisting of a number, a unit of measure, and a time period.

DOE has published DOE O 210.1, “Performance Indicators and Analysis of Operations Information,” and G 120.1-5, “Guidelines for Performance Measurement,” which indicate the following reasons for measuring performance:

- Performance measurement improves the management and delivery of products and services;

- Performance measurement improves communications internally among workers, as well as externally between the organization and its customers and stakeholders;
- Performance measurement helps justify programs and their costs;
- Performance measurement demonstrates the accountability of Federal stewardship of taxpayer resources; and
- Performance measurement is mandated by the Government Performance and Results Act of 1993 and is central to other legislation and administration initiatives.

Examples of uses of performance measures that provide management with mechanisms by which to proactively manage and continually improve their site-specific CBDPP are:

- Targeting activities and processes requiring additional control strategies,
- Identifying activities and processes with higher risk for causing CBD,
- Identifying workers actually or potentially exposed to beryllium who require medical surveillance,
- Evaluating the effectiveness of job-specific training programs, and
- Determining the need for additional monitoring.

8.3 Specific Implementing Guidance for Performance Feedback

8.3.1 Outcome Measures

Outcome measures are an assessment of the results of a program activity or effort compared to its intended purpose. Possible outcome measures include:

- Exposure level measures such as arithmetic means or percent exceeding OELs, administrative action limits, or detection limits,
- Incidence of CBD and beryllium sensitization,
- Number of workers potentially exposed,
- Percent of surface wipe samples exceeding administrative action limits, and
- Results of analyses of occurrence reports.

8.3.2 Output Measures

Output measures are the tabulation, calculation, or recording of an activity or effort and can be expressed in a quantitative or qualitative manner. Output measures that are potentially useful in managing the implementation of a site-specific CBDPP include:

- Percent of hazard assessments completed per month,
- Percent of beryllium workers participating in scheduled medical surveillance per month,

- Percent of beryllium workers completing scheduled hazard communication training per month,
- Percent of site workers completing scheduled general employee beryllium awareness training per month,
- Percent of the site's facilities that have completed baseline inventories and sampling per month, and
- Percent of beryllium workers who received personal monitoring that were targeted for this monitoring in the site's CBDPP.

8.3.3 Surveillance

Surveillance is closely related to performance measurement but includes analyses with the goal of identifying potential problems where intervention can improve performance. The following definition is from the Council of State and Territorial Epidemiologists.

“Surveillance is the ongoing, systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know. The final link in the surveillance chain is the application of these data to prevention and control.”

Medical surveillance analyzes health and clinical data for higher than expected incidence or sentinel events, such as CBD diagnoses or beryllium sensitization, to determine if corrective actions can prevent a recurrence. The physicians providing medical surveillance should be familiar with working conditions, have access to exposure information, have the

authority to report findings and make recommendations directly to line management, and deliver summaries and impacts of medical surveillance results to the multidisciplinary teams (see Section IV.8.3.4). Beryllium training should include this medical surveillance information.

Similarly, exposure surveillance includes the routine analysis of exposure data with the aim of identifying occupational exposures that require additional control. Exposures that are out of compliance with the site's OELs should be investigated to determine their cause and to determine corrective actions that can prevent a recurrence. Control charts of beryllium exposure levels and other analytical tools can be used to identify working conditions that require further investigation.

8.3.4 Teams To Identify Feedback Sources and Needs

Active performance feedback mechanisms are essential for day-to-day implementation and continual improvement of each element of site-specific CBDPPs and the DOE-wide program. (See Section III.1, Program Elements.) Active feedback can best be approached by having a multidisciplinary team representing line management, workers, maintenance, and worker protection and support functions collaborate on the content and format of the information that each function needs and can provide. Also, the team should use computerized information systems to manage and transfer the information. The amount of information and need for timely and easy input and access to the information can only be satisfied by computerized information systems.

Optimal performance measurement feedback to the various organizations and workers is facilitated by thoroughly integrating the staffs of the relevant functions, including workers, in monitoring performance. Performance feedback occurs naturally as a consequence of team activities in addition to the preparation and distribution of performance reports. The

mechanisms used for providing feedback to the various organizations and workers should be addressed in the written program.

APPENDIX A

BASIS FOR DEPARTMENTAL ACTION

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APPENDIX A

BASIS FOR DEPARTMENTAL ACTION

1. BASIS FOR DEPARTMENTAL ACTION

1.1 Unacceptable Prevalence

The Department is establishing a Chronic Beryllium Disease Prevention Program (CBDPP) in response to the unacceptably high current prevalence of approximately 1% confirmed cases among DOE workers who have been included in a worker health surveillance program for Chronic Beryllium Disease (CBD). CBD is a chronic, irreversible, and sometimes fatal lung disease. See Section 2 of this Appendix for a discussion of beryllium exposure groups and more information about CBD.

1.2 Recent Studies

Recent studies demonstrate that CBD continues to be identified in DOE workers. Worker health surveillance programs for CBD initiated in 1991 at DOE's Rocky Flats Environmental Technology Site (Rocky Flats) and the Oak Ridge Y-12 Plant provide screening to current and former beryllium workers and employees who may have received incidental exposures. Data from these programs confirm that CBD remains an ongoing problem. Through December 1996, 93 cases of CBD have been diagnosed among 9053 workers screened (1.0% prevalence).

1.3 Elusive Exposure Threshold for Disease

The occupational health community does not have sufficient exposure and health outcome data to satisfy the majority of occupational health practitioners in either confirming that the current limit is adequate or establishing a lower limit. Peer-evaluated journal articles (refs. 1, 2, and 3) indicate a high prevalence of CBD where average exposures were reported to be below the 2 micrograms/m³ limit, but the reported exposure data has been challenged as not representing the true exposures that the CBD cases received. Adding to the uncertainty are unpublished data from the United Kingdom Atomic Weapons Establishment Cardiff Facility that suggest that controlling their facility to 2 micrograms/m³ resulted in no cases of CBD among their workers (ref. 7). DOE is not considering a change to the exposure limit given this level of uncertainty.

1.4 Individual Susceptibility May Influence Who Gets CBD

Though workers having the highest levels of exposure are at greatest risk for CBD, individual susceptibility may play a role in who does or does not develop CBD. It has long been suspected that genetics plays a role in determining who will become ill, and recent research suggests that a genetic predisposition may play some role in determining who develops CBD (ref. 4). Currently, however, there is no reliable genetic test that identifies highly susceptible individuals.

1.5 Increasing Numbers of Beryllium Workers

DOE anticipates a large increase in workers who will be potentially exposed to beryllium during the deactivation and decommissioning of former nuclear weapons production sites. Beryllium parts for nuclear weapons were produced in DOE sites. See Attachment A-1, Section 2 for additional information on uses of beryllium in DOE sites.

1.6 Public Trust

The Department's handling of the beryllium issue is attracting public attention and is one of the many activities that affect the public's trust in DOE's ethics and competence. The Department's responsible actions to minimize future cases of CBD will maintain the public's trust.

1.7 Former Workers

Former workers are outside the scope of DOE N 440.1 and its Implementation Guide. DOE G 440.1-7 uses the term “former worker” to refer to workers who no longer work for DOE. The term “current worker” refers to current DOE workers who are potentially exposed as well as those no longer potentially exposed. All current workers who have current or past potential exposure are covered by DOE N 440.1. The Office of Occupational Medicine and Medical Surveillance (EH-61), however, is operating a Beryllium Worker Medical Surveillance Program that contacts and offers CBD screening examinations to former workers. The program is currently operating at the Rocky Flats Environmental Technology Site, the Oak Ridge Y-12 Plant, and the Mound Facility. (The Los Alamos National Laboratory is conducting a beryllium medical surveillance research project but only for current workers.). It is expected that a DOE-wide program will be established in response to a legislative mandate to offer medical examinations to former employees at risk for occupational diseases (refer to 42 USC Section 7274i. “Program to Monitor Department of Energy Workers Exposed to Hazardous and Radioactive Substances”).)

2. TECHNICAL INFORMATION

2.1 Beryllium-Containing Materials

DOE N 440.1 applies to elemental beryllium and any insoluble beryllium compound or alloy containing 0.15 percent beryllium or greater that may be released as an airborne particulate. The soluble forms of beryllium are not covered because these forms of beryllium apparently do not cause CBD (see Attachment A-1). The 0.15 percent beryllium was chosen because beryllium copper alloys are the most widely produced form of low-concentration beryllium and these alloys contain from less than 0.15 percent to approximately 2 percent (ref. 6). Omitting materials containing less than 0.15 percent beryllium is not likely to miss beryllium that would pose a significant health risk in DOE work sites. Also, DOE N 440.1 does not intend the CBDPP to cover copper that contains the trace amounts of beryllium that are likely to be found in non-beryllium copper products as a result of the common practice of recycling beryllium copper alloys along with waste copper. Covering materials that contain trace amounts of beryllium would be of inconsequential value in preventing CBD.

2.2 Definition of and Diagnostic Criteria for CBD

CBD is a granulomatous, interstitial inflammation affecting primarily the lungs. The most common manifestation is chronic interstitial pneumonitis. The interstitial pneumonitis is usually associated with noncaseating granulomas. See ref. 8 and Attachment A-1 for more information.

Different occupational medicine physicians use different diagnostic criteria for CBD but most use a definition similar to the following taken from ref. 9:

**PROPOSED DIAGNOSTIC CRITERIA FOR BERYLLIUM LUNG DISEASE,
SUBCLINICAL BERYLLIUM LUNG DISEASE, AND BERYLLIUM**

SENSITIZATION*

1. History of exposure to beryllium
2. Beryllium-specific immune response
 - positive peripheral blood LTT** and/or
 - positive bronchoalveolar lavage LTT
3. Histopathology on lung biopsy compatible with beryllium disease
 - noncaseating granulomas or
 - mononuclear cell infiltrates
4. Constellation of clinical findings that may include any of the following:
 - respiratory symptoms;
 - reticulonodular infiltrates on chest radiograph or other imaging technique;
 - altered pulmonary physiology with restrictive and/or obstructive physiology, decreased diffusing capacity for carbon monoxide, ventilatory impairment, or altered gas exchange on exercise testing

* Diagnosis of:

- "beryllium disease" requires all four criteria.
- "subclinical beryllium disease" requires Criteria 1 through 3.
- "beryllium sensitization" requires Criteria 1 and 2. The meaning of a positive peripheral blood lymphocyte transformation testing (LTT) in the absence of a positive lavage LTT requires further study.

** LTT is equivalent to the "Be-LPT" term used in G 440.1-7.

2.3 Beryllium Worker Exposure Groups

It can be useful to place individuals into groups based on their potential beryllium exposure. Beryllium workers are workers who are, or have been, potentially exposed to beryllium at or above the administrative action level that the site has established for personal air exposure. (DOE N 440.1, Attachment 1, 4.b, and Contractor Requirements Document, 7.d.(2) requires establishing administrative action levels.) Incidentally exposed workers are individuals who are, or have been, potentially exposed to beryllium at concentrations above naturally occurring background levels and below the administrative action level that the site has established for personal air exposure. This group includes individuals who tour beryllium areas unless personal air monitoring confirms no exposure above natural background levels during the tour. Site CBDPP managers should recognize that non exposed workers, who have no known prior, or anticipated potential future,

exposure to beryllium above natural background air levels, also are addressed since DOE N 440.1, Attachment 1, 4, and Contractor Requirements Document, Section 7.d, requires minimizing the number of individuals who become incidentally exposed or beryllium workers. This group includes individuals who tour beryllium areas and have personal air monitoring results confirming no exposure above natural background levels during the tour. Site CBDPP managers should determine the exposure group that individuals belong to based on the information obtained from baseline inventory and sampling (see Section IV.1), hazard assessment (see Section IV.2), exposure monitoring (see Section IV.3), and medical surveillance (see Section IV.5) and maintain records that are relevant to the CBDPP for these individuals (see Section IV.7).

