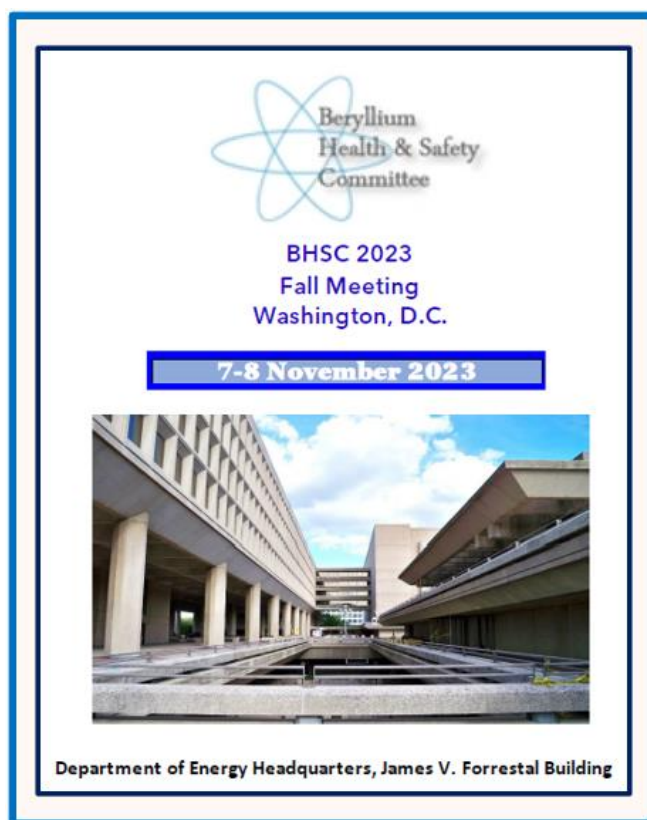




Executive Summary of the Beryllium Health & Safety Committee (BHSC) 2023 Fall Meeting



The Beryllium Health and Safety Committee (BHSC)
Washington, DC, U.S.A.

URL: <https://berylliumhealthandsafetycommittee.com/>

Executive Summary of the Beryllium Health & Safety Committee (BHSC) 2023 Fall Meeting

Christopher DORN^{1,2} and Josef SOBIERAJ³ (Editors)

¹Kyoto Fusioneering America Ltd., Seattle, Washington, U.S.A.

²Be4FUSION LLC, Upland, California, U.S.A.

³National Nuclear Security Administration (NNSA), U.S.A.

The Beryllium Health & Safety Committee (BHSC) 2023 Fall Meeting was held on 7-8 November 2023 at the U.S. Department of Energy Headquarters, James V. Forrestal Building, in Washington, DC. The meeting has been held annually since 1995, with a break due to the recent pandemic.

This Executive Summary is an abbreviated version of the Minutes of the Fall Meeting, which has omitted the images of the slides from the bulk of the technical presentations. A copy of the Meeting Minutes containing all presentation slides is available to dues-paid BHSC members in the Members Only area of the website, which may be accessed here: [Login \(berylliumhealthandsafetycommittee.com\)](https://berylliumhealthandsafetycommittee.com)

BHSC dues are \$40 (USD) per individual per year and may be paid here:

[Get Involved \(berylliumhealthandsafetycommittee.com\)](https://berylliumhealthandsafetycommittee.com)

As participation in events like the BHSC Spring Meeting is offered with no registration fee, if attendees found the meeting to be worthwhile, it is hoped that they will consider becoming members. Support from paying dues helps to make it possible for the BHSC, a non-profit organization run exclusively by volunteers, to continue its work in the field and offer more meeting programs like this one in the future.

The BHSC 2023 Fall Meeting was organized by the BHSC's Meetings & Symposia Sub-Committee, with local support from members of the US Department of Energy (DOE). The meeting was held both in-person and online. Overall, there were more than 110 participants, who came mainly from the U.S., but also from Canada, the UK, France, China, and India.

Keywords: Beryllium Health & Safety Committee (BHSC), Beryllium, Beryllium Oxide, Fusion Engineering, Irradiation Effects, Beryllide Intermetallic Compounds, Beryllium Carbide, Beryllium Fluoride, Plasma-Facing Materials, Neutron-Multiplier Materials, Health and Safety, Chronic Beryllium Disease, Beryllium Sensitization, Fusion Start-Ups, Molten Salt, FLiBe, FLiBe Purification, FLiBe Corrosivity, Tritium Extraction, Fluorescence Analysis, James Webb Space Telescope, U.S. DOE Headquarters, James V. Forrestal Building

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Introduction & Post-Meeting Overview

The Beryllium Health & Safety Committee (BHSC) 2023 Fall Meeting was held on 7-8 November 2023 at the U.S. DOE Headquarters, James V. Forrestal Building in Washington, DC. This meeting has been held annually as an in-person event from 1995-2019. Due to the pandemic, the Fall Meeting was not held in 2020-2021, and it was finally resumed again in 2022. There is also an annual Spring Meeting, and a larger BHSC Symposium that typically happens bi-annually.

Mission Statement

The BHSC is committed to promoting activities/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 mission is primarily educational in nature, and is accomplished through generation, collection, and dissemination of information to members and other interested parties.

The Fall Meeting is an activity resulting directly from carrying out the foregoing Mission Statement. This year's meeting was organized by the BHSC's Meetings & Symposia Sub-Committee, with major technical support from U.S. DOE staff. Participants came mainly from the U.S., but also from Canada, the UK, France, China, and India. Some key aspects to this year's meeting:

- Run in a hybrid format with both in-person and online attendees and presenters
- Highlighted beryllium molten salt (FLiBe) as an up-and-coming product form
- Featured presentations from both fission and fusion companies and research organizations
- Also featured a presentation about beryllium use in NASA's James Webb Space Telescope
- Included participation from vendors, who presented their products and services in the field

The technical portions of the meeting were comprised of 14 presentations, including remarks by U.S. DOE and NNSA senior leadership, advances in diagnosing beryllium sensitization and disease, updates and program activities from the U.S. Departments of Labor and Energy and the NNSA, history of the U.S. DOE, the state of the fusion industry, a summary of the 16th International Beryllium Workshop held in October, research on beryllium compounds including FLiBe molten salts at U.S. national laboratories, colorimetric beryllium detection, and the manufacturing of beryllium mirrors for the James Webb Space Telescope. All of these presentations called attention to the importance of beryllium health and safety to ensure the success of the research.

There was also a BHSC business meeting, at which the point was raised that there is now a vacancy on the Board for the position of International Member-at-Large, hopefully soon to be filled. The other important highlight was the announcement of the BHSC 2024 Spring Meeting, which will be held from 22-24 April 2024 at the Oak Ridge National Laboratory in Oak Ridge, Tennessee.

The final BHSC 2023 Fall Meeting agenda is included near the beginning of this document to introduce the abstracts and presentations that follow. A list of some of the organizations represented at the Meeting may also be found in the Appendices. Thanks again to all who participated to make this a great meeting!

Josef SOBIERAJ

Chair, BHSC Meetings & Symposia Sub-Committee

December 2023

BHSC 2023 Fall Meeting Agenda

The meeting agenda was organized under the leadership of BHSC Meetings & Symposia Sub-Committee Chair, Josef SOBIERAJ, with help from Committee Members Chris DORN of Kyoto Fusioneering and Be4FUSION, Gary GRIFFIN of GEG Consulting, as well as BHSC Chair Roland CHRETIEN. Local support at U.S. DOE HQ was provided by April BROWN and Joe DOBBINS. Below is the version of the agenda that was distributed to the participants at the meeting.

