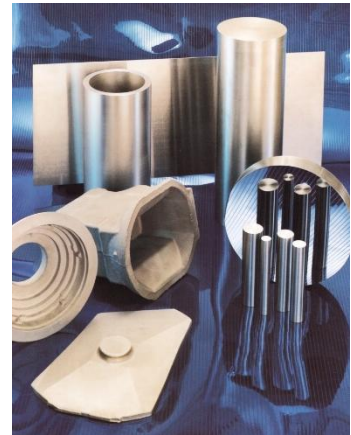




Copper-Beryllium Alloys



Beryllium Oxide Ceramics



Beryllium Metal

Executive Summary of

A Practitioner's Guide to

Beryllium Hazard Management

2nd Edition

April 2026



The Beryllium Health and Safety Committee (BHSC)
Washington, DC, U.S.A.
URL: <https://berylliumhealthandsafetycommittee.com/>

Executive Summary of A Practitioner's Guide to Beryllium Hazard Management

2nd Edition
April 2026

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This Executive Summary of *A Practitioner's Guide to Beryllium Hazard Management*, 2nd Edition has been prepared to provide a free, public-access document that gives an indication to interested parties as to what sort of content they can expect to find in the book.

An electronic version of the complete, 350-page book is available free as a benefit to members in good standing of the Beryllium Health and Safety Committee (BHSC), or it may be purchased online.

To become a BHSC member, dues are \$50 (USD) per year per individual and may be paid here:

<https://berylliumhealthandsafetycommittee.com/get-involved>

Students may join the BHSC at no cost with proof of current registration.

To purchase an electronic copy of the complete book as a PDF file, please use the following link, which will take you to a page on the BHSC website with a link to the purchasing site:

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A Practitioner's Guide to Beryllium Hazard Management

2nd Edition

April 2026

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The Beryllium Health and Safety Committee (BHSC) is an all-volunteer, non-profit organization committed to promoting activities and efforts that will help to understand and prevent beryllium-induced conditions and illnesses, including beryllium sensitization (BeS) and chronic beryllium disease (CBD), that may be caused or exacerbated by workplace exposure to beryllium.

The BHSC's mission is primarily educational in nature, and it is accomplished through generation, collection, and dissemination of information to members and other interested parties. The primary purpose of this Guide is to provide a reference to those who either have an interest in or a direct responsibility for the recognition, analysis, evaluation, and control of beryllium (Be) in the workplace.

The 1st Edition of this Guide was published in July 2018, and it was conceived to fill the need of Be practitioners whose work as technicians, engineers, health professionals, union representatives, manufacturers, and vendors involves beryllium. While briefer and more specific data sources may be available on single subject areas, as are multi-volume compendia, this Guide is intended to be an up-to-date compilation of information useful on a daily basis to the Be practitioner.

Keywords: Beryllium, Beryllium Health and Safety Committee (BHSC), Beryllium Oxide, Beryllide Intermetallic Compounds, Beryllium Fluoride, Beryl Ore, Bertrandite Ore, Health and Safety, Chronic Beryllium Disease (CBD), Beryllium Sensitization (BeS), FLiBe Molten Salt, Insoluble Beryllium, Soluble Beryllium

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About the Content of this Document

In the next few pages that follow, the Disclaimer, Foreword, and Contributors & Reviewers lists are all exactly as they appear in the complete book. This document consists of a short summary for each of the 15 chapters in the book.

These summaries were initially generated using artificial intelligence (AI), but those draft summaries have been reviewed by their respective Chapter Leads and the book's Editorial Staff and revised or even rewritten, as deemed appropriate. Special thanks to BHSC Board Member and Subcommittee Co-Chair Shian YADA of the National Nuclear Security Administration (NNSA) for her role in the creation of the AI draft summaries.

Shian's work was the key starting point, which has enabled the rest of the BHSC Team to participate in this process and make this Executive Summary a reality. We hope this document will be a useful resource to those investigating what is covered in the book and trying to make a decision to purchase it or to join the BHSC and receive a copy of the book as a benefit of membership.

-Chris DORN

Senior Editor, *A Practitioner's Guide to Beryllium Hazard Management*, 2nd Edition
Chair, Beryllium Health and Safety Committee

Disclaimer

This Guide has been prepared by members and interested parties of the Beryllium Health and Safety Committee (BHSC) who are experts with backgrounds, training, and experience in beryllium health and safety topics. The list of contributors to this Guide can be found on the subsequent pages. Except where specific regulatory requirements are cited, this Guide is intended to provide best practices and guidance regarding beryllium hazard management. The contributors have been diligent to ensure that the contents reflect current practices; however, it is possible that some practices may need to be modified due to changes in laws or regulations.