2.4 Properties, Hazards, and Uses of Beryllium

See Attachment A-1 for information about the properties, hazards, and uses of beryllium.

Appendix A References

- 1 Kreiss, K., et al., "Machining Risk of Beryllium Disease and Sensitization with Median Exposures Below 2 $\mu\text{g}/\text{m}^3$, " American Journal of Industrial Medicine, 30:16-25 (1996).
2. Stange, A.W., et al., "Possible Health Risks from Low Level Exposure to Beryllium," Toxicology, III: 213-224 (1996).
3. Barnard, A.E., et al., "Retrospective Beryllium Exposure Assessment at the Rocky Flats Environmental Technology Site," American Industrial Hygiene Association Journal, 57:804-808 (1996).
4. Richeldi, L., et al., "HLA-DPB1 Glutamate 69: A Genetic Marker of Beryllium Disease," Science, 262:242-244 (1993).
- 5 Pappas, G.P., et al., "Early Pulmonary Physiologic Abnormalities in Beryllium Disease," American Review of Respiratory Disease, 148:661-666 (1993).
6. Rossman, M.D., et al., *Beryllium: Biomedical and Environmental Aspects*. Williams & Wilkins, Baltimore, MD, 1990.
7. Atomic Weapons Establishment, Cardiff, U.K., U.S. Department of Energy, EH-5, *Beryllium Control Model*, June 25, 1997.
8. Green, D.M., et al., "Beryllium Toxicity," Case Studies in Environmental Medicine, Agency for Toxic Substances and Disease Registry, July 1992
9. Newman, L.S., et al., "Pathologic and Immunologic Alterations in Early Stages of Beryllium Disease," American Review of Respiratory Disease, 139:1479-1486

Attachment A-1**Properties, Hazards, and Uses of Beryllium**

This attachment is taken from the July 3, 1997 draft of the Defense Programs Beryllium Good Practice Guide. The Defense Programs Good Practice Guide paragraph numbering was retained.

1.2 Properties and Use

Beryllium is a silver-gray metal that has a low density, moderately high melting point, good stability, and good mechanical properties—particularly specific stiffness, which is six times greater than steel (see Table 1-1). Beryllium is a natural occurring mineral estimated to be present in the earth's surface in concentrations of 1 to 6 ppm. There are approximately 45 beryllium-containing minerals. The commercially important minerals include beryl, $3\text{BeOAl}_2\text{O}_3 \cdot 6\text{SiO}_2$, phenakite, $2\text{BeO} \cdot \text{SiO}_2$; bertrandite, $4\text{BeO} \cdot 2\text{SiO}_2 \cdot \text{H}_2\text{O}$; and chrysoberyl, BeOAl_2O_3 . Beryl has been known since ancient times as the gemstones emerald (green), aquamarine (light blue), and beryl (yellow). Today, the primary forms of beryllium used are pure metal, metal alloys, and beryllium oxide.

Beryllium is an essential material used in many applications within the Department of Energy (DOE), Department of Defense, and in private industry. It is used in a number of aerospace applications, including major components on satellites and spacecraft. The pure metal is used in high-strength, non-sparking copper alloy tools; as moderators and neutron reflectors in nuclear reactors; as components in nuclear weapons; in light-weight, high-performance aircraft brakes; and in mirrors in satellite optical systems. Because beryllium transmits x-rays 17 times greater than aluminum, it is also used extensively in making windows for x-ray tubes. The high-fired oxide (see Table 1-2) is used as a ceramic in electronic applications and in lasers.

Table 1-1. Physical properties of beryllium.	
Atomic number	4
Atomic weight	9.0122
Density	1.8477 g/cm ³
Melting point	1287°C
Boiling point	2472°C

Table 1-2. Physical properties of beryllium oxide.	
Formula	BeO
Molecular weight	25.01
Density	3.01 g/cm ³
Melting point	ca 2530°C
Boiling point	ca 3900°C

Beryllium alloyed with copper, aluminum, and other metals is a popular engineering material in the electronics, automotive, defense, and aerospace industries. Beryllium oxide powder formed into shapes by processes such as dry pressing and extruding and subsequent firing produces a ceramic with an exceptional combination of high thermal conductivity, high electrical resistivity, and excellent dielectric properties. The ceramic is used in a number of electronics, laser, automotive, and defense applications.

While a number of DOE facilities have used beryllium over the years, a few still use it today in operations such as

1. Fabrication of beryllium metal components for nuclear weapons. These operations consist principally of machining beryllium metal pieces purchased from a vendor. The finished pieces are handled by workers involved in quality assurance and assembly activities.
2. Fabrication of beryllium oxide ceramic components for nuclear weapons. The principal operation consists of diamond grinding, high-precision machining of ceramic pieces that are primarily purchased from a vendor.

3. Ceramic hot press where beryllium oxide powder is mixed with other compounds, pressed into the desired shape, and fired in a kiln.
4. Destructive testing operations associated with development of new devices in which beryllium components are included in a non-nuclear package that is destroyed using high explosives.
5. Weapons assembly and disassembly, where workers receive, handle, and store beryllium parts.
6. Beryllium alloy and process development.

2. Toxicology and Biological Effects of Beryllium

The toxicity of beryllium became apparent in the 1930s, but has only been generally recognized since the 1940s. This section provides a general review of the toxicity of beryllium to humans and experimental animals, and describes the characteristics of beryllium-related diseases and current issues. A more thorough review of the toxicology of beryllium can be found in several recent reviews (Meyer 1994; IARC 1993; Rossman, Preuss, and Powers 1991; Kriebel 1988; USEPA 1987; WHO 1990; ATSDR 1993; HSE 1992).

2.1 Extent of Exposure

The principal concern of beryllium exposure to humans is in occupational settings. The potential for such exposure by inhalation exist in the basic production industry, beryllium alloy casting operations, ceramic beryllium-oxide parts manufacturing, and beryllium metal and alloy fabrication (Preuss, 1991). It is estimated that workers potentially exposed to beryllium range from 30,000 (NIOSH 1972) to 800,000 (NIOSH 1978), although the latter estimate has been challenged as an overestimate (Preuss 1991).

To provide for review and ongoing evaluation of the acute and chronic forms of beryllium-induced disease, a Beryllium Case Registry was established in 1952. However, this Registry has not been maintained actively or uniformly in recent decades.

2.2 Effects on Humans

2.2.1 Acute Beryllium Disease

Acute beryllium-induced pulmonary disease, which is characterized by acute nasopharyngitis, tracheobronchitis, and chemical pneumonitis, results from exposure to relatively high levels of airborne beryllium (reviewed by Ridenour and Preuss 1991; Kreibel 1988). For the last 40 years, acute beryllium disease has been associated solely with the extraction of beryllium from ore. However, the potential for contracting the disease only exists in operations that involve handling or extraction of soluble forms of beryllium (e.g., beryllium fluoride and beryllium chloride). It has been noted that virtually all workers exposed to concentrations above 1,000 micrograms/m³ contracted acute beryllium disease, but there has been no reported cases among workers who were exposed to less than 100 micrograms/m³. When removed from exposure, employees who contracted acute beryllium disease gradually improved over a period of several weeks to a few months. The last confirmed case of acute beryllium disease in the United States was in 1967.

2.2.2 Chronic Beryllium Disease

Chronic beryllium disease (CBD) was first described by Hardy and Tabershaw (1946) as a chronic, delayed-type chemical pneumonitis. It is characterized clinically by pulmonary symptoms that include dyspnea, nonproductive cough, and detriments in lung function, although symptoms can also include progressive weakness and fatigue, pain, and anorexia. Histologically, features of CBD include the presence of progressive, noncaseating granulomas, mononuclear cell infiltrates, and calcific inclusions (Freiman and Hardy, 1970). Recently, several authors reviewed the clinical features, pathology, diagnosis, and treatment of CBD (Rossman 1996; Meyer 1994; Rossman

Pruess, and Powers 1991; Kriebel 1988). The disease results from the inhalation of airborne beryllium, and is most closely associated with the relatively insoluble forms (Eisenbud and Lisson 1983). The mean latency period for CBD may range from 1 to 40 years, with an incidence in exposed populations from 1 to 10%. This latter feature led Sterner and Eisenbud (1951) to suggest an immunologically mediated basis for the disease and the possibility that genetic susceptibilities may exist. Dermal effects may also exist in response to skin contact with soluble salts or beryllium slivers, and these effects may range from contact dermatitis to dermal granulomas.

2.2.3 Lung Cancer

There has been considerable debate on the extent to which beryllium and its compounds should be regarded as a human lung carcinogen. Several groups have undertaken epidemiological research on beryllium workers from two general populations: all identifiable beryllium workers, and workers listed in the Beryllium Case Registry. Throughout the 1970s, the former group of workers formed the basis of reports by Wagoner et al. (1980) and by Mancuso (1980), whereas the second group was examined by Infante et al. (1980). These studies have been extensively reviewed and critiqued (USEPA 1987; ATSDR 1993; IARC 1993). The general tone of these reviews is that serious methodological problems with the studies prevented definitive conclusions to be drawn. For this reason, but in consideration of the demonstrable carcinogenicity of beryllium in certain animal models (see Section 2.4), beryllium was classified in the early 1990s as a demonstrated animal carcinogen and a suspect human carcinogen.

More recently, these same two cohorts were reanalyzed. Steenland and Ward (1991) described a small, yet statistically significant increase in lung cancer for cases listed in the Beryllium Case Registry versus the United States population. Interestingly, the mortality rate for lung cancer was greater among individuals with acute beryllium disease (possibly because of greater beryllium exposure) compared with those having CBD. Ward et al. (1992) examined 9225 beryllium workers from 7 beryllium plants and also noted a small, yet significant increase in the mortality

rate for lung cancer from some, but not all of the plants. Presumably on the basis of these studies, the IARC (1993) voted to classify beryllium as a demonstrated lung carcinogen in humans. In spite of these findings, however, beryllium is still classified as a suspected human lung carcinogen in the United States.

2.3 Historical Aspects

2.3.1 Acute Beryllium Disease

Acute beryllium disease was first reported in the United States by Van Ordstrand (1943) and Kolaniz (1997). This disease is a chemical pneumonia, which for the last 40 years, has been solely associated with the extraction of beryllium from ore. Prior to 1950, acute beryllium disease was associated with the manufacture and usage of low-fired beryllium oxide in the fluorescent lamp industry. However, high-fired oxide used in the same application did not result in the disease. Hall et al. (1950) found that the low-fired oxide powder was actually an agglomeration of smaller particles, while the high-fired oxide was made up of larger particles. Also, low-fired oxide was much more soluble than high-fired oxide.

Today, the potential for contracting acute beryllium disease only exists in facilities that handle or extract soluble forms of beryllium (e.g., beryllium fluoride and beryllium chloride). The last confirmed case of acute beryllium disease in 1967 was caused by welding on ventilation duct work containing beryllium fluoride residue. Thus, it appears that acute beryllium disease does not occur in operations involving insoluble forms of beryllium (such as metallic beryllium powder or dust, high-fired beryllium oxide powder or dust, or fumes or dust from alloys containing beryllium).