AGENDA – Beryllium Health and Safety Committee Meeting 7-8 November 2023 – DOE Forrestal Building, Washington, D.C.

Also available virtually; links to be provided later

All times listed below are Eastern Standard Time (EST)

Day 1 – Tuesday, 7 November 2023
Room 1E-245

Time (EST)	Activity	Task Lead(s) or Speaker(s)
<i>Morning (EST) - available via webinar</i>		
07:00-08:30	Badging at Forrestal Front Lobby (Independence Avenue)	Brown, A.
	Coffee and Pastries / Meet and Greet	
08:30	BHSC Welcome and Overview	Chretien, Sobieraj
08:45	Break	
09:00	DOE/NNSA Senior Leadership Remarks	Roscetti, Al-Daouk
09:15	Three Borderlines as BeS Indicator	Mroz et al.
09:45	Department of Labor - Beryllium Program Updates	Vance, J.
10:15	Break	
10:30	NNSA Responses to Be Economic Assessment	Sobieraj et al.
11:00	10 CFR Part 850 CBD Update	Brown, A.
11:30	Presentation by DOE Chief Historian	Boyle, E.
12:00	Lunch	
<i>Afternoon (EST) – available via webinar except for Tours</i>		
13:30	Global Fusion Industry 2023	Holland, A.
14:00	Summary Report for Be Workshop (BeWS-16)	Dorn, C.
14:30	Break	
14:45	FLiBe Research at SRNL	Olson et al.
15:15	Wrap-up	Chretien/Sobieraj
16:00	Adjourn (End of Day)	
18:00	Crowne Plaza Evening Reception	

(Second day on next page)

Day 2 – Wednesday, 8 November 2023

Room 1E-245

Time (EST)	Activity	Task Lead(s) or Speaker(s)
<i>Morning (EST) – available via webinar</i>		
07:30	Coffee and Pastries	
08:00	Second-day agenda review	Chretien, Sobieraj
08:15	Conducting Safe Research on Be Solids	Campbell et al.
08:45	Colorimetric Beryllium Detection	Freiderich, M.
09:15	Break	
09:30	Ventilation for Machining and Welding Beryllium: Case Studies from Los Alamos National Laboratory and Savannah River Site	Brown, D. et al.
10:00	The Manufacture and Application of Beryllium for the James Webb Space Telescope	Smith, K.
10:30	Break	
10:45	Using Data Analytics for Be H&S (SAFER)	Luckey, M.
11:15	Lunch	
<i>Afternoon (EST) – available via webinar</i>		
13:00	Vendor Technical Presentations	Moderator: Griffin
13:15	Break	
13:30	BHSC Business Meeting	Board Members
14:30	Subcommittee Breakout Sessions	Members
15:15	Break	
15:30	Reports from Subcommittee Breakouts	S/C Chairs
15:45	Wrap-up	Chretien
16:00	Adjourn (End of Day)	
End of Day 2		

(Note: BHSC Board Meeting: Monday, 6 November 2023)

BHSC Meetings & Symposia Sub-Committee

Name	Position	Organization
Josef SOBIERAJ	Chair	National Nuclear Security Administration
Chris DORN	Communications, Program, and Meeting Minutes	Kyoto Fusioneering America Ltd. Be4FUSION LLC
Gary GRIFFIN	Vendor & Sponsor Liaison Meeting Hotel Arrangements	GEG Consulting LLC
Julie FOWLER	Logo Design	National Nuclear Security Administration

BHSC 2023 Fall Meeting Vendor Organizations

The organizers of the BHSC 2023 Fall Meeting would like to thank the following vendors for their support of the event:



ALS Testing Services Salt Lake City, Utah, U.S.A.	GVS-RPB: Respiratory Protection Solutions Royal Oak, Michigan, U.S.A.
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Day 1: Beryllium H&S: DOE, DOL & CBD Program Updates, Predicting BeS & CBD, NNSA Economic Assessment, Fusion & FLiBe Molten Salt

Three Borderline BeLPTs Predicting Beryllium Sensitization and Chronic Beryllium Disease

M. MROZ et al. (National Jewish Health, Colorado, USA)

Three Borderline Beryllium Blood Lymphocyte Proliferation Tests Predicting Beryllium Sensitization and Chronic Beryllium Disease

Margaret M. Mroz MSPH¹, Annyce Mayer MD MSPH¹, Lisa Barker MPH¹, and
Lisa A. Maier MD, MSPH^{1,2}

¹*National Jewish Health, Denver, Colorado, U.S.A.*

²*University of Colorado, Denver, Colorado, U.S.A.*

Background:

US Senator Patty Murray (D-WA) requested that National Jewish Health provide background and data regarding 3 borderline beryllium lymphocyte proliferation test (BeLPT) results to support The Beryllium Testing Fairness Act which was included in the National Defense Authorization Act. The Occupational Health and Safety Administration (OSHA) included 3 borderline BeLPTs in the definition of beryllium sensitization for the final beryllium rule based on studies by Middleton et al., 2008; 2011. Modeling of DOE data was used to look at the predictive value of the borderline BeLPT for beryllium sensitization (BeS) and it was found that the predictive value was similar to that of 2 abnormal results. Using limited clinical data from our institution, we hypothesized that repeated borderline BeLPTs, in the absence of an abnormal test, can predict BeS and chronic beryllium disease (CBD).

Methods:

A medical record review was performed which included workers evaluated in our clinic for possible CBD based on repeated borderline BeLPT results without any abnormal results. The diagnosis of CBD was confirmed by BeS (abnormal lung cell BeLPT) and granulomas on biopsy. The diagnosis of granulomatous lung disease (GLD) was established by granulomas on biopsy, no abnormal BeLPTs, and no evidence of another cause of GLD. An estimate of beryllium exposure (high, medium, low) was provided by an industrial hygienist. Demographics, PFTs, radiographic findings, BeLPT results, estimate of exposure, and final diagnosis were reviewed to characterize this population of beryllium-exposed workers. We also used existing data to estimate the prevalence of 3 borderline results in the DOE population.

Results:

Records of 10 patients were reviewed. Of the ten, 2 had evidence of BeS confirmed by subsequent abnormal blood or bronchoalveolar lavage BeLPTs. Two patients had confirmed CBD while 2 others had GLD without an identified cause. The other 4 workers had no evidence of BeS, CBD or GLD. No distinguishing differences were noted between CBD, BeS, and GLD groups in regard to demographics, exposure, radiographic abnormalities, or baseline PFTs, however, a greater decline in DLCO after diagnosis was observed in the CBD group. We estimated the prevalence of repeated borderlines to be 0.5% among those workers with repeat tests and that approximately 329 -750 cases of BeS/CBD are undetected and not receiving benefits.

Conclusions:

Three borderline BeLPTs (without any abnormal tests) is an uncommon result pattern. The results of this case series support the model-based prediction that 3 borderline BeLPTs can predict BeS and our hypothesis that it can also predict CBD. The Beryllium Testing Fairness Act expands the definition (of sensitization) under EEOICPA, so that three borderline test results would qualify.