This Guide represents the viewpoints of the contributors and does not necessarily reflect the viewpoints of their employers or of any government agency. This Guide has not been prepared at the request of any government agency, nor has it been prepared in consultation with any federal agency. Any mention of commercial products in this Guide is for informational purposes and should not be considered either an endorsement or a criticism.

The BHSC, the contributors, and the reviewers disclaim any liability, loss, or risk resulting from the use of the practices described in this Guide. In addition, it is the responsibility of the user to stay informed of any changing laws or regulations that might affect the use of the content of this Guide, as well as policies or procedures in the user's workplace. It is the responsibility of the user to implement controls in compliance with all applicable laws, regulations, and/or organizational policies. This Guide is not a substitute for legal or medical advice.

This Guide is intended for use in any country, although much of the content is based on U.S. practices since many of the contributors are from the U.S. and because the U.S. has the largest and most developed commercial beryllium industry in the world.

Please send any comments regarding this Guide to BeHSCCommittee@gmail.com.

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Foreword

The Beryllium Health and Safety Committee (BHSC) has the stated mission to promote activities/efforts that help people better understand and prevent beryllium-induced conditions and illnesses including Beryllium Sensitization (BeS) and Chronic Beryllium Disease (CBD). The BHSC mission is primarily educational in nature and is accomplished through generation, collection, and dissemination of information to members and other interested parties. In that regard, the publishing in 2018 of *A Practitioner's Guide to Beryllium Hazard Management*, 1st Edition, represents the crown jewel of BHSC's educational accomplishments.

However, there have been many changes in the beryllium industry and emergence of new technologies since 2018. Therefore, in September 2024, as the Chair of the Technical Practices Subcommittee, I led the kickoff meeting to write the 2nd edition of this Guide. Interest was strong with chapter teams, reviewers, and editors working in full swing by January 2025.

I was truly inspired by the expanded breadth and authoritative depth achieved by fifty-eight Contributors, Reviewers, and Editors from six different countries (Canada, Germany, Japan, Switzerland, United Kingdom, and United States) representing beryllium leaders from academia, government, and industry. The leadership and tireless dedication of Chris Dorn, BHSC Chair, and Dr. Josef Sobieraj, BHSC Vice Chair, were instrumental not only in identifying key team members but also in shaping the content and structure of this revised edition.

After an eighteen-month journey by our world-class team, we are pleased to offer *A Practitioner's Guide to Beryllium Hazard Management*, 2nd Edition, in 2026. This latest version updates chapters from the 1st Edition to incorporate new studies, methodologies, technologies, and references—which constitute a significant stand-alone resource—but also introduces three new chapters, including:

- Chapter 12: Case Studies Involving Decontamination, Decommissioning, and Demolition of Beryllium Facilities;
- Chapter 13: Comparative Analysis of International Beryllium Health and Safety Programs; and
- Chapter 14: FLiBe and Other Beryllium Molten Salts.

As Chair of the Technical Practices Subcommittee, I extend my sincere appreciation to the numerous professionals who dedicated their personal time developing this amazing product. This book would not have been completed without their technical insight, extensive experience, collaborative spirit, and unwavering perseverance. Please enjoy!

-Wesley ADAMS, CIH, CSP
Chair, BHSC Technical Practices Subcommittee

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Table Note: The above list is alphabetical by last name after the Senior Editor.

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Chapter 1: Introduction and Purpose of this Guide

Beryllium (Be) is an alkaline earth metal with an atomic number of 4. Known for being the lightest stable solid element in air, it is highly valued for its unusual combination of properties, including low density, high stiffness, superior thermal conductivity, and excellent neutron-reflecting capabilities. Because it does not naturally occur in its elemental form, its discovery and subsequent commercial isolation occurred in the late 18th and early 19th centuries, respectively.

Today, the majority of industrial beryllium is produced as low-beryllium-content copper alloys (containing less than 2% Be), while the rest is utilized as pure beryllium metal, beryllide intermetallic compounds, and beryllium oxide ceramics. This unusual combination of structural and physical attributes make beryllium a critical material for use in vital sectors such as aerospace, defense, telecommunications, medicine, and emerging clean energy technologies.