2.3.2 Chronic Beryllium Disease

As previously noted, CBD was first identified in 1946. In subsequent years, several hundred cases were identified and entered into the Beryllium Case Registry. Eisenbud and Lisson (1983) found a significant reduction in CBD among workers first exposed after 1950. Associated with the decreased incidence of CBD, in spite of increased beryllium use in the 1950s and 1960s, Eisenbud found a decrease in the latency period (Eisenbud, 1990). For various plants and beryllium-working operations, the estimated level of exposure did not correlate well with the incidence of CBD. The role of beryllium-specific sensitization was confirmed in both laboratory and clinical studies.

The identification of a CBD case in a DOE facility in 1984 resulted in increased scrutiny of both industrial hygiene practices and individuals working with beryllium. The lymphocyte proliferation test (LPT), combined with more definitive medical examinations, is now being used in large-scale programs to screen patients' blood or lung lymphocytes. The test involves placing the lymphocytes in cell culture with a soluble form of beryllium and measuring proliferation of the cells (see Section 2.5.2). To date, over 100 new cases of beryllium sensitization and/or CBD have been identified.

2.3.3 Neighborhood Cases

A curious feature of the early literature was the occurrence of several cases of CBD in people residing in the vicinity of beryllium plants. Although it was not possible to always estimate airborne beryllium concentrations near these plants, it was clear that air concentrations could not have been as large as within the plants. However, investigations concluded that insufficient personnel hygiene practices of plant workers, largely from laundering contaminated work clothes in the home, was responsible (Eisenbud 1982, 1990). These investigations also lead to the adoption in 1950 by the AEC of the 0.01 micrograms/m³ concentration standard for air in the vicinity of beryllium plants.

2.4 Animal Models

2.4.1 Biokinetics

Most of our knowledge on the excretion biokinetics of beryllium in humans comes from experimental studies in laboratory animals. Limited information that exists on the topic has been recently summarized in various works (USEPA 1987; Reeves 1991a; ATSDR 1993; IARC 1993; Finch et al. 1996).

Systemic absorption of beryllium through the skin after dermal exposure or through the gastrointestinal tract after oral ingestion is low. Retention in the lung, distribution to other tissues and organs, and excretion is largely due to the physicochemical form of the beryllium inhaled. More soluble beryllium is cleared relatively quickly from the lungs, but can be retained longer, presumably due to precipitation into relatively insoluble forms. Forms of lower solubility, such as the metal or oxide, can be cleared following conventional lung kinetics of clearance of relatively insoluble particles, although toxicity induces delayed clearance (Finch et al. 1996), or by dissolution. Systemically distributed beryllium is retained predominantly in bone, but has been noted in other compartments. Excretion in feces is largely due to unabsorbed beryllium passing from the respiratory to gastrointestinal tract; urinary excretion is more important for systemically distributed beryllium (Reeves 1991b).

2.4.2 Toxic and Immunological Effects

Non-cancer toxic and immunological effects of beryllium compounds have been observed in systems ranging from cultured cells to intact animals (EPA 1987; WHO 1990; Reeves 1991b; ATSDR 1993; IARC 1993; Finch et al. 1996). At sufficiently high exposure levels, beryllium compounds can cause death in periods ranging from minutes to weeks. Beryllium is cytotoxic and can also induce severe, chronic inflammatory pulmonary responses even from single inhalation exposures to the metal.

Animal models have been useful in demonstrating the immunological nature of responses to beryllium. Barna et al. (1984) have demonstrated differential sensitivity of two strains of guinea pigs, suggesting a genetic component of response. Most of the components of human CBD have been demonstrated in either mice (Huang et al. 1992; Finch et al., 1996), rats (Votto et al. 1987), dogs, or monkeys (Finch et al. 1996). Unfortunately, an animal model that incorporates all the significant features of human CBD (including the progressive nature of the disease) has not yet been identified despite efforts by numerous investigators. The development of such a model would allow for investigation of many of the current uncertainties regarding responses to beryllium (see Section 2.5).

2.4.3 Cancer

Recent reviews of the carcinogenicity of beryllium compounds in various tissues of several species of laboratory animals can be found in various works (EPA 1987; WHO 1990; Reeves 1991b; ATSDR 1993; IARC 1993). Most notable have been bone cancer induced by various routes of exposure and, more pertinent to humans, lung cancer induced by inhalation or intratracheal instillation of several different beryllium-containing materials. Marked species differences in pulmonary carcinogenic responses to inhaled beryllium metal between rats (relatively susceptible) and mice (relatively resistant) have been observed (Finch et al. 1996). Experimental data are sufficient to permit both the EPA (600/8-84/026F, 1987) and IARC (1993) to conclude that beryllium and its compounds are demonstrated carcinogens in animals.

2.5 Current Issues

2.5.1 Relationship Between Sensitization and Disease

Because of the development and widespread use of the blood LPT within only the last decade, the relationship between Be-sensitization and the development of clinical CBD is not clear. While it is generally accepted that CBD cases were preceded by detectable sensitization, the extent to which

sensitization, as measured by the LPT, predestines an individual to contract the clinical disease is not known. Some investigators have provided a few instances where this progression has occurred (Kreiss 1993a), but a definitive answer to the question must await follow up of individuals who have recently been identified as sensitized, but who are clinically free of any signs of CBD.

2.5.2 Current Large-scale Screening Programs

Efforts are currently under way at two DOE sites (Rocky Flats and the Y-12 plant at Oak Ridge) and in the private sector to test current and former beryllium workers for Be-specific sensitization using the blood LPT. The largest effort is at Rocky Flats, where 4,268 workers have been tested (Stange et al. 1996). About 1,000 workers at Oak Ridge have been or will be tested.

Large-scale screening programs include an initial blood LPT test, follow-up tests if the initial test is positive, medical counseling, and possible removal from beryllium work. Follow-up tests may include a lung LPT and collection of a transbronchial biopsy sample for analysis of possible lung granulomas. Medical removal from Be-related work is problematic in the private sector where beryllium work may be the only business. It is anticipated that prospective follow up of sensitized, asymptomatic individuals will provide important information on the relationship between beryllium-specific sensitization and the development of clinical CBD.

An enzyme-linked immunosorbent assay (ELISA) (a beryllium antibody test) was developed to screen individual employees for possible exposure to beryllium in the workplace (Clarke 1991). This exceptionally sensitive assay has been used to assess beryllium exposures in a variety of jobs (i.e., engineers, maintenance staff, filter replacement technicians, and laboratory workers), and has identified beryllium exposures within weeks at concentrations as low as 0.08 micrograms/m³ (Clarke 1993). It has also been shown to be effective at detecting antibodies in laboratory mice following inhalation exposures.

2.5.3 Effect of Physicochemical Form and Frequency of Exposure

Despite a 50-year relationship between beryllium exposure and CBD, industrial hygiene assessments have not definitively identified the relationship among specific forms of beryllium, the frequency of exposure (single acute, chronic, or multiple episodic exposure), and the disease. It has been apparent for some time, however, that exposure to the less soluble forms of beryllium (e.g., beryllium metal or beryllium oxide), compared to more soluble forms, are more likely to be associated with CBD cases. Eisenbud and Lisson (1983) showed that machinists working with beryllium metal had the greatest risk of contracting CBD although recent data indicate that exposure to beryllium oxide, even when fired at relatively high temperatures, may be the more hazardous exposure (Kreiss 1996). Cases attributable to exposures to beryllium-containing alloys also exist, although these are apparently more rare (Levin 1991).

There is considerable uncertainty regarding the role of beryllium exposure frequency. CBD cases attributable to a single or only a few exposures are rare, but do exist (see, for example, Newman and Kreiss 1992). As for the relative importance of low-level, chronic exposure, versus periodic “spikes” of exposure, neither industrial hygiene data on human exposures nor data from experimentation on animals permit this question to be adequately answered.

2.5.4 Human Carcinogenicity

Beryllium and its compounds was classified as a demonstrated human carcinogen by the IARC (1993) based on cohort epidemiology studies conducted by Ward et al. (1992) and Steenland and Ward (1991). The interpretation of the findings of these studies is controversial, and factors other than beryllium exposure might explain the results (MacMahon 1994; Vainio and Rice 1997; BISEC 1997). Some agencies in the United States classify beryllium as a suspect human carcinogen (USEPA 1987; ATSDR 1993). Thus, an unresolved dichotomy exists between Europe and the United States regarding the regulatory classification of beryllium as a human carcinogen.

Appendix A, Attachment A-1 References

- ACGIH, American Conference of Governmental Industrial Hygienists. Industrial Ventilation: A Manual of Recommended Practice. 22nd Edition. Cincinnati, OH: ACGIH; 1995.
- ACGIH, American Conference of Governmental Industrial Hygienists. 1996 TLVs and BEIs Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH: ACGIH; 1996a.
- ACGIH, American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. Sixth Edition. Cincinnati, OH: ACGIH; 1996b.
- ANSI, American National Standards Institute. Acceptable concentrations of beryllium and beryllium compounds. New York: ANSI; ANSI Z37.29; 1970.
- ANSI, American National Standards Institute. American National Standard Practices for Respiratory Protection. New York: ANSI; ANSI Z88.2-1991; 1991.
- ATSDR, Agency for Toxic Substances and Disease Registry, Public Health Service. Toxicological Profile for Beryllium. Washington, DC: U.S. Department of Health and Human Services; ATSDR/TP-92/04; 1993.
- Barna, B. P.; Deodhar, S. D.; Chiang, T.; Gautam, S.; Edinger, M. Experimental Beryllium-Induced Lung Disease. Differences in Immunologic Responses to Beryllium Compounds in Strains 2 and 13 Guinea Pigs. Int. Archs. Allergy Appl. Immunol. 73:42–48; 1984.
- BISAC, Beryllium Industry Scientific Advisory Committee. Is Beryllium Carcinogenic in Humans? J. Occup. Env. Med. 39(3):205–208; 1997.
- Caplan, K.J. The Significance of Wipe Samples. Am. Ind. Hyg. Assoc. J. 54:70–75; 1993.
- CFRa, Code of Federal Regulations. DOE National Environmental Policy Act Implementing Procedures. Washington, DC: U.S. Government Printing Office; Title 10, Part 1021.
- CFRb, Code of Federal Regulations. OSHA Hazardous Waste Operations and Emergency Response. Washington, DC: U.S. Government Printing Office; Title 29, Part 1910.120.