Corresponding Author:

Ms. Margaret (Peggy) MROZ, MSPH

National Jewish Health

EMAIL: mrozp@NJHealth.org

URL: <https://www.nationaljewish.org/home>

DOE Employees Occupational Illness Compensation: Beryllium Program Update
J. VANCE (US Department of Labor, District of Columbia, USA)

Division of Energy Employees Occupational Illness Compensation: Beryllium Program Update

John VANCE

U.S. Department of Labor, Washington, DC, USA

The Division of Energy Employees Occupational Illness Compensation Program (DEEOIC), within the United States Department of Labor, provides lump-sum compensation benefits and medical coverage to current or former employees (or their survivors) for illnesses arising from civilian work developing nuclear weapons for the U.S. government. Coverage extends to past and present workers exposed to beryllium at Department of Energy (DOE) or beryllium vendor sites and who can establish qualifying diagnosis of Beryllium Sensitivity and/or Chronic Beryllium Disease.

DEEOIC works with claimants to acquire the necessary evidence to establish covered employment, the medical evidence needed to confirm the diagnosis, and an opinion on how the two are related. It is important to understand that each claimed condition has its own requirements for acceptance.

This presentation details the evidence needed to establish Beryllium Sensitivity and Chronic Beryllium Disease, then provides a discussion regarding the benefits afforded to those individuals with one of these covered conditions. With continual updates to covered sites and procedures, DEEOIC recommends subscribing to the Program and Policy email distribution list. To sign up for the email list and/or to learn more about the program, visit the DEEOIC website at: dol.gov/agencies/owcp/energy.

Corresponding Author:

Mr. John VANCE

Chief, Policy

Office of Workers' Compensation Programs (OWCP)

U.S. Department of Labor

EMAIL: Vance.John@dol.gov

URL: dol.gov/agencies/owcp/energy

NNSA Site Responses to Beryllium Economic Assessment Questionnaire

J. SOBIERAJ et al. (National Nuclear Security Administration, District of Columbia, USA)

NNSA Site Responses to Beryllium Economic Assessment Questionnaire

Josef A. SOBIERAJ, Danny FIELD, and Julie FOWLER

National Nuclear Security Administration, USA

In December 2022, the Department of Energy (DOE) Office of Environment, Health, Safety and Security (EHSS) requested assistance in obtaining the information needed to update the costs, benefits, and paperwork burden information in support of an economic assessment for amendments to 10 CFR Part 850 Chronic Beryllium Disease Prevention Program.

An economic assessment is an essential part of the rulemaking process because it ensures that decisions to amend regulations are informed by the best available information and provides DOE with the information needed to compare the action with reasonable alternatives. The DOE *Economic Assessment Questionnaire* was developed to assist the beryllium sites, including all NNSA sites, in providing information on the potential impact to costs, benefits, and the paperwork burden of implementing the amendment to the final rule. The responses from the questionnaire will be used to prepare the *Final Economic Assessment and Paperwork Reduction Act* documents for the Office of Management and Budget.

This presentation summarizes the responses from eight NNSA Beryllium sites to proposed changes in Beryllium Economic Assessment Questionnaire in select areas including:

- Action Level
- Permissible Exposure Limits
- Regulated Areas
- Exposure Monitoring
- Medical Surveillance, Restriction, Removal
- Labeling/Release/Transfer
- Other areas

This presentation provides useful information and insights as to how proposed regulatory changes will have economic as well as program management and implementation impacts.

Corresponding Author:

Dr. Josef A. SOBIERAJ

National Nuclear Security Administration

EMAIL: Josef.Sobieraj@nnsa.doe.gov

URL: <https://www.energy.gov/nnsa/national-nuclear-security-administration>

10 CFR Part 850 Chronic Beryllium Disease Prevention Program Rulemaking Update
A. BROWN (US Department of Energy, Maryland, USA)

10 CFR Part 850 Chronic Beryllium Disease Prevention Program Rulemaking Update

April BROWN, CIH

*US Department of Energy, Office of Environment, Health, Safety & Security,
Germantown, Maryland, USA*

The Department of Energy (DOE) published a Notice of Proposed Rulemaking (NPR) for public comment in the Federal Register (81 FR 36704) on June 7, 2016, proposing to amend its existing CBDPP regulations. The period for public comments ended on September 6, 2016. The proposed amendments in the NPR were intended to strengthen the existing CBDPP and the worker protection programs established under 10 CFR part 851, Worker Safety and Health Program. The proposed amendments to the NPR would have reduced the action level for worker exposure to ambient beryllium concentrations to 0.05mg/m³, based on an 8-hour TWA exposure. DOE also proposed adopting OSHA's current and prospective PELs for worker exposure to beryllium and beryllium compounds in the NPR. DOE did not propose adopting a short-term exposure limit (STEL) due to the fact that DOE's proposed action level of 0.05mg/m³ would be exceeded in less than the 15-minute sampling period for the STEL if exposure levels were at OSHA's PEL of 2.0µg/m³.

OSHA issued new regulations in 29 CFR parts 1910, 1915, and 1926 on January 9, 2017 (82 FR 2470) to protect employees from exposure to beryllium and beryllium compounds in the workplace, following the publication of DOE's NPR. OSHA's regulations included two new PELs for occupational exposure to beryllium and beryllium compounds: (1) an 8-hour TWA PEL of 0.2µg/m³ and (2) a 15-minute STEL of 2.0µg/m³. In its final rule, OSHA stated that it was establishing an 8-hour TWA PEL of 0.2µg/m³ because it determined that occupational exposure to beryllium at the previous PEL of 2.0µg/m³ posed a substantial risk of material impairment to the health of exposed workers and that the lower TWA PEL of 0.2µg/m³ would substantially reduce this risk. To reduce the risk of beryllium sensitization and chronic beryllium disease among beryllium-exposed employees, OSHA established a STEL of 2.0µg/m³, as measured over a 15-minute sampling period. OSHA also adopted an action level for ambient beryllium of 0.1µg/m³, based on an 8-hour time-weighted average.

Instead of adopting OSHA's current or prospective TWA PELs, DOE is issuing this SNOPR to propose that the Department set its own 8-hour TWA PEL of 0.2µg/m³ for dispersed beryllium, which is consistent with OSHA's current TWA PEL. As an alternative to the previously proposed airborne action level of 0.05mg/m³, the Department proposes an airborne action level of 0.1µg/m³, computed as an 8-hour TWA exposure, as measured in the worker's respiratory zone by personal monitoring. The Department proposes a STEL of 2.0µg/m³, measured over a fifteen-minute period. The Department's proposed TWA PEL, STEL, and action level would be consistent with OSHA's current TWA PEL, STEL, and action level. The presentation will discuss both the NPR and SNOPR for 10 CFR 850.

Corresponding Author:

Ms. April BROWN, CIH
U.S. Department of Energy, Worker Safety and Health Policy
Office of Environment, Health, Safety, and Security (EHSS-11)
EMAIL: april.brown@hq.doe.gov

A Brief History of the U.S. Department of Energy

E. BOYLE (US Department of Energy, District of Columbia, USA)

A Brief History of the U.S. Department of Energy

Eric W. BOYLE

US Department of Energy, Washington, DC, USA

The Department of Energy Organization Act of 1977 created one of the most interesting and diverse agencies in the Federal government. Activated on October 1, 1977, the twelfth cabinet-level department brought together for the first time within one agency two programmatic traditions that had long coexisted within the Federal establishment: 1) defense responsibilities that included the design, construction, and testing of nuclear weapons dating from the Manhattan Project effort to build the atomic bomb; and 2) a loosely knit amalgamation of energy-related programs scattered throughout the Federal government.