Despite its important industrial utility, beryllium-containing materials pose serious health risks to humans. Exposure to airborne beryllium particles has historically led to severe conditions, including acute beryllium disease (ABD) and chronic beryllium disease (CBD), a debilitating lung illness. Consequently, regulatory bodies like the U.S. Atomic Energy Commission and Department of Energy have enforced strict Occupational Exposure Limits (OELs) and air-monitoring protocols since the late 1940s.

Because there are often no viable alternative materials for many of its high-tech applications, the use of beryllium is projected to continue growing. Therefore, *A Practitioner's Guide to Beryllium Hazard Management* serves as an essential, non-regulatory resource designed to help occupational health and safety professionals recognize, assess, sample, and control workplace exposures, ensuring industrial processes remain safe, compliant, and protective of human health.

Chapter 2: The Background of Beryllium Disease

Beryllium was first recognized as an occupational health hazard in Europe during the 1930s, when workers extracting the metal and handling beryllium-based compounds in the fluorescent lamp industry suffered from severe respiratory and skin-related illnesses. These early cases led to the identification of Acute Beryllium Disease (ABD) a form of chemical pneumonitis triggered by short-term exposure to high concentrations of beryllium dust—which eventually forced the lamp industry to abandon the material.

By the mid-20th century, scientific understanding shifted to recognize that beryllium-related diseases can be immunologically mediated. This led to the creation of the Beryllium Case Registry in 1952, which helped differentiate acute poisoning from Chronic Beryllium Disease (CBD) and Beryllium Sensitization (BeS). BeS is a cell-mediated, type IV immunological response resulting from genetic susceptibility—specifically linked to the HLA-DPB1 Glu69 genetic marker—and can progress to CBD even at very low exposure levels.

While historical threshold limits like the 1949 Permissible Exposure Limit (PEL) of $2.0\mu\text{g}/\text{m}^3$ significantly reduced the occurrence of ABD, CBD and BeS were still prevalent. Current research indicates that dermal contact can trigger BeS. Increased beryllium exposure leads to increased risk for BeS and CBD. The factors that affect the progression from BeS to CBD are not fully understood, and there is currently no medical intervention to prevent progression of BeS to CBD.

Driven by these health risks, modernized standards have been instituted, including OSHA's 2020 final rule establishing a stringent PEL of $0.2\mu\text{g}/\text{m}^3$ alongside medical surveillance testing like the Beryllium Lymphocyte Proliferation Test (BeLPT). Medical removal of affected employees was also implemented. Since beryllium is still used in electronics and defense applications, understanding the immunological distinction between BeS and CBD, implementing strict exposure controls, and conducting early medical interventions remain critical strategies for protecting workers and managing this chronic occupational health hazard. Overall, reducing beryllium exposure reduces risk.

Chapter 3: Development of Exposure Limits and Regulations

This chapter provides a comprehensive historical review of the development and implementation of beryllium occupational exposure limits (OELs) and regulatory standards. In the early 1940s, initial scientific understanding characterized beryllium toxicity as primarily acute. In subsequent years, a steady rise in respiratory illnesses and deaths led the Atomic Energy Commission (AEC) to establish the first occupational exposure limit of $2.0\mu\text{g}/\text{m}^3$ in 1949, derived by comparing beryllium's atomic weight and toxicity to that of heavy metals like lead (Pb) and mercury (Hg).

Over many decades, this standard was adopted by major health and safety organizations including OSHA, NIOSH, and ACGIH. By the late 1980s, the emergence of advanced diagnostic techniques revealed that while the $2.0\mu\text{g}/\text{m}^3$ limit successfully made acute beryllium disease rare, it was insufficient to prevent Chronic Beryllium Disease (CBD) and beryllium sensitization (BeS). This gap sparked decades of advocacy, petitions, and collaborative industry negotiations, eventually driving regulatory bodies toward much more stringent safety thresholds.

With the advancement of science in recent years, the regulatory landscape has evolved to focus heavily on exposure minimization and surveillance for sensitization, resulting in much tighter standards both in the United States and internationally. In the U.S., following draft recommendations jointly submitted by industry leaders and labor unions, OSHA finalized a new rule in 2017 (which was revised and finalized in 2020) that drastically lowered the Permissible Exposure Limit (PEL) to $0.2\mu\text{g}/\text{m}^3$, established an Action Level (AL) of $0.1\mu\text{g}/\text{m}^3$, and a short-term exposure limit (STEL) of $2\mu\text{g}/\text{m}^3$.