- Clarke, S. M. A Novel Enzyme-Linked-Immunosorbent-Assay (ELISA) for the Detection of Beryllium Antibodies. *J. Immunol. Methods.* 137:65–72; 1991.
- Clarke, S. M.; Thurlow, S. M.; Hilmas, D. E. Occupational Beryllium Exposure/Recovery Monitored by Beryllium Antibody Assay: Six Year Case Study. *The Toxicologist.* 13:440(Abtract); 1993.
- Colton, C. E.; Birkner, L. R.; Brosseau, L. M., eds. *Respiratory Protection: A Manual and Guideline.* Second Edition. Akron, OH: American Industrial Hygiene Association; 1991.
- Deodhar, S. D.; Barna, B. P. Immune Mechanisms in Beryllium Lung Disease. *Cleve. Clin. J. Med.* 58:157–160; 1991.
- Eisenbud, M. Origins of the Standards for Control of Beryllium Disease (1947-1949). *Environ. Res.* 27:79–88; 1982.
- Eisenbud, M.; Lisson, J. Epidemiological Aspects of Beryllium-Induced Nonmalignant Lung Disease: A 30-Year Update. *J. Occup. Med.* 25:196–202; 1983.
- Eisenbud, M. Health Problems in the Beryllium Industry. *An Environmental Odyssey: People, Pollution, Politics in the Life of a Practical Scientist.* Seattle, WA: University of Washington Press; 1990:48–54.
- Epstein, W. L. Cutaneous Effects of Beryllium. Rossman, M. D.; Preuss, O. P.; Powers, M. B. *Beryllium, Biomedical and Environmental Aspects.* Baltimore, MD: Williams and Wilkins; 1991:113–119.
- Finch, G. L.; Hoover, M. D.; Hahn, F. F.; Nikula, K. J.; Belinsky, S. A.; Haley, P. J.; Griffith, W. C. Animal Models of Beryllium-Induced Lung Disease. *Environ. Hlth. Perspect.* 104(Suppl. 5):973–979; 1996.
- Freiman, D. G.; Hardy, H. L. Beryllium Disease: The Relation of Pulmonary Pathology to Clinical Course and Prognosis Based on a Study of 130 Cases from the U.S. Beryllium Case Registry. *Hum. Pathol.* 1:25–44; 1970.
- Hall, R. H.; Scott, J. K.; Laskin, S.; Stroud, C. A.; Stokinger, H. E. Acute Toxicity of Inhaled Beryllium. Observations Correlating Toxicity with the Physicochemical Properties of Beryllium Oxide Dust. *Arch. Ind. Hyg. Occup. Med.* 2:25–48; 1950.

- Hardy, H. L.; Tabershaw, I. R. Delayed Chemical Pneumonitis Occurring in Workers Exposed to Beryllium Compounds. *J. Ind. Hyg. Toxicol.* 28:197–211; 1946.
- Hawkins, N. C., Norwood, S. K.; Rock, J. C. A Strategy for Occupational Exposure Assessment. Fairfax, VA: American Industrial Hygiene Association; 1991.
- HSE, Toxicity Review 27: Triglycidyl isocyanurate, Beryllium and beryllium compounds. Health and Safety Executive. Sheffield, United Kingdom: 1992.
- Huang, H.; Meyer, K. C.; Kubai, L.; Auerbach, R. An Immune Model of Beryllium-Induced Pulmonary Granulomata in Mice: Histopathology, Immune Reactivity, and Flow-Cytometric Analysis of Bronchoalveolar Lavage-Derived Cells. *Lab Invest.* 67:138–146; 1992.
- IARC, International Agency for Research on Cancer. Monographs on the Evaluation of Carcinogenic Risks to Humans: Vol 58. Beryllium, Cadmium, Mercury, and Exposures in the Glass Manufacturing Industry. Lyon, France: World Health Organization; 1993.
- ILO, International Labor Organization. Guidelines for the use of ILO international classification of radiographs of pneumoconioses. Geneva, Switzerland: ILO; Occupational Safety and Health Series No. 22 (Rev):1980.
- Infante, P. F.; Wagoner, J. K.; Sprince, N. L. Mortality Patterns from Lung Cancer and Non-neoplastic Respiratory Disease among White Males in the Beryllium Case Registry. *Environ. Res.* 21:35–43; 1980.
- Klingner, T.D.; McCorkle, T. The Application and Significance of Wipe Samples. *Am. Ind. Hyg. Assoc. J.* 55:251–254; 1994.
- Kolanz, M. E. Sample "Request for Quotation" for cleaning and decontamination of a beryllium facility, Brush Wellman Inc., Cleveland, OH, February, 7, 1996.
- Kolanz, M. E. Comments of Brush Wellman, Inc. on the Department of Energy's Notice Requesting Information Relative to Control of Occupational Exposure to Beryllium in DOE Facilities. Cleveland, OH: Brush Wellman, Inc.; 1997.
- Kreiss, K.; Newman, L. S.; Mroz, M. M.; Campbell, P. A. Screening Blood Test Identifies Subclinical Beryllium Disease. *J. Occup. Med.* 31:603–608; 1989.
- Kreiss, K.; Mroz, M. M.; Zhen, B.; Martyny, J. W.; Newman, L. S. Epidemiology of Beryllium Sensitization and Disease in Nuclear Workers. *Am. Rev. Resp. Dis.* 148:985–991; 1993a.

- Kreiss, K.; Wasserman, S.; Mroz, M. M.; Newman, L. S. Beryllium Disease Screening in the Ceramics Industry: Blood Lymphocyte Performance and Exposure-disease relations. *J. Occup. Med.*; 35:267–274; 1993b.
- Kreiss, K.; Mroz, M. M.; Newman, L. S.; Martyny, J.; Zhen, B. Matching Risk of Beryllium Disease and Sensitization with Median Exposures Below 2 micrograms/m³. *Am. J. Ind. Med.* 30:16–25; 1996.
- Kriebel, D.; Brain, J. D.; Sprince, N. L.; Kazemi, H. The Pulmonary Toxicity of Beryllium. *Am. Rev. Respir. Dis.* 137:464–473; 1988.
- Levin, L. Letter to the Editor (in response to Hoover, M. D.; Finch, G. L. Release of Aerosols during Milling of Metal and Beryllium Alloys.) *Appl. Occup. Environ. Hyg.* 6:567; 1991.
- Lichtenwalner, C.P. Evaluation of Wipe Sampling Procedures and Elemental Surface Contamination. *Am. Ind. Hyg. Assoc. J.* 53:657–659; 1992.
- MacMahon, B. The Epidemiological Evidence on the Carcinogenicity of Beryllium in Humans. *J. Occup. Med.* 36(1):15–24; 1994.
- Mancuso, T. Mortality Study of Beryllium Industry Workers' Occupational Lung Cancer. *Environ. Res.* 21:48–55; 1980.
- Markham, T. N. Medical examination programs. Rossman, M. D.; Preuss, O. P.; Powers, M. B., eds. *Beryllium: Biomedical and Environmental Aspects*. Baltimore, MD: Williams & Wilkins; 1991:185–192.
- Meyer, K. C. Beryllium and Lung Disease. *Chest.* 106:942–946; 1994.
- Mitchell, R.N.; Eutsler, B. C. A Study of Beryllium Surface Contamination and Resuspension. B.R. Fish, Editor, *Symposium on Surface Contamination Gatlinburg, TN, June 1964*. Elmsford, NY: Pergamon Press; 1966:349–352.
- Newman, L. S.; Kreiss, K.; King, T. E., Jr.; Seay, S.; Campbell, P. A. Pathologic and Immunologic Alterations in Early Stages of Beryllium Disease. *Am. Rev. Respir. Dis.*; 139:1479–1486; 1989.
- Newman, L. S.; Kreiss, K. Nonoccupational Beryllium Disease Masquerading as Sarcoidosis: Identification by Blood Lymphocyte Proliferative Response to Beryllium. *Am. Rev. Respir. Dis.* 145:1212–1214; 1992.

- NIOSH, National Institute for Occupational Safety and Health. Occupational Exposure to Beryllium (Criteria for a Recommended Standard). Rockville, MD: U.S. Department of Health, Education, and Welfare; NIOSH-TR-003-72; PB 210-806; 1972.
- NIOSH, National Institute of Occupational Safety and Health. Public Hearing on the Occupational Standard for Beryllium. Cincinnati, OH: U.S. Department of Health, Education, and Welfare; NIOSHDPB83-182378; 1977.
- NIOSH, National Institute of Occupational Safety and Health. Health Hazard Evaluation Determination. Report No. 78-028-480. Persolite Products Inc.: Florence, Colorado. Cincinnati, OH: U.S. Department of Health, Education and Welfare; NIOSH-TR-HHE-78-028-480; 1978.
- NIOSH, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. Method 7102: Beryllium and compounds, as Be. Cincinnati, OH: U.S Department of Health and Human Services; 1987.
- Preuss, O. P. Assessment of Risk Potential. Rossman, M. D.; Preuss, O. P.; Powers, M. B., eds. Beryllium: Biomedical and Environmental Aspects. Baltimore, MD: Williams and Wilkins; 1991:263–273.
- Preuss, O. P.; Rossman, M. D. Clinical Picture and Nonimmunological Laboratory Findings in Chronic Beryllium Disease. Rossman, M. D.; Preuss, O. P.; Powers, M. B., eds. Beryllium: Biomedical and Environmental Aspects. Baltimore, MD: Williams & Wilkins, 1991:133–140.
- Reeves, A. L. Toxicodynamics. Rossman, M. D.; Preuss, O. P.; Powers, M. B., eds. Beryllium: Biomedical and Environmental Aspects. Baltimore, MD: Williams & Wilkins; 1991a:87–93.
- Reeves, A. L. Toxicokinetics. Rossman, M. D.; Preuss, O. P.; Powers, M. B., eds. Beryllium: Biomedical and Environmental Aspects. Baltimore, MD: Williams & Wilkins; 1991b:77-86.
- Richeldi, L.; Sorrentino, R.; Saltini, C. HLA-DPB1 Glutamate 69: A Genetic Marker of Beryllium Disease. Science. 262:242-244; 1993.

- Ridenour, P. K.; Preuss, O. P. Acute Pulmonary Beryllium Disease. Rossman, M. D.; Preuss, O. P.; Powers, M. B., eds. Beryllium: Biomedical and Environmental Aspects. Baltimore, MD: Williams & Wilkins; 1991:103–112.
- Rossman, M. D.; Kern, J. A.; Elias, J. A. et al. Proliferative response of bronchoalveolar lymphocytes to beryllium: a test for chronic beryllium disease. *Ann. Intern. Med.* 108:687–693; 1988.
- Rossman, M. D.; Preuss, O. P.; Powers, M.B., eds. Beryllium: Biomedical and Environmental Aspects. Baltimore, MD: Williams & Wilkins; 1991.
- Rossman, M. D.; Jones-Williams, M. Immunopathogenesis of Chronic Beryllium Disease. Rossman, M. D.; Preuss, O. P.; Powers, M. B. Beryllium, Biomedical and Environmental Aspects. Baltimore, MD: Williams and Wilkins; 1991:121–132.
- Rossman, M.D. Chronic Beryllium Disease Diagnosis and Management. *Environmental Health Perspectives.* 104(S5):945–947; 1996.
- Stange, A. W.; Hilmas, D. E.; Furman, F. J. Possible Health Risks from Low Level Exposure to Beryllium. *Toxicology.* 111:213–224; 1996.
- Steenland, K.; Ward, E. Lung Cancer Incidence Among Patients With Beryllium Disease: A Cohort Mortality Study. *J. Natl. Cancer Inst.* 83:1380–1385; 1991.
- Sterner, J. H.; Eisenbud, M. Epidemiology of Beryllium Intoxication. *Arch. Ind. Hyg. Occup. Med.* 4:123–151; 1951.
- Stokes, R. F.; Rossman, M. D. Blood cell proliferation response to beryllium: analysis by receiver-operating characteristics. *J. Occup. Med.* 33:23-28; 1991.
- USDOE, U.S. Department of Energy. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Requirements. Washington, DC: DOE; DOE Order 5400.4. 1989.
- USDOE, U.S. Department of Energy. Decommissioning Handbook. Washington, DC: DOE; DOE/EM-0412; March 1992.
- USDOE, U.S. Department of Energy. Decommissioning Manual. Washington, DC: DOE; DOE/EM-0246; August 1995.