The Manhattan Project involved some of the most renowned scientists of the century combining with industry, the military, and tens of thousands of ordinary Americans working at sites across the country to translate original scientific discoveries into an entirely new kind of weapon. When the existence of this nationwide, secret project was revealed to the American people following the atomic bombings of Hiroshima and Nagasaki, most were astounded to learn that such a far-flung, government-run, top-secret operation existed, with physical properties, payroll, and a labor force comparable to the automotive industry. At its peak, the project employed 130,000 workers and, by the end of the war, had spent \$2.2 billion.

Following the war, Congress engaged in a contentious debate over civilian versus military control of the atom. Ultimately, the Atomic Energy Act of 1946 created the Atomic Energy Commission (AEC), which took over the Manhattan Project's sprawling scientific and industrial complex.

During the early Cold War years, the AEC focused on designing and producing nuclear weapons and developing nuclear reactors for naval propulsion. The Atomic Energy Act of 1954 ended exclusive government use of the atom and began the growth of the commercial nuclear power industry, giving the AEC authority to regulate the new industry.

In the 1950s, the AEC embarked on a series of projects designed to develop peaceful uses of atomic energy. From this effort emerged the International Atomic Energy Agency and other bilateral and multilateral agreements but also the nascent domestic nuclear power industry that the Eisenhower Administration hoped would be closely tied to the growth of nuclear power in Europe and other areas. Other peaceful uses programs included the distribution of radioisotopes from the X-10 Graphite Reactor at Oak Ridge. These radioisotopes were used in the field of physics and chemistry, for industrial and agricultural applications, and in the biomedical field, radioisotopes were used in cancer therapy and as radioactive tracers for studying biological processes. Additionally, in 1954, in another show of nuclear power for peaceful purposes, the AEC initiated construction of the world's first full-scale nuclear power plant at Shippingport, Pennsylvania. And by the mid-1960s, 75 nuclear power plants were on order.

Until the 1970s, the Federal government played a limited role in formulating national energy policy in an era of relatively cheap and abundant energy. The nation relied on the private sector to fulfill most of its energy needs. Historically, Americans expected private industry to establish production, distribution, marketing, and pricing policies. When free market conditions were absent, Federal regulations were established to control energy pricing.

No overall energy policy existed. Government officials generally thought in terms of particular fuels, technologies, and resources rather than “energy.”

The Energy Crisis and the Department of Energy

Two major developments fundamentally changed the role of the federal government in the energy field in the 1970s. First, the energy crisis of the 1970s hastened a series of government reorganizations as both the executive and legislative branches sought to better coordinate Federal energy policy and programs. Second, while the AEC’s activities in developing and commercializing nuclear energy had represented the Federal government’s largest and most significant energy project for decades to that point, questions about the need to separate nuclear licensing and regulation functions from the development and production of nuclear power and weapons hastened the abolition of the Atomic Energy Commission, and the establishment of the Energy Research and Development Administration and the Nuclear Regulatory Commission in its place in 1974.

In 1977, the [establishment of the Department of Energy](#) brought most Federal energy activities under one umbrella and provided the framework for a comprehensive and balanced national energy plan. While the Nuclear Regulatory Commission maintained its regulatory duties in areas like reactor safety and radiation protection, the Department of Energy undertook responsibility for long-term, high-risk research and development of energy technology, Federal power marketing, energy conservation, the nuclear weapons program, energy regulatory programs, and a central energy data collection and analysis program.

Security and Prosperity through World-Class Science

Over the [course of its history](#), the Department of Energy has shifted its emphasis and focus as the needs of the nation have changed. During the late 1970s, the Department emphasized energy development and regulation. In the 1980s, nuclear weapons research, development, and production took a priority. With the end of the Cold war in the 1990s, the Department focused on environmental clean-up of the nuclear weapons complex and nonproliferation and stewardship of the nuclear stockpile.

In the 2000s, the Department’s priority has been ensuring the nation’s security and prosperity by addressing its energy, environmental and nuclear challenges through science and technology solutions. The Department has sought to transform the nation’s energy system and secure leadership in clean energy technologies, pursue world-class science and engineering as a cornerstone of economic prosperity, and enhance nuclear security through defense, nonproliferation, and environmental efforts.

Corresponding Author:

Dr. Eric W. BOYLE

Chief Historian

U.S. Department of Energy

EMAIL: eric.boyle@hq.doe.gov

URL: <https://www.energy.gov/lm/doe-history>

The Global Fusion Industry in 2023

A. HOLLAND (Fusion Industry Association, District of Columbia, USA)

The Global Fusion Industry in 2023

Andrew HOLLAND

Fusion Industry Association (FIA), Washington, DC, USA

The fusion industry has now attracted a total of \$6.21 billion in investment (up from \$4.8 billion last year), after another \$1.4 billion flowed in over the last year, according to the Fusion Industry Association (FIA). The data is reported in the FIA's '[The Global Fusion Industry in 2023](#)' [\[DL1\]](#) report, which surveyed 43 private fusion companies.

The additional funding comes from 27 individual investments, which include \$250 million for TAE, \$200 million for ENN, \$79 million for Kyoto Fusioneering, \$55 million for Energy Singularity, and many more.

Growth comes not just from established companies, but from new entrants to the fusion race. Thirteen fusion companies were founded or emerged from stealth mode in the past year, making this year's fusion industry survey, with 43 entrants, the largest ever.

Though the US continues to lead the race with 25 active fusion companies (including many of the largest) the industry is becoming more geographically diverse, with 12 countries now fielding at least one fusion company. This year's survey included new entrants from New Zealand (Openstar), Sweden (Novatron), Germany (Gauss, Proxima), and China (Energy Singularity).

While the total new funding announced this year is less than last year's \$2.8 billion, it shows continued investment in and excitement about the industry, even as many technology investors have pulled back in other fields. Last year's survey was dominated by a couple of big investments (\$1.8 billion in Commonwealth Fusion Systems and \$500 million in Helion Energy), this year saw a much wider range of smaller but significant investments, including bets on emerging companies and new fusion approaches.

Meanwhile, companies who had previously secured funding, are growing. Respondents claimed to have created 975 new jobs in the last year at their companies, and around 3,000 jobs in the supply chain, though this is likely to be an undercount as not all companies responded to this question.

Optimism about fusion remains high, but delivering power is not the same as being commercially viable, and challenges remain. Commercial viability requires low enough cost, and high enough efficiency in converting energy, to make fusion profitable. Eighteen companies predict that their fusion approach will be commercially viable by 2035 and a further thirteen (13) by 2040.

Corresponding Author:

Mr. Andrew HOLLAND

Chief Executive Officer, Fusion Industry Association

EMAIL: aholland@fusionindustryassociation.org

URL: www.FusionIndustryAssociation.org

Summary Report on the 16th International Workshop on Beryllium Technology (BeWS-16)
C.K. DORN (Kyoto Fusioneering America Ltd., Washington, USA)

Summary Report on the 16th International Workshop on Beryllium Technology (BeWS-16)

Christopher DORN

*Kyoto Fusioneering America Ltd., Seattle, Washington, USA
Be4FUSION LLC, Upland, California, USA*

In the technical field of beryllium, there are currently two workshops that take place in alternating years, the longest-running of which is the IEA International Workshop on Beryllium Technology (BeWS), which normally happens during odd-numbered years. The Beryllium Workshops are usually held in conjunction with a larger fusion conference, most often the ICFRM (International Conference on Fusion Reactor Materials) but also sometimes the ISFNT (International Symposium on Fusion Nuclear Technology).