This modern federal standard mandate also introduced strict ancillary requirements across general, construction, and shipyard industries—encompassing rigorous exposure assessments, regulated work areas, engineering controls, respiratory protection, and medical surveillance. On an international scale, exposure limits vary widely but reflect a similar downward trend, with some jurisdictions adopting limits as low as $0.02\mu\text{g}/\text{m}^3$ and incorporating specific hazard notations to prevent dermal absorption and carcinogenicity.

Chapter 4: Beryllium Program Management and Conduct of Sampling

This chapter details the critical role of systematic sampling strategies in identifying, evaluating, and controlling occupational and environmental beryllium hazards. To effectively manage beryllium exposure risks, the seven-step exposure assessment strategy developed by the American Industrial Hygiene Association (AIHA) is recommended.

Written exposure assessment programs should be developed and consider elements such as basic characterization of the workplace, grouping workers into Similar Exposure Groups (SEGs) and performing statistically defensible sampling. By comparing results against established Occupational Exposure Limits (OELs) and using an appropriate decision statistic, practitioners can classify exposures as acceptable, uncertain, or unacceptable, and define necessary engineering, PPE or administrative controls.

To ensure data quality and regulatory compliance, the Guide outlines collection methods across air, surface, soil, and bulk media. There is a focus on use of validated consensus standards from organizations such as ASTM International (formerly the American Society for Testing and Materials), ISO (International Organization for Standardization), and NIOSH (National Institute for Occupational Safety and Health), guided by the U.S. Environmental Protection Agency's (EPA) Data Quality Objectives (DQO) process.

Considerations regarding suitability of various sampling methods and media to sampling objectives are discussed. This includes technical topics such as management of wall deposits, size-selective sampling, colorimetric field-screening tests, and use of metal ratios to distinguish anthropogenic contamination from natural background beryllium concentrations in soil.

Chapter 5: Conduct of Laboratory Analysis

This chapter emphasizes that the primary goal of the beryllium practitioner is to ensure the generation of analytical laboratory data that is both scientifically defensible and tailored to specific project requirements. Due diligence in selecting commercial laboratories is crucial, requiring careful validation of their capabilities, specialized licensing (especially in radiation-controlled environments), and formal ISO/IEC 17025 accreditation.

Practitioners should prioritize laboratories that participate in dedicated proficiency testing (PT) programs, such as those administered by AIHA PAT to verify accuracy in both soluble and oxide forms of beryllium. Furthermore, robust pre-sampling communication regarding the presence of potential chemical interferences, specialized sample matrices like PVA wipes, and timeline constraints is essential to construct a comprehensive project plan that aligns with stringent regulatory targets under OSHA, DOE, and EU standards.

From a technical standpoint, the guide highlights the critical dependency of data quality on thorough sample preparation and high-instrument sensitivity. Since all forms of beryllium must be completely solubilized prior to instrumental analysis, standard digestion methods like NIOSH 7300 must be modified with specific fluoride or sulfate reagents (e.g., ammonium bifluoride or sulfuric acid) when refractory beryllium oxide (BeO) is present in the sample.

Choosing the appropriate instrumental technique—ranging from molecular fluorescence and flame atomic absorption to highly sensitive ICP-AES and ICP-MS—depends on the target reporting limits and sample volumes collected. To ensure ongoing quality control, laboratories must establish rigorous analytical batch protocols, including method blanks, Laboratory Control Samples (LCS), and documented initial and continuing calibration verifications (ICV/CCV) to maintain high precision and low systematic bias.

Chapter 6: Data Evaluation and Related Topics

This chapter outlines the structured statistical and logical protocols required to effectively obtain, interpret, and make regulatory decisions using beryllium (Be) data. The Guide recommends integrating the U.S. EPA's (Environmental Protection Agency) Data Quality Objective (DQO) and Data Quality Analysis (DQA) frameworks early in the project planning phases. This systematic planning ensures that stakeholders agree on defined Survey Units (SUs), select appropriate sampling designs—such as simple random, systematic, or stratified random sampling—and anticipate the statistical implications of decision limits.

Practitioners are cautioned that while non-random "judgment sampling" may target known areas of concern, it prevents the valid application of confidence limits or hypothesis testing. Furthermore, because a significant portion of laboratory-reported Be data is left-censored (reported as "<RL"), project managers must navigate the conceptual contradictions of reporting limits, detection limits, and censoring policies enforced by different bodies like the EPA and AIHA-LAP to ensure accurate data archiving and compliance checks.