USDOE, U.S. Department of Energy. Environmental Restoration Program Decommissioning Implementation Guide. Washington, DC: DOE; DOE/EM; May 22, 1995.

USDOL, U.S. Department of Labor. OSHA Technical Manual, Fourth Edition. Washington, DC: Government Institutes, Inc. 1996.

USEPA, U.S. Environmental Protection Agency. Health Assessment Document for Beryllium. Washington, DC: EPA; EPA/600/8-84/ 026F; 1987.

Vainio, H.; Rice, J. M. Editorial: Beryllium Revisited. J. Occup. Env. Med. 39(3):203; 1997.

Van Ordstrand, H. S.; Hughes, R.; Carmody, M. G. Chemical Pneumonia in Workers Extracting Beryllium Oxide: Report of Three Cases. Cleve. Clin. J. Med. 10:10–18; 1943.

Votto, J. J.; Barton, R. W.; Gionfriddo, M. A.; Cole, S. R.; McCormick, J. R.; Thrall, R. S. A Model of Pulmonary Granulomata Induced by Beryllium Sulfate in the Rat. Sarcoidosis. 4:71–76; 1987.

Wagoner, J. K.; Infante, P. F.; Bayliss, D. L. Beryllium: An Etiologic Agent in the Induction of Lung Cancer, Non-neoplastic Respiratory Disease, and Heart Disease Among Industrially Exposed Workers. Environ. Res. 21:15-34; 1980.

Ward, E.; Okun, A.; Ruder, A.; Fingerhut, M.; Steenland, K. A Mortality Study of Workers at Seven Beryllium Processing Plants. Am. J. Ind. Med. 22:885–904; 1992.

WHO, World Health Organization. Environmental Health Criteria 106: Beryllium. Geneva, Switzerland: WHO; 1990.

APPENDIX B

CATALOG OF

CHRONIC BERYLLIUM DISEASE PREVENTION PROGRAM

EXAMPLES AND DESCRIPTIONS

The following are examples and descriptions of chronic beryllium disease prevention programs and tools that various organizations have developed and used. These materials have not been reviewed for accuracy or regulatory compliance, and are not endorsed by DOE, unless otherwise indicated in DOE G 440.1-7. Copies of the material are available on the DOE EH Chronic Beryllium Disease Prevention Program Web Site at <http://tis-nt.eh.doe.gov/be/>.

No.	Title	Description
1	Rocky Flats Environmental Technology Site (RFETS) Site Beryllium Characterization Sampling and Analysis Plan	The plan that was used by RFETS to characterize the site for beryllium. Includes personal air, area air, and surface sampling; statistical treatment of sample selection and sample results; sampling, analysis, chain of custody and quality assurance procedures, decision rules to adjust sampling as results become available, and the development of a database for the results.
2	Los Alamos National Laboratory Site Characterization for TA-3-141, Sampling and Testing Plan, December 15, 1995	The plan that was used by LANL to characterize the facility that formerly was used for beryllium and will be renovated into their state-of-the-art beryllium facility. Includes personal air, area air, and surface sampling; statistical treatment of sample selection and sample results; sampling, analysis, chain of custody and quality assurance procedures, and decision rules to adjust sampling as results become available.
3	Los Alamos National Laboratory Site Characterization for TA-3-141, Volume 1-Summary of Site Characterization Results, Volume 2-Detailed Analysis of Site Characterization Results (abbreviated)	Results of a detailed survey for beryllium (and other toxic materials) in a facility that had been used for beryllium activities. Includes typical sample collection and hazard assessment forms that were completed in the field.
4	Brush Wellman Company, Inc., Beryllium Air Sampling Procedure, CLGREG01 Doc: 194776_1, Beryllium Surface Sampling Procedure, CLGREG01 Doc: 194777_1	Brush Wellman, Inc.'s procedures for sampling air and surfaces for beryllium.

No.	Title	Description
5	Atomic Weapons Establishment, Cardiff Facility, AWE Cardiff, U.K., Health Physics Process Instruction Number 13, Personal Air Sampling Project Be Area, November 1993	Cardiff's procedure for personal air sampling for beryllium.
6	Atomic Weapons Establishment, Cardiff Facility, AWE Cardiff, U.K., Health Physics Process Instruction Number 14, Static Air Sampling Project Be Area, November 1993	Cardiff's procedure for sampling area air for beryllium.
7	Atomic Weapons Establishment, Cardiff Facility, AWE Cardiff Health Physics Process Instruction Number 15, Smear Samples Project Be, February 1994	Cardiff's procedure for sampling surfaces for beryllium.
8	Atomic Weapons Establishment (AWE) Cardiff, U.K., Beryllium Control Model description prepared by AWE and EH-5	Summary of Cardiff's beryllium control practices and results over their 37 years of operation.
9	Los Alamos National Laboratory Beryllium Technology Facility Auditable Safety Analysis	Descriptions of the state-of-the-art Los Alamos National Laboratory beryllium facility. The descriptions include engineering, work practice, and administrative controls, and how these controls work together. The descriptions also describe industrial hygiene support and emissions and waste controls.

No.	Title	Description
10	Rocky Flats Plant Procedure 1-15310-HSP-13.04, Beryllium Protection, Revision 0, September 27, 1992	Rocky Flats Environmental Technology Site responsibilities and requirements for working with and monitoring beryllium.
11	Los Alamos National Laboratory Administrative Requirements, AR Section 6: Hazardous Materials, Beryllium, AR 6-7, August 16, 1991	Provides Los Alamos National Laboratory requirements for air quality, surface swipes, and other general requirements for beryllium operations.
12	Brush Wellman Medical Surveillance Program, 2/7/96	Describes beryllium exposure groups, medical surveillance procedures, and diagnostic criteria for CBD.
13	Rocky Flats Industrial Hygiene Procedure Manual, 4-15310-IHPM-5.2, Beryllium Control Program, March 27, 1992	Rocky Flats Environmental Technology Site worker protection personnel responsibilities, exposure monitoring procedures, and exposure reduction and minimization procedures for working with beryllium.
14	Atomic Weapons Establishment (AWE), Cardiff, U.K., Beryllium Facility (Project "Be") Building Regulations	Cardiff's administrative, work practice, and personal protective equipment controls.

APPENDIX C

EXAMPLE TRAINING MATRICES

APPENDIX C

EXAMPLE TRAINING MATRICES

Two matrices are provided as examples for consideration by sites. The first matrix defines training needs by position. The second matrix offers a simplified version with four training levels and suggests positions to be included at each level. The training needs indicated in site specific CBDPPs should reflect that site's beryllium hazards.

TRAINING MATRIX BY POSITION

*TOPIC	POSITION										
	A	B	C	D	E	F	G	H	I	J	K
CBDPP	x	x	x	x	x	x	x	x	x	x	x
Goals	x	x	x	x	x				x		
Performance Measures	x	x	x	x	x				x		
Health Effects	x	x	x	x	x	x	x	x	x	x	x
Physical Properties	x	x		x		x	x	x	x		x
MSDS	x	x		x		x	x	x	x		x
Methods to detect the presence or release	x	x		x		x	x				x
Exposure Reduction/Minimization	x	x	x	x	x		x		x		x
Labeling/Warnings Signs	x	x		x		x	x		x	x	x
Exposure Monitoring	x	x		x	x				x		
Standards	x	x	x	x	x				x		x
Use & Limitations of PPE	x	x		x	x		x		x		x
Medical Surveillance	x	x	x	x	x		x				
Hazard Assessments	x	x		x							
Analytical Techniques				x							
Assessment of Risk			x	x							
Activity/Process Descriptions	x	x	x	x	x						
Activity/Process Locations	x	x	x	x	x				x	x	x
Waste Management	x	x	x	x					x		
Lessons Learned	x	x		x	x						

A Beryllium exposed and potentially exposed workers (includes employees working directly with beryllium, maintenance workers, waste workers, laundry staff, etc.)

B Line Supervisors

C	Management
D	Industrial Hygiene Staff
E	Medical Personnel
F	Workers in areas adjacent to beryllium restricted-access areas
G	Emergency Responders
H	Procurement Staff
I	Planners
J	General Site Personnel
K	Visitors

*The content of each topic could vary depending on the group receiving the training.

TRAINING MATRIX BY LEVEL

*TOPIC	LEVEL			
	I	II	III	IV
CBDPP	x	x	x	x
Goals	x		x	
Performance Measures	x		x	
Health Effects	x	x	x	x
Physical Properties	x	x		
MSDS	x	x		
Methods to detect the presence or release	x	x		
Exposure Reduction/Minimization	x	x	x	
Labeling/Warnings Signs	x	x		x
Exposure Monitoring	x			
Standards	x	x	x	
Use & Limitations of PPE	x	x		
Medical Surveillance	x		x	
Hazard Assessments	x			
Analytical Techniques	x			
Assessment of Risk	x		x	
Activity/Process Descriptions	x		x	
Activity/Process Locations	x	x	x	x
Waste Management	x		x	
Lessons Learned	x			

I Beryllium exposed and potentially exposed workers
 (includes employees working directly with beryllium,
 maintenance workers, waste workers, laundry staff, etc.)
 Line Supervisors
 Industrial Hygiene Staff
 Medical Personnel
 Planners

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Appendix C-5 (and C-6)

- II Workers in areas adjacent to beryllium restricted-access areas
 - Emergency Responders
 - Procurement Staff
 - Visitors
- III Management
- IV General Site Personnel

APPENDIX D

TRAINING RESOURCE MATERIALS

APPENDIX D

TRAINING RESOURCE MATERIALS

As of the publication date of this guide, DOE's Training Resources and Data Exchange (TRADE) is developing a Beryllium Health Risk Communication Prototype specifically to assist in implementing CBDPPs.

The following two videos are endorsed by DOE's Office of Worker Health and Safety:

1. Beryllium Disease, EG&G, Inc., Rocky Flats Plant, September, 1993
2. Beryllium, Course No. HPH107, DOE Environment Safety and Health, May 28, 1997

The following list of items was submitted by Brush Wellman Inc. in response to the Department of Energy's request for information relevant to a DOE beryllium standard. The list includes items that would be useful as training materials. These materials have not been reviewed for accuracy or regulatory compliance, and their inclusion should not be considered an endorsement by DOE. All of these items are Brush Wellman Inc. products unless otherwise noted. Brush Wellman makes the following disclaimer: "Brush Wellman, Inc. (BWI) materials and information are specific to Brush Wellman's operations and products. This information should only be used as a reference in developing other materials. In providing this information, BWI is not undertaking any responsibility for Department of Energy (DOE) facilities or employees, or its industrial hygiene, safety or work practices and expressly disclaims any responsibility. It remains DOE's sole responsibility and obligation to take those actions necessary to protect its employees from exposures to airborne beryllium particulate."