The BeWS-16 took place on 19-20 October 2023 in Santander, Cantabria, Spain. This year's workshop featured presentations on the following specific topics, encompassing all forms of beryllium materials with potential uses in fusion, including Be metal, beryllide intermetallic compounds, molten salts (FLiBe), alloys, and composites:

- Production, forming and joining
- Chemical compatibility and corrosion
- Composition control and characterization
- Thermal and mechanical properties
- Irradiation effects
- Materials development and characterization
- Plasma/tritium interactions
- High heat flux performance
- Monitoring, disposal, and recycling
- Environmental, health and safety (EH&S) issues

This presentation will summarize the technical program at the BeWS-16, and it will highlight any presentations of particular overall significance or with special relevance to the BHSC.

Corresponding Author:

Mr. Chris DORN

Technical & Business Advisor

Kyoto Fusioneering America Ltd.

EMAIL: c.dorn@kyotofusioneering.com

URL: <https://kyotofusioneering.com/en/>

Overview of LiF-BeF₂ Research & Management at Savannah River National Laboratory
L. OLSON et al. (Savannah River National Laboratory, South Carolina, USA)

Overview of LiF-BeF₂ Research and Management at Savannah River National Laboratory

Luke OLSON, Christopher DANDENEAU, Gavin MATTINGLY,
Justin EPPENBROCK, Sherolyn BISHOP, Robert SINDELAR, and
Brenda GARCIA-DIAZ

Savannah River National Laboratory, Aiken, South Carolina, USA

Savannah River National Laboratory (SRNL) is conducting research on LiF-BeF₂ salt, more commonly known as FLiBe, for fusion applications. Molten FLiBe is being investigated as a blanket material for fusion reactors, where it captures neutrons produced by fusion reactions in the plasma, carries away thermal energy for power production, and breeds tritium to fuel the deuterium-tritium fusion reaction. Recent work has focused on the development of viable FLiBe reference electrodes and demonstration of corrosion mitigation using metallic beryllium in contact with the salt.

Toxicological concerns arise when working with FLiBe due to potential exposure to beryllium and fluorine compounds. To ensure worker safety when performing beryllium-related operations, SRNL has implemented a beryllium management plan. The plan includes informing workers on best practices regarding beryllium handling during glovebox, hood, and clean-up operations. Voluntary enrollment in the Beryllium Medical Surveillance program is also available to workers conducting beryllium-related research.

As-received FLiBe salt is maintained in an anhydrous environment. BeF₂ is hygroscopic and deliquescent at room temperature, whereby upon heating any adsorbed water will react to form HF, which can in turn attack containment materials. For this reason, all FLiBe work at SRNL is undertaken in a glovebox designated for beryllium use, with additional protocols in place for both minimizing contamination within the glovebox and eventual decontamination. Once experimental cells are loaded with FLiBe in the glovebox, they are sealed, removed from the glovebox, and transported into a fume hood where electrochemical measurements are acquired under inert gas flow; any potential off-gassing is captured in a bubbler apparatus. All beryllium waste generated, including solid waste from testing and liquid waste streams from rinsing, cleaning, and off-gas bubbling, is designated and separated. The SRNL beryllium management plan encompassing safe conduct of operations and ensuring worker safety will be discussed in detail.

A significant part of the SRNL beryllium management plan is the development of protocols for the decommissioning, clean-up, and rehabilitation of gloveboxes and facilities upon completion of beryllium-related work. Early identification of clean-up tasks is expected to aid in the implementation of operating practices that will facilitate future clean-up operations and help contain costs. These identified tasks will be presented for discussion and feedback.

Corresponding Author:

Dr. Luke OLSON
Savannah River National Laboratory
EMAIL: luke.olson@srnl.doe.gov

Day 2: Beryllium H&S: Research on Be Solids, Colorimetric Be Detection, Ventilation for Fabrication Operations, and Be in the JWST Program

Conducting Safe Research on Beryllium-Containing Solid Materials

A. CAMPBELL et al. (Oak Ridge National Laboratory, Tennessee, USA)

Conducting Safe Research on Beryllium-Containing Solid Materials

**Anne CAMPBELL¹, Blake HENRY², Susan FISCOR²,
Erica PAXTON², and April CASE²**

¹*Materials Science & Technology Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA*

²*Safety & Operations Services Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA*

Beryllium is a material of importance in multiple nuclear applications. For fission reactors, it is an ideal material for neutron moderation, neutron multiplication, and neutron reflection. In fusion reactors, beryllium has been discussed as the plasma facing for first walls and divertors, and for the use as a neutron multiplier for tritium breeder/blanket systems.

In both areas, the use of pure beryllium is not necessarily ideal because of multiple technical or practical challenges. As such, the interest has expanded to beryllium-containing solid materials like beryllium carbide for fission applications and beryllium intermetallic compounds (beryllides) for fusion applications. The same health and safety concerns that arise with pure beryllium are also expected with beryllium-containing solid materials. Therefore, work that is occurring at Oak Ridge National Laboratory (ORNL) is following similar principles.

Recent work at ORNL has looked at the preliminary development of beryllium carbide as a future core internal for molten salt fission reactors. This work included room temperature X-ray diffraction, high-temperature thermal stability testing, and kinetics of beryllium carbide decomposition. Each of these measurements required specialized hazard analysis and handling procedures to perform the work safely. This presentation will discuss the practices that have been implemented to ensure the safe conduct of research.

Support for this work was provided by the US Department of Energy Office of Nuclear Energy Molten Salt Reactor Program. Oak Ridge National Laboratory is managed by UT-Battelle, LLC, under contract No. DE-AC05-00OR22725 for the U.S. Department of Energy.

Corresponding Author:

Dr. Anne CAMPBELL

Oak Ridge National Laboratory

EMAIL: campbellaa@ornl.gov

Colorimetric Beryllium Detection

M. FREIDERICH et al. (Y-12 National Security Complex, Tennessee, USA)

Colorimetric Beryllium Detection

Melissa FREIDERICH, Courtney HUNTLEY, and Laurie LINDSAY

Y-12 National Security Complex, Oak Ridge, Tennessee, USA

Current detection methods for Be are expensive, time consuming, and require advanced analytical techniques and instrumentation. At Y-12, a simple colorimetric Be detection method has been developed to provide a near-real-time detection capability in the field for both solid and liquid samples. The method is based on the rapid color change that occurs when a chelating dye interacts with Be. In addition to the simplicity of the method, the detection limit is lower than that of the current fluorescence method.

Strips embedded with dye and other additives can be used to detect both aqueous and solid Be via simple smear tests. For liquid samples, a small aliquot of solution can be placed on the strip. For solid samples, the strips can be wetted prior to sampling or after, and the sampling can be performed in the same manner as the current Be smears/swipes. These strips are being used at Y-12 in some areas as yes/no indicators of the presence or absence of Be to aid in cleaning operations.

The color change varies based on the concentration of Be, indicating that quantitative results may be possible in the future. To aid in quantification, a colorimeter is used to ascertain the numerical value of the color. Data are being collected to correlate CIE color values to Be concentration ranges.