From a statistical evaluation perspective, the chapter details methods for comparing datasets with established Rarely-To-Exceed Limits (RTEs) or natural background levels. To assess compliance with occupational or release limits under a "dirty until proven clean" rationale, industrial hygienists typically compute 95%-95% Upper Tolerance Limits (UTLs) or utilize Non-Parametric UTLs (NPUTLs) once sample sizes reach or exceed 59.

When comparing test area soils with background soils under a "clean until shown dirty" hypothesis, parametric Welch's t-tests, Levene's tests, or non-parametric Wilcoxon rank-sum and Kolmogorov-Smirnov tests can be leveraged. An additional issue that arises is that of Multiple Comparisons. Statistical false positive and false negative rates are typically established for individual tests on individual datasets. One must keep in mind, though, that a site or and IH professional is likely to be involved with many studies or decisions during a year, and it would be appropriate to consider the likelihood of finding at least one "reportable" event during a given year.

To address the challenge of distinguishing natural background Be from manmade (anthropogenic) contamination on surface wipes, the guide details the execution of the Metal Ratio Method (ASTM D8299-19). This method utilizes mathematically derived prediction equations using ratios of beryllium with other naturally occurring metals to identify anomalous anthropogenic Be contributions with high statistical confidence. An example application of this approach is provided.

Chapter 7: Hierarchy of Controls

This chapter discusses the critical importance of performing comprehensive hazard assessments prior to conducting beryllium work, ensuring that exposures are managed to "As Low As Reasonably Practicable" (ALARP) standards. Beryllium's designation as a carcinogen and the unique hazards associated with its different forms—such as inhalation risks from metallic dust versus thermal and chemical burn risks from molten salts (FLiBe)—necessitate a structured, priority-based approach to ensure employee exposures are managed appropriately.

In accordance with global occupational safety and health standards, this chapter presents a strict descending order of preference within the classic hierarchy of controls: elimination, substitution, engineering controls, administrative controls, and Personal Protective Equipment (PPE). The Guide emphasizes that practitioners must justify moving down this hierarchy, and that combining multiple layers of protection is often required to achieve robust as well as redundant safety margins.

Moving beyond conceptual definitions, this chapter details the technical application and limitations of these control levels in shifting facility conditions and specialized settings. Engineering controls, such as fully enclosed glove boxes, partial enclosures, and Local Exhaust Ventilation (LEV) systems with certified HEPA filtration (meeting a 99.97% efficiency criterion), serve as the primary defense against airborne dispersal.

When engineering boundaries are breached or during maintenance tasks, like filter change-outs, administrative controls (such as work permits, training, and clean hygiene practices), and PPE (including nitrile or neoprene gloves, coveralls, and respiratory protective equipment) must be dynamically tailored. For nuclear facilities, a specialized design philosophy is highlighted—entailing the principles of minimization, substitution, moderation, and simplification—to prioritize inherently safer, passive, and preventive systems over mitigative or personal protection protocols at the source of the hazard.

Chapter 8: Release of Equipment and Other Items

This chapter details the strategic rationale and regulatory frameworks governing the safe release of equipment and items from beryllium-controlled areas to prevent the spread of surface contamination. Exposure to particulate beryllium is strongly linked to beryllium sensitization (BeS) and chronic beryllium disease (CBD), and because no clear hazard thresholds exist, implementing a formalized release process is essential.

Under U.S. OSHA (29 CFR 1910.1024) and DOE (10 CFR 850) regulations, materials containing at least 0.1% beryllium by weight must be strictly evaluated, labeled, and cleaned to the lowest practicable levels. While OSHA mandates cleaning "as free as practicable" without setting a specific surface limit, the DOE establishes a strict public release limit of $0.2\mu\text{g}/100\text{cm}^2$. This chapter recommends a cautious, structured approach to material characterization, classifying items into clean, unknown, or contaminated categories, with appropriate labeling, segregation, and stakeholder alignment to minimize liabilities.

To achieve compliant decontamination, the chapter evaluates both dry and wet cleaning methods tailored to different surface profiles and item sizes. Dry methods, such as certified HEPA vacuuming, are highly effective at capturing dry bulk particulate in crevices but can leave particles embedded on porous surfaces. Wet techniques provide a scalable alternative, ranging from high-pressure wash downs for large areas to solvent wet wiping for low-to-moderate contamination on smooth surfaces.