1. Video: Beryllium Alloys...Safe Handling
2. Video: Beryllium Metals...Safe Handling
3. Video: Beryllia Ceramics...Safe Handling
4. Video: Working Safely with Beryllium
5. Material Safety Data Sheets
6. Flash Cards: Copper Beryllium Machining Operations
7. Beryllium Surface Sampling Procedure
8. Guide to Beryllium Copper
9. Machining Beryllium Copper

10. Beryllium Copper Casting and Master Alloys
11. Moldmax^R /Protherm^R Health and Safety Hints
12. Potential Beryllium Exposure While Processing Beryllium Ceramics for Electronic Applications
13. Hazard Materials Minimization Program in Government Electronic Ceramics
14. Editorial: Re: The Epidemiological Evidence on the Carcinogenicity of Beryllium by MacMahon
15. Federal Register: EPA National Emission Standards for Hazardous Air Pollutants: Asbestos, Beryllium and Mercury
16. Health, Safety and Environmental Policy
17. ES&H News: Special Edition
18. High Velocity - Low Volume Ventilation System
19. Medical Facts: Beryllium Disease by National Jewish Center
20. Beryllium - Its Industrial Hygiene Aspects
21. Health Protection in Beryllium Facilities - Summary of Ten Years of Experience by USAEC Health and Safety Laboratory
22. Wipe Test of Surface Dust on Beryllium Shapes or Containers
23. Safety Facts: Thin Film Processing
24. Safety Facts: Destructive Testing
25. Safety Facts: Machining
26. Safety Facts: Laser Operations
27. Safety Facts: Regulatory
28. Safety Facts: Disposal
29. Safety Facts: Thick Film Processing
30. Safety Facts: Safety Practices for Welding Beryllium Copper
31. Safety Facts: Safety Practices for Handling AlBeMET^R Products
32. Safety Facts: Safety Practices of Sanding and Grinding Beryllium Copper Parts
33. Safety Facts: Safety Practices for Buffing and Polishing Beryllium Copper Parts

34. Safety Facts: Safety Practices for Electrical Discharge Machining Beryllium Copper
35. Safety Facts: Safety Practices for Heat Treating Beryllium Copper Parts
36. Safety Facts: Respiratory Protection for Processing Beryllium-containing Materials
37. Safety Facts: Airborne Beryllium Exposure Standards
38. Safety Facts: Ventilation of Beryllium Dust Generating Operations
39. Safety Facts: Safety Practices for Stamping and Plating Beryllium Copper
40. Safety Facts: Safety Practices for Machining Beryllium Copper (Drilling, Boring, Milling, Turning, Tapping, Reaming and Sawing)
41. Safety Facts: Beryllium Copper Foundry Safety Practices
42. Safety Facts: Health Effects Related to Beryllium Exposure
43. Safety Facts: Safety Practices for Handling and Disposal of Electronic Components Containing Beryllium Copper
44. EH&S Corporate Standard: Respiratory Protection
45. Safe Practice Procedure: Maintenance Work on Be-contaminated Equipment
46. Safe Practice Procedure: Plant Housekeeping Program
47. Safe Practice Procedure: New and Transferred Employee Safety Training Program
48. Safe Practice Procedure: Welding and Burning Permit System
49. Safe Practice Procedure: Procedure for Managing Solid Wastes Contaminated with Metallic Beryllium and Beryllium Compounds
50. Safe Practice Procedure: Transportation Accidents Involving Powdered Beryllium Products
51. Safe Practice Procedure: Visitors and Contractors
52. Safe Practice Procedure: Air Cleaning Equipment Operations, Inspection and Maintenance
53. Safe Practice Procedure: Supervisor's Investigation of High Air Count Values
54. Safe Practice Procedure: Serious Air Contamination
55. Industrial Hygiene Procedure: Control Areas
56. Industrial Hygiene Procedure: Control of Contaminated Equipment Leaving Plant Site

57. Plant Housekeeping
58. Customer Form Letter #30: Building/Equipment Decontamination
59. Memo: Supplement to Safety Practice Procedure 8.6 Entitled, Visitors and Contractors
60. Memo: 3000# Arc Furnace Bay Entry and Work Practices
61. Memo: Whiting Furnace and Ladle Bay Entry and Decontamination Practices for Maintenance and Production Activities
62. Memo: Re-drumming Beryllium-containing By-Products or Wastes
63. Memo: Revised - Air Cleaning/Product Collecting Equipment Bat/Cartridge Changes and System Maintenance
64. Memo: Work Practice Clarification for Working Near Ceiling Structures
65. Janitorial Maintenance Guidelines
66. Respirator Use/Facial Hair Limitations Policy
67. Memo: MSA Spectacle Kits
68. Employee Guideline for Using Airline Respiratory Protection Equipment
69. Air Sampling Philosophy
70. Guiding Principles
71. Air Sampling Trains
72. Face Velocities
73. Sampling Rates vs Face Velocity
74. Air Sampler Calibration Procedure
75. Characterization of Potential PO15 Wastes
76. Customer Letter on Copper Beryllium as Hazardous Waste
77. Designing with Beryllium
78. Producing Defect-free Beryllium and Beryllium Oxide

APPENDIX E

DOE DIRECTIVES CITATIONS RELEVANT TO THE CBDPP

CROSSWALK TO APPLICABLE DOE DIRECTIVES

APPENDIX E

DOE DIRECTIVES CITATIONS RELEVANT TO THE CBDPP

CROSSWALK TO APPLICABLE DOE DIRECTIVES

The following matrix provides a crosswalk of the guidance provided in G 440.1-7 to those DOE Directives (Orders, Notices, and Guides) and DOE Technical Standards relating to the CBDPP.

DOE G 440.1-7 Paragraph No.	DOE *	Requirement and Associated Guidance
III.4.1 Written Program	O 440.1	<p>4.a. and Attachment 2, 1: Implement a written worker protection program that...provides a place of employment free from recognized hazards that are causing or are likely to cause death or serious physical harm to their employees; and...integrates all requirements contained in paragraphs 4a through 4l of this Order; program requirements, contained in Title 29 Code of Federal Regulations (CFR) Part 1960, "Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters"; applicable functional area requirements contained in Attachment 1; and other related site-specific worker protection activities.</p> <p>4.b and Attachment 1, 2: Establish written policy, goals, and objectives for the worker protection program.</p> <p>Attachment 2, 18.a.(2): A formal, written contractor occupational medical program detailing the methods and procedures used to implement the occupational medical requirements necessary for worker protection and the promotion of a healthful work environment shall be established, maintained, reviewed, and updated.</p>
	N 440.1	<p>4.b.: Include in the CBDPP written plans, schedules, and other measures for achieving the objectives and requirements of this Notice. The program shall address, at a minimum, the following elements: baseline inventory and sampling, hazard assessment, medical surveillance, exposure monitoring, training, exposure reduction and minimization, recordkeeping, and performance feedback.</p> <p>Attachment 1, 4.a. and Attachment 2, 6.d.(1): Developing a documented program that includes exposure reduction and minimization goals using a risk-based (tailored) approach, a plan for meeting goals, measures that will be used to assess status of attaining goals, and the rationale for determining reduced and minimized exposures.</p> <p>Attachment 1, 4.e.: Documenting the rationale used for determining reduced and minimized exposures.</p> <p>Attachment 2, 4.: Include in the CBDPP written plans, schedules, and other measures for achieving the objectives of DOE Notice 440.1 and requirements of this CRD. The program shall address at a minimum, the following: baseline inventory and sampling, hazard assessment, exposure monitoring, medical surveillance, training, exposure reduction and minimization, recordkeeping, and performance feedback. The CBDPP shall be approved by the contractor's site senior health and safety executive and the Head of the DOE Field Organization.</p>

III.4.2 Occupational Exposure Limits	O 440.1	<p>4.l(1): Comply with the following worker protection requirements: American Conference of Governmental Industrial Hygienists (ACGIH), "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices" (most recent edition), when ACGIH Threshold Limit Values (TLVs) are lower (more protective) than Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits. [When ACGIH TLVs are used as exposure limits, DOE operations shall nonetheless comply with the other provisions of any applicable OSHA-expanded health standard.] The TLVs for exposures to laser emissions in the ACGIH Indices are excluded from this requirement.</p> <p>Attachment 2, 12.a,e: Comply with the following worker protection requirements: a. Title 29 of the Code of Federal Regulations (CFR), Part 1910, "Occupational Safety and Health Standards," . . . e. Title 29 CFR, Part 1926, "Safety and Health Regulations for Construction."</p>
	N 440.1	Attachment 1, 4.b. and Attachment 2, d.(2).: Using administrative action levels that trigger actions to reduce or minimize worker exposure and the potential for exposures.
	G 440.1-3	4.4.6.2: The Administrative Control Limit is a useful statistical tool for providing confidence that exposures are acceptable. Usually, an initial ACL set at 10% to 25% of the OEL is used until sufficient data are obtained to generate a statistically valid exposure profile. (See the <i>AIHA Exposure Assessment Strategy</i> document for a discussion of "trigger points" and details on obtaining statistically significant sampling.) If the ACL is not exceeded, then it can be reasonably assumed that the actual exposures are acceptable with respect to the OEL and additional exposure monitoring may not be needed
III.4.4 Teaming	O 440.1	<p>4.e.: Encourage the involvement of employees in the development of program goals, objectives, and performance measures and in the identification and control of hazards in the workplace.</p> <p>Attachment 2, 17.g.: Coordination with cognizant occupational medical, environmental, health physics, and work planning professionals.</p> <p>Attachment 2, 18.a.(4): To carry out this goal, the contractor occupational medical professional staff shall participate as members of a worker protection team.</p>
III.4.5.1 Goals for Exposure Reduction and Minimization	N 440.1	<p>Attachment 1, 4: Exposure Reduction and Minimization. Manage and control exposures to beryllium by: reducing airborne levels of beryllium as-low-as-practical, minimizing the number of current workers exposed and potentially exposed to beryllium, minimizing the number of opportunities to be exposed, and setting reasonable exposure reduction and minimization goals using a risk-based (tailored) approach.</p> <p>Attachment 1, 4.a: Developing a documented program that includes exposure reduction and minimization goals using a risk-based (tailored) approach, a plan for meeting goals, measures that will be used to assess status of attaining goals, and the rationale for determining reduced and minimized exposures.</p>
III.4.7 Labor Relations Requirements	N 440.1	5.f: Modify the requirements of this Notice for a contractor or subcontractor when necessary to accommodate the obligations of a contractor whose employees are represented for collective bargaining purposes by a labor organization consistent with the requirements of the National Labor Relations Act.

III.4.8 Qualified Personnel	O 440.1	<p>4.c: Use qualified worker protection staff to direct and manage the worker protection program.</p> <p>Attachment 2, 17.k: Professionally and technically qualified industrial hygienists to manage and implement the industrial hygiene program.</p> <p>Attachment 2, 18.i.(1): The physician responsible for the delivery of medical services shall be a graduate of a school of medicine or osteopathy who meets the licensing requirements applicable to the location in which the physician works.</p> <p>Attachment 2, 18.i.(2): Occupational medical physicians, occupational health nurses, physician's assistants, nurse practitioners, psychologists, and other occupational health personnel shall be graduates of accredited schools and shall be licensed, registered, or certified as required by Federal or State law where employed.</p>
	N 440.1	<p>3.a: Conduct comprehensive inventory and hazard assessments for beryllium by qualified professional industrial hygienists to ensure that current workers not involved with beryllium activities or processes and the public are not exposed to beryllium.</p> <p>Attachment 2, 6: Ensure all aspects of the CBDPP are managed and implemented by professionally and technically qualified industrial hygienists and medical personnel.</p>
	G 440.1-4	<p>4.8.1: Physicians who are providing occupational medical services to contractor employees need to have a degree from an accredited school of medicine or osteopathy and meet the licensing requirements applicable to the locations in which they work. Board certification in occupational medicine is preferred. It is desirable that the responsible physician report to the contractor site manager, appropriate laboratory director, or another management level with sufficient authority to participate in health and environmental issues at policy-making levels to ensure program effectiveness. They should be afforded opportunities for continuing education, including attendance at professional meetings.</p> <p>4.8.2: It is recommended that occupational health nurses, physician's assistants, nurse practitioners, and other occupational health personnel be graduates of accredited schools, licensed, registered, or certified, and legally qualified to practice by Federal or State law where employed. They should be afforded opportunities for continuing education, including attendance at professional meetings.</p>
IV.1.3.1 Baseline Inventory	O 440.1	<p>4.i: Identify existing and potential workplace hazards and evaluate the risk of associated worker injury or illness.</p> <p>Attachment 1, 5.a: Initial or baseline surveys of all work areas or operations to identify and evaluate potential worker health risks.</p>
	N 440.1	Attachment 1,1: Develop a baseline inventory of beryllium locations and operations; identify exposed and potentially exposed workers by location; and conduct sampling.
	G 440.1-3	4.4.1: (The section provides guidance about initial hazard identification as the first step in determining potential worker exposures.)