Corresponding Author:

Dr. Melissa FREIDERICH

Y-12 National Security Complex

EMAIL: melissa.freiderich@pxy12.doe.gov

Ventilation for Machining & Welding Beryllium: Case Studies from Los Alamos National Laboratory and Savannah River Site

D. BROWN (Merrick & Company, New Mexico, USA) et al.

Ventilation for Machining and Welding Beryllium: Case Studies from Los Alamos National Laboratory and Savannah River Site

Douglas BROWN, P.E.¹, Aaron DICKERSON, P.E.², and Todd HAVENS³

¹*Merrick & Company, Los Alamos, New Mexico*

²*Merrick & Company, Greenwood Village, Colorado*

³*Merrick & Company, Albuquerque, New Mexico*

Beryllium is a chemical element with the symbol Be and atomic number 4. It is a relatively rare and lightweight metal that is known for its exceptional strength, low density, and high thermal conductivity. However, beryllium is also highly toxic, and exposure to its dust, fumes, or compounds can lead to a serious lung disease called chronic beryllium disease (CBD) or berylliosis. Beryllium is non-combustible in solid form but may cause an explosion when in a dust or powder form. It is important to protect workers from exposure to beryllium in all forms.

There are special design considerations that must be considered when machining or welding beryllium within an enclosure such as a glovebox or free-standing lathe enclosure:

- **HEPA Filtration:** Specifying the right type and capacity of HEPA filters ensures optimal containment and protection.
- **Inlet Velocity Requirements:** It is important to calculate and maintain the appropriate inlet velocity to prevent worker exposure.
- **Source Capture:** Capturing dust at the source of generation is an efficient method of dust control when combined with a wet or dry collection system.
- **Atmosphere:** Performing dust generating operations within an inert atmosphere is a potential method to mitigate explosion and flammability risks.
- **Collaboration with Equipment Vendors and Clients:** Collaboratively working with the client ensures that their specific needs, safety concerns, and operational requirements are considered during system modifications. Vendors are a great source of technical expertise that should be utilized during design development.

At Los Alamos National Laboratory (LANL), there were some other unique design challenges to overcome:

- **Limited Capacity of Existing System:** Utilizing an existing exhaust system can be complex, especially if it was not initially designed to handle the specific needs of hazardous materials like beryllium.
- **Limitations of Fixed Manual Dampers:** LANL's preference for manual fixed dampers created additional challenges in controlling volumetric flow rates.

In summary, there are many factors to consider when working with beryllium, which requires a combination of expertise, collaboration, and careful consideration of safety and operational needs. By working closely with equipment vendors and the client, you can develop effective solutions that enhance containment, protect workers, and meet regulatory obligations.

Corresponding Author:

Mr. Doug BROWN, P.E.

Merrick & Company

EMAIL: Doug.Brown@merrick.com

URL: www.merrick.com

The Manufacture of the Beryllium Mirror Segments for the James Webb Space Telescope
K. SMITH (Materion Brush Inc., Ohio, USA)

The Manufacture of the Beryllium Mirror Segments for the James Webb Space Telescope

Keith SMITH

Materion Brush Inc., Elmore, Ohio, USA

Since its launch and deployment in December 2021, NASA's James Webb Space Telescope (JWST) has provided mankind with stunning images from the beginnings of time. The JWST is the largest, most powerful space telescope ever built.

As a national asset, it is the culmination of many years of development, testing, construction, and integration. Materion is proud to have played a role in the JWST program. The eighteen (18) beryllium hexagonal primary mirror blanks, secondary and tertiary optics, and structural components were produced at the Materion Elmore, Ohio facility.

Materion has also supplied numerous other components to the program from its various businesses. This presentation includes an overview for the manufacture of beryllium from ore to mirror blank. It also provides a basic description of the JWST functionality and the reasons why beryllium was selected for the optical components of the telescope.

Corresponding Author:

Mr. Keith SMITH

Materion Brush Inc.

EMAIL: keith.smith@materion.com

URL: <http://www.materion.com>

Using Data Analytics to Monitor Health of Beryllium Health & Safety Programs
M. LUCKEY (National Nuclear Security Administration, District of Columbia, USA)

Using Data Analytics to Monitor Health of Beryllium Health and Safety Programs

Morgan LUCKEY

National Nuclear Security Administration, USA

The U.S. Department of Energy (DOE), National Nuclear Security Administration (NNSA) is committed to a data-driven decision-making approach that can efficiently capture, use, and share information related to safety. The NNSA Office of Safety, Infrastructure, and Operations (NA-ESH) is facing a critical era where mission complexity is increasing rapidly, but human resources are constrained.

The efficacy of safety oversight must increase as fast, or faster, than the increase in mission targets. NA-ESH is currently conducting operations using a wide variety of information from multiple databases, which makes data difficult to use or share effectively. These data do not have standardized formats and therefore, broader systems-level analysis is not achievable. As such, data collected is seldom shared across functions and field offices.

The DOE is investing in data analytics software across all areas of business. These tools leverage the data that DOE collects to glean systems-level insights. Some of these tools are available, at no cost, to DOE federal staff and management and operating contractor (M&O) partners. The Safety Analytics, Forecasting, and Evaluation Reporting (SAFER) platform is available to DOE users to consolidate disparate data sources and track program health indicators.

NA-ESH is developing SAFER to

- More efficiently and effectively collect, process, analyze, and disseminate data,
- Improve the ability to measure, track, communicate, and manage safety risks, and
- Capture the knowledge of the NNSA workforce ensuring its availability across the enterprise and for the future.

SAFER does this by bringing together site and enterprise data, mapping it to universal concepts, and displaying it in a way that reflects subject matter experts think about and use the data. The tools in SAFER can be used by all NNSA safety professionals and DOE safety professionals from select offices.

Corresponding Author:

Ms. Morgan LUCKEY

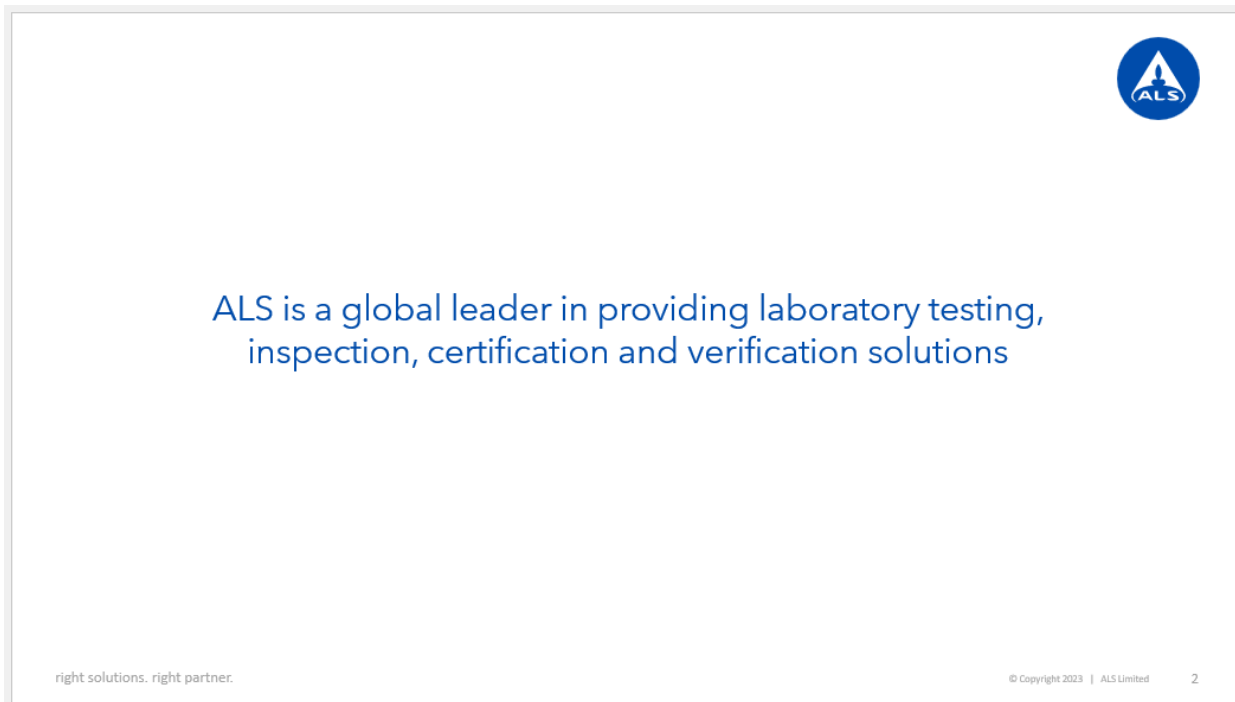
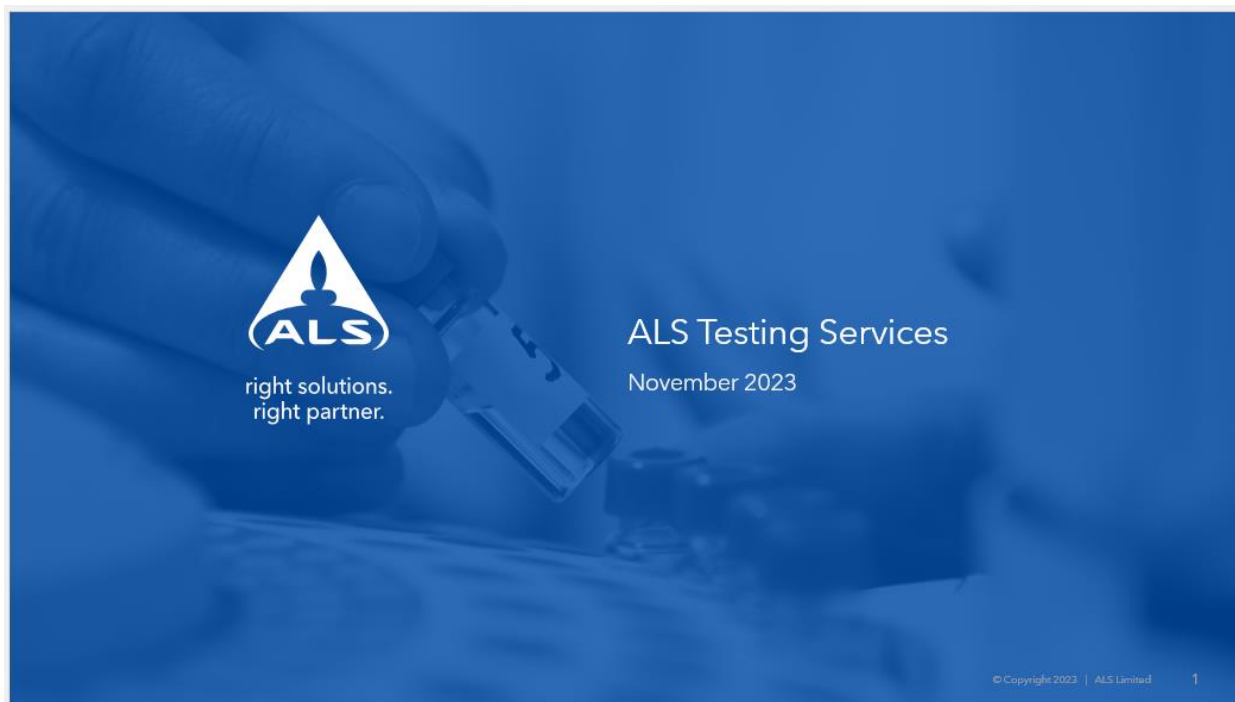
National Nuclear Security Administration

EMAIL: morgan.luckey2@nnsa.doe.gov

Day 2: Vendor Technical Presentations

ALS Testing Services, Salt Lake City, Utah, USA

Bevan MEADE



GVS-RPB Respiratory Protection Solutions, Michigan, USA
Jeremy KENIMER

GVS-RPB® Respiratory Protection Solutions

Prepared for Department of Energy





Who is GVS-RPB®?





- GVS-RPB is the culmination of two strong brands, offering a full solution set for respiratory protection
- Made in USA
- Our US headquarters are located in the greater Detroit area
- Strong supply chain
- Greater than 90% DIFOT through the pandemic
- Offer best in class cooling to remove heat stress issues.

Day 2: BHSC Business Meeting

Led by Roland CHRETIEN, BHSC Chair

Business Meeting Minutes compiled by Jack BENNETT, BHSC Recording Secretary

AGENDA – BHSC 2023 Fall Business Meeting

8 November 2023

13:30-14:30 Eastern Standard Time

BHSC Business meeting is being held on site and may use Webinar

Per the BHSC By-Laws, a quorum is ten members or 20% of active membership, whichever is greater. This will apply to the voting session. The non-voting session will not require a quorum.

Agenda (Items 1-5 are in the voting session; remainder are in non-voting session)

1. Approval of this agenda – The meeting has a quorum. Motion to approve the draft agenda, which was seconded, approved.
2. By-Laws Revisions – Discussed results of vote, which approved the revision to Section 1.5. The revised by-laws will be uploaded to the website. Lisa noted that there was a typo in the section included below. The voted version is correct.

Proposed (new): Section 1.5: Ethical conduct. It is expected of all participants in BHSC and its subcommittee activities that members and guests will openly and willingly share experiences and information that advance the BHSC mission as outlined in the charter. In order to do so, no member or participant shall pursue details of worker, worker affiliation, employer, employer affiliation or any other attribute that would uniquely identify a situation, scenario or exposure event such that undue influence (marketing opportunity for health services to a worker, communication of the event to a regulatory authority as examples) may occur. Occasions where such undue influence occurs may be called out by the subcommittee chair, BHSC board members or other participants. Repeat offenses shall be referred by the subcommittee chair to the BHSC executive committee for consideration of further action.

3. Election of Officers
 - Report of Nominating Committee (D. Field)
 - i. Vice chair, Chris Dorn will take Steve Jahns place as Vice-Chair.
 - ii. Jack Bennett recently took the role of Secretary.
 - iii. There are opportunities for members to become involved in subcommittee chairs and as vice chairs.
 - iv. Greg Heldt replaced Marc Kolan as Member-at-Large (Industry) and will serve as a member on the Med/Epi subcommittee.
 - v. Dan Field gave an overview of current board membership and responsibilities of positions and subcommittees.
 - vi. Cindy Casalina resigned her position as Co-chair of the Technical Practices Subcommittee.