For complex geometries, advanced techniques like ultrasonic cleaning use sound wave vibrations to agitate solvents and dislodge deep contaminants without physical damage, while strippable cleaning gels physically encapsulate and peel away surface particles. The chapter also outlines specialized handling protocols for both large machinery and ultra-small components (under 100cm^2), emphasizing the application of composite sampling, mathematical extrapolation to the 100cm^2 benchmark, and the use of temporary wrapping or fixatives to mitigate contamination, manage waste, and maintain rigorous historical documentation.

Chapter 9: Training

This chapter highlights training as a critical administrative control, universally recognized by international safety organizations to mitigate risks associated with beryllium sensitization (BeS) and chronic beryllium disease (CBD). Because these risks persist despite physical exposure reductions, establishing comprehensive educational programs is vital to ensure that workers understand exposure pathways, health hazards, and their legal and procedural responsibilities.

Using structured frameworks, such as the systematic training management approach outlined in ISO 10015 (2019), organizations are urged to perform needs analyses, continuously measure program effectiveness, and update training parameters to reflect process or workplace changes. Successful industry-wide safety models are frequently built on collaborative partnerships, such as those between National Jewish Health and OSHA (Occupational Safety and Health Administration) or Materion Brush and NIOSH (National Institute for Occupational Safety and Health), which have yielded modern, validated e-learning tools and targeted curricula designed to improve hazard communication throughout the industrial supply chain.

The chapter also provides a thorough comparative analysis of international training mandates, showing that while specific frequencies and criteria differ across jurisdictions, all major regulations require training prior to starting beryllium-related work. For instance, U.S. OSHA (29 CFR 1910.1024) requires initial and annual training and a demonstrated understanding of exposure control plans and PPE (personal protective equipment), whereas U.S. DOE (10 CFR 850) mandates biennial training that explicitly integrates family-risk counseling and the facility's Chronic Beryllium Disease Prevention Program (CBDPP).

European and Canadian standards, such as COSHH (Control of Substances Hazardous to Health) in the UK and COHSR (Canada Occupational Health and Safety Regulations) in Canada, place a strong emphasis on achieving verified worker "competence" through rigorous information, instruction, and active consultation with health committees. Ultimately, the chapter outlines targeted educational topics tailored to specific roles—ranging from visitors and handlers to specialized laboratory and occupational medical staff—while defining strict international guidelines for preserving training records and retention histories.

Chapter 10: Risk Communication

This chapter outlines risk communication as a vital and dynamic discipline for managing beryllium exposure hazards across modern industrial and nuclear sectors. Driven by the re-emergence of beryllium in advanced energy technologies—such as fusion, microreactors, and small modular reactors (SMRs)—reliable risk communication must address six baseline elements: who is receiving the message, what risk is being conveyed, where the hazards occur, when proactive or reactive messaging is initiated, why the information is shared, and how the communication is delivered.

Anchored by the fundamental mantra pioneered by U.S. Government agencies—"Be first. Be right. Be credible."—effective risk communication focuses on clear, honest, and rapid data exchange. These efforts build trust, dispel rumors, prevent the overestimation or underestimation of hazards, and empower workers and communities to make highly informed, voluntary safety decisions.

In practice, successful programs must tailor their messaging, signage, and documentation to accommodate diverse stakeholder backgrounds, security constraints, and multilingual workforces. Operational hazards should be communicated systematically through standardized signage (such as color-coded Danger, Warning, and Caution placards), GHS health-hazard pictograms, and structured training programs that integrate OSHA Hazard Communication (HAZCOM) standards.

Furthermore, the chapter details specialized requirements for handling risk communication in sensitive or classified environments, implementing multi-language safety translations, and using resources such as the U.S. EPA's "Seven Cardinal Rules of Risk Communication" or the U.S. DOE's 10 CFR 850 implementation guidelines. Ultimately, the text highlights the importance of utilizing standard templates, checklists, and feedback loops to continuously refine communication strategies and protect workers from emerging or unknown beryllium hazards.

Chapter 11: Medical Screening and Surveillance Programs

This chapter reviews the role of medical surveillance and screening in protecting workers with actual or potential beryllium exposure. It explains that beryllium sensitization (BeS) is an immune response that may precede chronic beryllium disease (CBD), a progressive granulomatous lung disease with a variable latency period that may range from months to decades. Although modern exposure controls have reduced the frequency of acute disease, continued surveillance remains important because BeS and CBD can occur in workers with direct, intermittent, or historical exposure.

The chapter emphasizes that surveillance programs should support both individual worker health and workplace risk management. Core program elements include exposure and work history, respiratory and skin assessment, symptom questionnaires, pulmonary function testing, appropriate imaging, and the beryllium lymphocyte proliferation test (BeLPT).