IV.1.3.2 Sampling	O 440.1	<p>4.i.2-3: Assess worker exposure to chemical, physical, biological, or ergonomic hazards through appropriate workplace monitoring (including personal, area, wipe, and bulk sampling), biological monitoring, and observation. Monitoring results shall be recorded. Documentation shall describe the tasks and locations where monitoring occurred, identify workers monitored or represented by the monitoring, and identify the sampling methods and durations, control measures in place during monitoring (including the use of personal protective equipment), and any other factors that may have affected sampling results. Evaluate workplaces and activities accomplished routinely by workers, supervisors, and managers and periodically by qualified worker protection professionals.</p> <p>Attachment 1, 5.a,c and d: Initial or baseline surveys of all work areas or operations to identify and evaluate potential worker health risks. Periodic resurveys and/or exposure monitoring as appropriate. Documented exposure assessment for chemical, physical, and biological agents and ergonomic stressors using recognized exposure assessment methodologies and use of accredited industrial hygiene laboratories.</p>
	N 440.1	Attachment 1, 1: Develop a baseline inventory of beryllium locations and operations; identify exposed and potentially exposed workers by location; and conduct sampling.
	G 440.1-3	4.4.6: (The section provides guidance about conducting qualitative exposure monitoring, including development of exposure profiles, identification of exposure groups, and use of administrative control limits.)
IV.2 Hazard Assessment	O 440.1	<p>4.i.(1): Analyze or review: (a) designs for new facilities and modifications to existing facilities and equipment; (b) operations and procedures; and (c) equipment, product, and service needs.</p> <p>4.i.(3): Evaluate workplaces and activities accomplished routinely by workers, supervisors, and managers and periodically by qualified worker protection professionals.</p> <p>4.i.(4): Report and investigate accidents, injuries, and illnesses (reference DOE O 231.1, 232.1, and 225.1) and analyze related data for trends and lessons learned (reference DOE O 210.1).</p>
	N 440.1	Attachment 1, 2a.-c.: a. Conduct a beryllium hazard assessment and determine whether in-depth analysis is warranted... b. Conduct in-depth analysis, where appropriate, to ascertain the nature of the exposure risk to beryllium... c. Include in the beryllium hazard assessment an analysis of existing conditions, exposure data, medical surveillance trends, and the exposure potential of planned activities.
	G 440.1-1	<p>4.3.1: (This section discusses the types of analyses and reviews that can be useful in identifying and evaluating hazards.)</p> <p>4.3.3: (This section gives guidance on effective approaches to routine evaluation of workplaces and activities.)</p>
	G 440.1-3	4.4.6: (The section provides guidance about conducting qualitative exposure monitoring, including development of exposure profiles, identification of exposure groups, and use of administrative control limits.)

IV.3 Exposure Monitoring	O 440.1	4.i.(2): Assess worker exposure to chemical, physical, biological, or ergonomic hazards through appropriate workplace monitoring (including personal, area, wipe, and bulk sampling), biological monitoring, and observation. Monitoring results shall be recorded. Documentation shall describe the tasks and locations where monitoring occurred, identify workers monitored or represented by the monitoring, and identify the sampling methods and durations, control measures in place during monitoring (including the use of personal protective equipment), and any other factors that may have affected sampling results. Attachment 1, 5c: Periodic resurveys and/or exposure monitoring as appropriate.
	N 440.1	Attachment 1, 3.a-f and Attachment 2, 7.c.(1)-(6): (1): Identify the operations and areas in which workers must be monitored...Conduct personal breathing zone sampling for all workers exposed and potentially exposed to beryllium, or provide the rationale for monitoring a limited subset of workers...Conduct area sampling where appropriate to determine operational control...Conduct surface sampling to determine housekeeping conditions and to identify contamination that has the potential to become airborne...Establish the required frequency of monitoring by using a risk-based (tailored) approach...Require additional monitoring when warranted due to changes in operations or procedures, or as necessary to ensure that exposure reduction and minimization goals are met.
	G 440.1-3	4.2-4.5: (These sections contain guidance about exposure assessment approaches, conducting qualitative exposure assessments, and conducting quantitative exposure assessments.)
IV.3.3.1 Personal Air Monitoring	N 440.1	Attachment 1,3.b., f. and Attachment 2, 7.c.(2), (6): Conduct personal breathing zone sampling for all workers exposed and potentially exposed to beryllium, or provide the rationale for monitoring a limited subset of workers...Require additional monitoring when warranted due to changes in operations or procedures, or as necessary to ensure that exposure reduction and minimization goals are met.
IV.3.3.2 Area Air Monitoring	N 440.1	Attachment 1,3.c. and Attachment 2, 7.c.(3): Conduct area sampling where appropriate to determine operational control.

IV.3.3.3 Surface Monitoring	N 440.1	Attachment 1, 3.d and Attachment 2, 7.c.(4): Conduct surface sampling to determine housekeeping conditions and to identify contamination that has the potential to become airborne.
IV.4 Exposure Reduction and Minimization	O 440.1	<p>4.j: Implement a hazard prevention/abatement process to ensure that all identified hazards are managed through final abatement or control.</p> <p>4.j(1): For hazards identified either in the facility design or during the development of procedures, controls are incorporated in the appropriate facility design or procedure.</p> <p>4.j(2): For existing hazards identified in the workplace, abatement actions prioritized according to risk to the worker are promptly implemented, interim protective measures are implemented pending final abatement, and workers are protected immediately from imminent danger conditions.</p> <p>4.j(3): Hazards are addressed when selecting or purchasing equipment, products, and services.</p> <p>4.j(4): Hazard control methods are selected based on the following hierarchy: (a) Engineering controls. (b) Work practices and administrative controls that limit worker exposures. (c) Personal protective equipment.</p> <p>4.l(1): Comply with the following worker protection requirements: American Conference of Governmental Industrial Hygienists (ACGIH), "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices" (most recent edition), when ACGIH Threshold Limit Values (TLVs) are lower (more protective) than Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits. [When ACGIH TLVs are used as exposure limits, DOE operations shall nonetheless comply with the other provisions of any applicable OSHA-expanded health standard.] The TLVs for exposures to laser emissions in the ACGIH Indices are excluded from this requirement.</p> <p>Attachment 1, 5.b: . . . Industrial hygiene programs shall include . . . coordination with planning and design personnel to anticipate and control health hazards that proposed facilities and operations would introduce.</p> <p>Attachment 1, 5.e: Specification of appropriate engineering, administrative, work practice, and/or personal protective control methods to limit hazardous exposures to acceptable levels.</p> <p>Attachment 2, 12.a,e: Comply with the following worker protection requirements: a. Title 29 of the Code of Federal Regulations (CFR), Part 1910, "Occupational Safety and Health Standards," . . . e. Title 29 CFR, Part 1926, "Safety and Health Regulations for Construction."</p>

IV.4 Exposure Reduction and Minimization (cont.)	N 440.1	Attachment 1,4.a-e and Attachment 2, 7. d. (1)-(5): Elements of reduction and minimization strategies include: Developing a documented program that includes exposure reduction and minimization goals using a risk-based (tailored) approach, a plan for meeting goals, measures that will be used to assess status of attaining goals, and the rationale for determining reduced and minimized exposures...Using administrative action levels that trigger actions to reduce or minimize worker exposure and the potential for exposures...Establishing contamination control to preclude exposures to the extent practical...Implementing work control strategies to reduce exposures to as low as practical using the established hierarchy of industrial hygiene controls (i.e., engineering and administrative controls, and personal protective equipment) to reduce the potential for worker exposure...Documenting the rationale used for determining reduced and minimized exposures.
	G 440.1-1	4.4: (This section contains guidance for implementing a hazard prevention/abatement process to ensure that all identified hazards are managed through final abatement or control.)
	G 440.1-3	4.6.1.2: (This section explains how exposure reduction goals for individuals and groups should be established and tracked for each significant risk group to help reduce exposures. It gives some suggested questions that should be considered in measuring management's performance in conducting exposure assessment.)
IV.4.3.1 Goals, Plans, and Performance Measures	O 440.1	4.b: Establish written policy, goals, and objectives for the worker protection program.
	N 440.1	Attachment 1, 4 and Attachment 2, 7.d.: Exposure Reduction and Minimization. Manage and control exposures to beryllium by: reducing airborne levels of beryllium as-low-as practical, minimizing the number of current workers exposed and potentially exposed to beryllium, minimizing the number of opportunities to be exposed, and setting reasonable exposure reduction and minimization goals using a risk-based (tailored) approach. Attachment 1, 4.a and Attachment 2, 7.d.(1): Developing a documented program that includes exposure reduction and minimization goals using a risk-based (tailored) approach, a plan for meeting goals, measures that will be used to assess status of attaining goals, and the rationale for determining reduced and minimized exposures.
	G 440.1-3	4.6.1.2: (This section explains how exposure reduction goals for individuals and groups should be established and tracked for each significant risk group to help reduce exposures. It gives some suggested questions that should be considered in measuring management's performance in conducting exposure assessment.)
IV.4.3.2 Administrative Action Levels	N 440.1	Attachment 1, 4.b and Attachment 2, 7.d.(2): Using administrative action levels that trigger actions to reduce or minimize worker exposure and the potential for exposures.
	G 440.1-3	4.4.6.2: (This section explains the concept of administrative control limits.)
IV.4.3.3.1 Engineering Controls	O 440.1	4.j(4)(a): Hazard control methods are selected based on the following hierarchy: Engineering controls, . . .
	N 440.1	Attachment 1, 4.d and Attachment 2, 7.d.(4): Implementing work control strategies to reduce exposures to as low as practical using the established hierarchy of industrial hygiene controls (i.e., engineering and administrative controls, and personal protective equipment) to reduce the potential for worker exposure.