- vii. The Sampling and Analysis Sub-committee is very active. Kul Garg is chair and Dan Jensen is co-chair.
 - viii. Josef noted that there is information on the website about the vacancies.
 - Roland noted that the BHSC has been revitalized since COVID and encouraged people to get involved because it is a good opportunity for networking.
 - Jackie Rogers still supports BHSC, such as helping with the non-profit license and other ways.
- 4. Other new business requiring a vote today – None.
- 5. Chairman's Brief Report (R. Chretien)
 - Review of activities since Spring 2023:
 - i. There has been more activity on the website, with people looking for information.
 - ii. The last three meetings have been very successful.
 - iii. We are doing better from a financial perspective.
 - Succession planning
 - i. We need to look at people who can fill our roles and encourage them to participate. Look for your successor from day 1.
- 6. Status of Funds (D. Jensen)
 - Pay Pal: \$4,939.69
 - Wells Fargo: \$7,913.14
 - There are a few upcoming expenses anticipated to cost approximately \$500.
 - We need to look at polishing the website. Everything costs money, but this would be a worthwhile expense.
 - Symposium: We will start planning for a symposium to be held in the near future and possibly next fall. However, there will be a \$10k upfront cost. The last symposium in Las Vegas was well attended, so it makes sense to go back there.
- 7. Membership Report (J. Fowler)
 - 47 active paid members.
- 8. Web Site Report (R. Chretien)
 - Significant improvements have already been made including board member bio-sketches. Julie & April did a good job updating the website, but there is still more to do.
 - Members currently have the ability to see presentations from these meetings. We are retrieving the historical backlog of documents that will be made available to paid members.
- 9. Plans for 2024 Spring Meeting (C. Dorn & J. Sobieraj)
 - Spring meeting, ad hoc planning team is meeting this afternoon. The meeting will be held in Oak Ridge in April, and more details will be provided later this afternoon.
- 10. Subcommittee Reports
 - **Risk Communication:** No updates

- **Research Needs:** No updates
- **Technical Standards/Practices/Measures:** No updates
- **Medical/Epidemiological:** Trying to figure out a way to follow workers from site to site is not as simple as thought. The sub-committee will pursue a white paper on the topic. They meet every other month. A current topic is the Be ELISPOT, a new method to identify Be-sensitized workers more quickly. The sub-committee is working with industry on what it will take to make it a validated test. Additional activities include: starting a group to work on a practical guide and inter-lab testing program for the BeLPT.
- **Meetings and Symposia:** The dates of spring meeting are 4/22 for the board meeting and 4/23 & 24 for the general meeting.
 - i. Currently there are four potential venues. Will look into finalizing the choice next week. The space needs to accommodate at least 100 and several do not have options for registering foreign nationals. Field trips being considered include a BeLPT lab tour, a demo of real-time sampling, a tour of the Calutron at Y-12, and the HFIR (High-Flux Isotope Reactor) tour at ORNL. Gary is coordinating reserving a block of rooms and already has a sponsor for the evening reception. Will try to get Ray Smith, the historian, to speak at evening reception. The JOWOG meeting will be decoupled from BHSC because it will take place at AWE in the UK in May 2024.
 - ii. Planning is underway for a Symposium next November in Las Vegas at the Golden Nugget. Details will be forthcoming.
- **Sampling and Analysis:** Is meeting every other month; Kul asked, “Do we have a charter?” Roland said that we needed to get it to Kul. Kul also asked who owns the Practitioners Guide. Dan Field said that it is a coordinated effort and farmed out to subcommittees. Last time was a two-year effort, this time should be easier. Active participants will get a copy of the current guide. Also, Charters are in Article 6 of the bylaws. Kul said that the group had discussion about limits and STEL sampling.

11. New Business (not requiring a vote)

- There was a proposal for a new subcommittee on beryllium molten salt technologies involving fission, fusion, and FLiBe. Greg said that it has become apparent that Be in FLiBe is becoming more important to the BHSC. Chris said it is a great idea with a lot of interest, no doubt, from the H&S side. FLiBe has been dormant since the 1960s but is now moving forward on the fission side, and there is also interest on the fusion side. Chris won’t have time to lead but will participate. Greg will develop a charter, start as working group and then move through the process. Anyone who is interested should reach out to Greg. Roland volunteered to provide guidance.
- Greg found parties interested in developing a general standard for lab handling of FLiBe because it is a soluble form of Be, unlike insoluble forms typically found in industry. Private industry and commercial vendors are on board, and several universities have reached out because they are either working with FLiBe now or will be working with it in the future.

12. Adjournment: There was a motion to adjourn. It was seconded and approved. The meeting was adjourned at 3:37PM.

Appendices

BHSC 2023 Fall Meeting Participants List

Below is a sampling of some of the organizations that were represented at the meeting. For access to the complete BHSC 2023 Fall Meeting Participant List, please see a copy of the complete Meeting Minutes.

<u>Family Name</u>	<u>First Name</u>	<u>Organization</u>	<u>Country</u>	<u>Status</u>
		Oak Ridge Associated Universities	USA	
		Idaho National Lab	USA	
		National Nuclear Security Administration	USA	
		Dept of Energy	USA	
		ITER Organization	France	
		DOE Portsmouth/Paducah Project Office	USA	
		Ashley & Associates	USA	
		NNSA Production Office	USA	
		Dept of National Defence	Canada	
		National Jewish Health	USA	
		Commonwealth Fusion Systems	USA	
		Lawrence Livermore National Lab	USA	
		Dept of Energy Brookhaven National Lab	USA	
		TerranearPMC LLC	USA	
		Environmental Mgmt. Los Alamos	USA	
		Merrick & Company	USA	
		University of Michigan	USA	
		Bhabha Atomic Research Centre (BARC)	India	
		Edgewater Technical Associates	USA	
		Princeton Plasma Physics Laboratory	USA	
		Advanced Research Corp.	USA	
		Dept of Energy, Office of Environmental Management	USA	
		General Dynamics Missions Systems	USA	
		Savannah River National Lab	USA	
		Kyoto Fusioneering America	USA	
		eSpin Technologies Inc.	USA	
		Materion Brush Inc.	USA	
		Lawrence Livermore National Lab	USA	
		Y-12 National Security Complex	USA	
		General Dynamics Mission Systems	USA	
		UK Atomic Weapons Establishment	UK	
		Dept of Energy ORAU/ORISE	USA	
		Los Alamos National Lab	USA	
		GEG Consulting, LLC	USA	

Meeting & Venue Photos

Below is a sampling of some of the photos that were taken of the in-person meeting. For access to all BHSC 2023 Fall Meeting photos, please see a copy of the complete Meeting Minutes.



BHSC Chair, Roland CHRETIEN, delivered his opening welcome to more than 40 in-person attendees at the DOE Forrestal Building and another 60-70 participants online. Photo credits: Jack BENNETT, LLNL.



BHSC organizers took advantage of having the meeting at DOE Headquarters by including some remarks from senior leadership in Washington. From left to right: Christopher ROSCETTI, DOE Deputy Director for EH&S; Kevin DRESSMAN, DOE Director, Office of Health & Safety; and Ahmad AL-DAOUK, NNSA Associate Administrator for the Office of EH&S. Photo credits: Left: DOE, Center & Right: Jack BENNETT, LLNL.



Participants look on as John VANCE, US Dept of Labor Policy Chief, reports on his department's role in the Beryllium Program. Photo credits: Jack BENNETT, LLNL.