The BeLPT is described as the primary screening tool for identifying sensitization, but its limitations are also highlighted, including variability between laboratories, false-positive and false-negative results, borderline findings, and uninterpretable results that may require repeat testing. Because screening outcomes can affect medical follow-up, work placement, and employment decisions, informed consent, confidentiality, and clear risk communication are essential.

Regulatory approaches from OSHA and the U.S. Department of Energy are presented as key examples, including employer obligations to offer surveillance, the voluntary nature of participation for workers, medical removal considerations, and the need for case-by-case fitness-for-duty decisions. The chapter also outlines diagnostic evaluation and follow-up for workers with BeS or suspected CBD, including referral to clinicians with expertise in occupational lung disease.

Finally, it stresses the importance of post-employment surveillance, as former workers may develop Be-related health effects after leaving the workplace and may no longer have access to occupational health services. Overall, effective medical surveillance links early detection, prevention, exposure control, clinical follow-up, and program evaluation to reduce the health burden of beryllium exposure.

Chapter 12: Case Studies Involving Decontamination, Decommissioning, and Demolition of Beryllium Facilities

This chapter examines the complex requirements, practical applications, and lessons learned during the decontamination, decommissioning, and demolition (D&D) of facilities contaminated with beryllium. As early nuclear-era and industrial sites reach the end of their operational lifecycles, stakeholders must choose between decontaminating structures to an "unconditional release" state for reoccupation or executing controlled demolitions. Because beryllium D&D is highly specialized with sparse published literature, the chapter relies on U.S. Department of Energy (DOE) and commercial case studies to outline critical risk factors.

D&D operations represent severe health challenges because workers are at high risk of beryllium sensitization (BeS) and chronic beryllium disease (CBD) when disturbing decades of settled process dust. These facilities are also frequently co-contaminated with radiological isotopes (such as plutonium and uranium) and hazardous materials like asbestos, lead, and mercury, requiring integrated multi-hazard safety plans and rigorous regulatory compliance under frameworks like 10 CFR 850.

Through detailed case studies of both indoor and outdoor facilities—including the WessDel commercial machine shop in California, the Avimo aerospace fabrication facility in the UK, the Low Intensity Test Reactor (LITR) at Oak Ridge, and outdoor high-explosive test ranges—the chapter establishes industry best practices and decontamination techniques. Key strategies include comprehensive early characterization of the facility layout using historical records and baseline wipe sampling, isolating work zones using building-scale modular enclosures under HEPA-filtered negative pressure, and implementing strict dust suppression methods such as high-viscosity fixative coatings and water cannons.

All projects utilize standardized wet-wiping protocols (often using EDTA/detergent solutions) and specialized equipment like HEPA vacuums for "shadow vacuuming" prior to demolition or equipment release. The chapter concludes that successful D&D relies on early stakeholder alignment, careful contractor selection experienced in hazardous abatement, robust waste stream routing for contaminated debris, and real-time monitoring tools like Laser Induced Breakdown Spectroscopy (LIBS) to verify that final release criteria are met without exposing workers or the public to harm.

Chapter 13: Comparative Analysis of International Beryllium Health and Safety Programs

This chapter provides a comprehensive comparative evaluation of the legal, regulatory, and administrative frameworks governing beryllium hazards across different nations, including the United States (U.S.), Canada, Australia, Japan, Switzerland, the United Kingdom (UK), and the European Union (EU). Because only a few nations produce and process primary beryllium on a commercial scale, the complexity and specificity of local regulations vary widely.

In the U.S., where the largest cohort of exposed workers exists, regulatory bodies like OSHA (Occupational Safety and Health Administration) and the DOE (Department of Energy) enforce comprehensive frameworks to manage exposure risks in nuclear, defense, and industrial sectors. Conversely, nations with smaller exposed worker populations often manage risks through broader, generalized occupational health and hazard communication standards rather than beryllium-specific statutes.

This is the first international comparison that highlights substantial global variability in practical implementation requirements across key programmatic areas. These areas include exposure and hazard assessments, permissible airborne concentration limits, medical surveillance protocols, and recordkeeping. For instance, while the United States and India enforce stringent quantitative surface contamination limits (such as the DOE's $0.2\mu\text{g}/100\text{cm}^2$ release limit and India's more conservative $0.1\mu\text{g}/100\text{cm}^2$ public release limit), the EU and UK focus primarily on qualitative work-practice controls and cleaning methods to keep exposures as low as reasonably practicable (ALARP) without mandating specific surface thresholds.