IV.4.3.3.1 Engineering Controls (cont.)	G 440.1-1	4.4.4.1: Where controls are necessary to reduce worker risk from exposure to workplace hazards, engineering controls should be implemented to the extent feasible. Principal engineering controls include: substituting a less hazardous substance or process, enclosing a hazard, locating hazardous operations or equipment in remote and/or unoccupied areas, establishing physical barriers and guards, and using local and general exhaust ventilation.
	G 440.1-3	4.6.3: (This section discusses the role of exposure assessment in exposure prevention and hazard control.)
IV.4.3.3.2 Administrative Controls	O 440.1	4.j(4)(b): Work practices and administrative controls that limit worker exposures.
	N 440.1	Attachment 1, 4.d and Attachment 2, 7.d.(4): Implementing work control strategies to reduce exposures to as low as practical using the established hierarchy of industrial hygiene controls (i.e., engineering and administrative controls, and personal protective equipment) to reduce the potential for worker exposure.
	G 440.1-1	4.4.4.2: The effectiveness of work practice and administrative controls depends on the ability of line management to make employees aware of established work practices and procedures, to reinforce them, and to provide consistent and reasonable enforcement. Administrative controls include: written operating procedures, safety work practices, and work permits; exposure time limitations; limits on the use of hazardous materials and monitoring of such operations; health and safety plans; altered work schedules, such as working in the early morning or evening to reduce the potential for heat stress; and training employees in methods of reducing exposure.
	G 440.1-3	4.6.3: (This section discusses the role of exposure assessment in exposure prevention and hazard control.)
IV.4.3.3.3 Personal Protective Equipment	O 440.1	4.j(4)(c): Personal protective equipment. 4.l(3): Comply with . . . American National Standards Institute Z88.2, "Practices for Respiratory Protection."
	N 440.1	Attachment 1, 4.d and Attachment 2, 7.d.(4): Implementing work control strategies to reduce exposures to as low as practical using the established hierarchy of industrial hygiene controls (i.e., engineering and administrative controls, and personal protective equipment) to reduce the potential for worker exposure.

IV.4.3.3.3 Personal Protective Equipment (cont.)	G 440.1-1	4.4.4.3: When engineering and/or administrative controls have been considered and implemented and are not sufficient to fully protect the worker from a recognized hazard, personal protective equipment can be used to supplement these other controls as appropriate. PPE is acceptable as a control method: to supplement engineering, work practice, or administrative controls when such controls are not feasible or do not adequately reduce the hazard; as an interim measure while engineering controls are being developed and implemented; during emergencies when engineering controls may not be feasible; and during maintenance and other non-routine activities where other controls are not feasible. The use of PPE can itself create significant worker hazards, such as heat stress, physical and psychological stress, and impaired vision, mobility, and communication. An example would be a worker wearing several layers of clothing (for warmth and anti-contamination), a respirator, gloves, and a helmet while welding or cutting. This arrangement of PPE could prevent the worker from being aware of the environment in the event of a fire or other emergency. Research has also confirmed that fabric assemblies with high percentages of cotton fiber in their outer wear and/or underwear layers and no air space between layers yielded the highest maximum heat transfer rate and total heat transfer. These assemblies have more burn potential than assemblies containing higher amounts of polyester and more space between layers. In these situations, engineering and/or administrative controls (e.g., a fire watch to ensure the safety of the worker as well as the property) should be implemented to supplement PPE. Equipment and clothing should be selected that provide an adequate level of protection. The selection process should involve representatives of the affected safety disciplines (e.g., health physicist, industrial hygienist, fire protection staff, etc.) working in concert. Two basic objectives of any PPE practice should be to protect the wearer from safety and health hazards, and to prevent injury to the wearer from incorrect use and/or malfunction of the PPE. To accomplish these objectives, a comprehensive PPE practice should include hazard identification (hazards that PPE will protect against and hazards caused by the use of PPE), medical monitoring, environmental surveillance, selection, use, maintenance, and decontamination of PPE and its associated training.
	G 440.1-3	4.6.3: (This section discusses the role of exposure assessment in exposure prevention and hazard control.)

IV.5 Medical Surveillance	O 440.1	<p>Attachment 2, 18.c(1)(c)-(e): Occupational medical physicians and selected medical staff shall: . . . © perform targeted examinations based on an up-to-date knowledge of work site risk,. . . (d) identify potential or actual health effects resulting from work site exposures, and (e) communicate the results of health evaluations to management and to those responsible for mitigating work site hazards.</p> <p>Attachment 2, 18.d(1): Health examinations shall be conducted by an occupational health examiner under the direction of a licensed physician in accordance with current sound and acceptable medical practices.</p> <p>Attachment 2, 18.d(2): The content of health examinations shall be the responsibility of the physician responsible for delivery of medical services.</p> <p>Attachment 2, 18.d(3)(d): The following classes of examinations are required . . . medical surveillance and health monitoring.</p> <p>Attachment 2, 18.d(4): The occupational medical department shall be informed of all job transfers and shall determine whether a medical evaluation is necessary.</p> <p>Attachment 2, 18.e(1): The occupational medical program shall be responsible for the review of all monitored care of ill and injured employees to maximize their recovery and safe return to work, and to minimize lost time and its associated costs.</p> <p>Attachment 2, 18.g(1)-(3): An employee medical record shall be developed and maintained for each employee for which medical services are provided. The confidentiality of all employee medical records shall be observed. Employee medical records shall be adequately protected and stored permanently.</p>
	N 440.1	<p>Attachment 1, 5.a.-d. and Attachment 2, 7.e.(1)-(4): Offer to enroll in a medical surveillance program all workers at risk for chronic beryllium disease (CBD) due to exposure or potential exposure to beryllium...Maintain an updated roster of workers at risk for CBD...Conduct pulmonary medical histories and lung function tests as part of the preplacement examination for workers to be assigned to beryllium areas. If the occupational medicine physician concludes that the medical history and the lung function test results warrant a chest x-ray, it must be offered to the worker...Provide on a voluntary basis, beryllium-specific peripheral blood lymphocyte proliferation testing, or other available preferred beryllium-specific tests considered appropriate by an occupational medicine physician, to screen for beryllium sensitization and provide early detection of CBD. Physicians must notify workers of the procedures and associated risks of the tests...Workers' occupational histories and clinical stages of the disease must be included in investigation reports of recordable beryllium disease (see DOE Order 231.1). Contact DOE (EH-6) for guidance on the content of the reports. Send copies of reports to DOE (EH-6).</p>
	G 440.1-3	<p>4.6.2: (This section discusses the role of exposure assessment in occupational medicine and medical monitoring.)</p>

<p>IV.5 Medical Surveillance (cont.)</p>	<p>G 440.1-4</p>	<p>4: (This section contains guidelines for an occupational medical program, including implementation of an onsite program, maintenance of a healthful work environment, employee health evaluations, diagnosis and treatment of injury or disease, medical records, organization, staffing, facilities, and equipment.)</p> <p>4.3.2: The medical professional responsible for the occupational medical program should have responsibility for health evaluation content. Initial or baseline evaluations should be comprehensive, and follow-up evaluations should be additionally targeted as determined by employee exposure data, job task and hazard analysis information, or other occupationally related factors. Minimum elements of a comprehensive evaluation are: medical/occupational history, physical examination, laboratory studies, and review and evaluation of findings. The protocols for x-ray examinations should follow the recommendations and guidance contained in 43 FR 4377, dated 2-1-78. All radiographs should be interpreted by a qualified radiologist or as specified by OSHA/DOE.</p> <p>4.3.3.2: Standards and requirements for special health evaluations and health monitoring of employees who work in jobs involving specific physical, chemical, or biological hazards should be in accordance with applicable OSHA/DOE standards. When employees are exposed to potential hazards not covered by regulations, appropriate special evaluations may be required as determined by the physician responsible for medical services and approved by the DOE Director, Office of Occupational Medicine and Medical Surveillance.</p> <p>4.3.3.5: All employees with occupationally related injuries or illnesses should be evaluated before returning to work. The scope and content of this evaluation should be determined by the OHE, based upon the nature and extent of the injury or disease, and should be sufficient to ensure that the employee may return to work without undue health risk to self or others. The employee should obtain written clearance from the occupational medical department before returning to work.</p> <p>4.4.1: The management of occupational injury or disease should be in accordance with the laws and regulations of the state in which the facility is located. Diagnosis and treatment of occupational injury or disease should be prompt, with emphasis placed on rehabilitation and return to work at the earliest time compatible with job safety and employee health. Contractor management has the responsibility to establish procedures to ensure that all employees with occupational injuries or illnesses receive medical clearance before returning to work. The responsible first-line management and health and safety groups (health physics, industrial hygiene, or safety) should be notified of unhealthy work situations detected by the occupational medical staff.</p>
<p>IV.6 Training</p>	<p>O 440.1</p>	<p>4.k: Provide workers, supervisors, managers, visitors, and worker protection professionals with worker protection training.</p> <p>Attachment 1, 5.f: Industrial hygiene programs shall include the following elements: . . . Worker education, training, and involvement.</p>

IV.6 Training (cont.)	N 440.1	Attachment 1, 6 and Attachment 2, 7.f.: Implement a training program that provides workers exposed and potentially exposed to beryllium, and supervisors, managers, medical personnel, industrial hygienists, and others involved in beryllium activities and processes, with information concerning the proper handling and control of beryllium, hazards of exposure to beryllium, controls (e.g., engineering, administrative, and personal protective equipment) and work practices of the job assignment, minimization of worker exposure, the purpose and use of personal protective equipment, medical monitoring, and waste management and decontamination procedures.
	G 440.1-1	4.5: (This section contains guidance on providing worker protection training and refers to other training requirements in DOE O 360.1 and 29 CFR 1960, Subpart H.)
IV.7 Recordkeeping	O 440.1	4.i(4): Report and investigate accidents, injuries, and illnesses (reference DOE O 231.1, 232.1, and 225.1) and analyze related data for trends and lessons learned (reference DOE O 210.1).
	N 440.1	Attachment 1, 7 and Attachment 2, 7.g.: Maintain records of all beryllium inventory information, hazard assessments, exposure measurements, controls, and medical surveillance pursuant to DOE Order 440.1, paragraph 4.i.(2), to demonstrate program effectiveness... Maintain the records in an electronic, easily retrievable manner for transmittal to DOE Headquarters on request... Create links between data sets on working conditions and health outcomes to serve as a basis for understanding the beryllium health risk.
	G 440.1-1	4.3.4: (This section contains guidance on recordkeeping, reporting, and data analysis for accidents, injuries, and illnesses.)
IV.8 Performance Feedback	O 440.1	<p>4.I(4): Report and investigate accidents, injuries, and illnesses (reference DOE O 231.1, 232.1, and 225.1) and analyze related data for trends and lessons learned (reference DOE O 210.1).</p> <p>Attachment 1, 5.g: Industrial hygiene programs shall include . . . coordination with cognizant occupational medical, environmental, health physics, and work planning professionals.</p> <p>Attachment 2, 18.c(1)(a),(e): Occupational medical physicians and selected medical staff shall: (a) coordinate with other safety and health professionals (industrial hygienists, health physicists, safety specialists/managers) to identify work-related or work site hazards and their possible health risks to employees, . . . (e) communicate the results of health evaluations to management and to those responsible for mitigating work site hazards.</p> <p>Attachment 2, 18.c(2)(a)-(c): Contractor management shall provide to the physician responsible for delivery of medical services: (a) employee job task and hazard analysis information; (b) summaries of potential work site exposures of employees prior to mandatory health examinations; and (c) the opportunity to participate in worker protection team meetings and committees.</p>
	N 440.1	Attachment 1, 8 and Attachment 2, 7.h.: Conduct periodic analysis and assessment of monitoring results, hazards identified, medical surveillance results, attainment of exposure reduction and minimization goals, and occurrence reporting data...Feed back results to line managers, planners, worker protection staff, workers, medical staff, and others to ensure that needed information is available to improve all elements of the CBDPP continuously.

IV.8 Performance Feedback (cont.)	G 440.1-1	4.3.4: (This section contains guidance on recordkeeping, reporting, and data analysis for accidents, injuries, and illnesses.)
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DOE N 440.1 *Interim Chronic Beryllium Disease Prevention Program*
DOE G 440.1-1 *Worker Protection Management for DOE Federal and Contractor Employees Guide*
DOE G 440.1-3 *Occupational Exposure Assessment*
DOE G 440.1-4 *Occupational Medical Program*