Similarly, medical surveillance strategies differ; U.S. regulations rely heavily on the Beryllium Lymphocyte Proliferation Test (BeLPT) as a primary screening tool, whereas UK guidelines rely instead on clinical evaluations and urinary testing. Ultimately, this chapter serves as an essential tool for global practitioners to navigate international compliance, share best practices, and work toward a more unified terminology in beryllium hazard management.

Chapter 14: FLiBe and Other Beryllium Molten Salts

This chapter examines FLiBe—a molten-salt mixture of lithium fluoride (LiF) and beryllium fluoride (BeF₂)—and its renewed importance as a high-performance coolant and fuel carrier for advanced nuclear systems, including Fluoride-Salt-Cooled High-Temperature Reactors (FHRs) and emerging commercial fusion energy platforms. FLiBe offers several unusual physical properties that differentiate it from commercially-available solid beryllium metal, including exceptional high-temperature stability, low vapor pressure, low viscosity, and high heat capacity.

Originally demonstrated during the Molten-Salt Reactor Experiment (MSRE) at Oak Ridge National Laboratory in the 1960s, FLiBe production has evolved from laboratory-scale mixing to full industrial-scale manufacturing through a joint venture between Kairos Power and Materion. As next-generation small modular reactors and magnetic-confinement fusion devices—such as Commonwealth Fusion Systems' SPARC and ARC designs—move toward commercial deployment in the late 2020s and early 2030s, the global demand and supply chain for this beryllium-containing molten salt are expected to expand substantially.

However, as a soluble beryllium compound, the hazards associated with safely handling FLiBe can differ from those used for traditional beryllium handling. This rapid transition to large-scale industrial handling of FLiBe requires a fundamental shift in occupational safety and industrial hygiene practices, marking the first commercial-scale production of a soluble beryllium compound. Soluble beryllium salts present hazards distinct from insoluble metal forms and have historically been associated with acute beryllium disease (ABD), a rapid-onset and potentially fatal chemical pneumonitis, as well as contact dermatitis and risk of dermal beryllium sensitization. In addition, workers must be protected from secondary chemical risks associated with corrosive fluorides, toxic hydrofluoric acid (HF) gas byproducts, and highly reactive lithium metal.

To address these complex hazards, the chapter outlines specialized enhancements to worker protection programs, including recommended use of Powered Air-Purifying Respirators (PAPRs) with an Assigned Protection Factor (APF) of 1000, high-permeation-resistant chemical protective clothing with welded seams, multi-zone containment and decontamination suites equipped with air showers, and rigorous housekeeping protocols based on 5S principles to prevent migration of soluble beryllium contamination within and beyond facility boundaries.

Chapter 15: Where to Go for Help

This chapter serves as a comprehensive directory and resource map to assist beryllium practitioners in identifying reliable support networks, professional groups, and reference materials. Recognizing that complex safety concerns, scientific advancements, and regulatory demands continuously evolve, the chapter highlights vital global organizations committed to preventing chronic beryllium disease (CBD) through collaborative research, education, and shared best practices.

Chief among these is the Beryllium Health and Safety Committee (BHSC), established in 1995, which uses dedicated subcommittees in medical epidemiology, sampling methods, and risk communication to disseminate empirical knowledge. Other major international bodies, such as the Brussels-based Beryllium Science and Technology Association (BeST), the IEA International Workshop on Beryllium Technology (BeWS), and the BeYOND Industrial Forum, further bridge the gap between nuclear research communities, commercial suppliers, and industrial practitioners worldwide.

In addition to professional committees, the chapter outlines extensive digital repositories and specialized web resources spanning government, academic, and medical institutions. Practitioners are directed to authoritative U.S. government portals—including the Department of Energy's (DOE) Chronic Beryllium Disease (CBD) Prevention Program site, the Beryllium-Associated Worker Registry (BAWR) managed by the Oak Ridge Institute for Science and Education (ORISE), and OSHA's dedicated regulatory pages—alongside prominent international assets from Safe Work Australia and the United Kingdom's Health and Safety Executive (HSE).

Furthermore, the chapter catalogues elite clinical and medical-epidemiological centers of excellence, such as National Jewish Health, the Cleveland Clinic, and the University of California San Francisco (UCSF), which provide specialized care, diagnostics, and counseling. Accessing these resources represents a vital step for any safety professional or student looking to engage with a community dedicated to the safe handling of beryllium materials and the protection of the worker, public, and the environment.