



Minutes of the Beryllium Health & Safety Committee (BHSC) 2025 Spring Meeting



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

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

Minutes of the Beryllium Health & Safety Committee (BHSC) 2025 Spring Meeting

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

The Beryllium Health & Safety Committee (BHSC) 2025 Spring Meeting was held on 25-26 March 2025 at the Venture 13 Center under the sponsorship of Cameco Fuel Manufacturing in Cobourg, Ontario, Canada. The spring meeting has been held annually since 1995, with a break due to the recent pandemic.

The Minutes of the Spring Meeting have been compiled from the documents generated by the meeting organizers, combined with the abstracts and presentation files submitted by the participants in the event.

The BHSC 2025 Spring Meeting was organized by the BHSC's Meetings & Symposia Sub-Committee, with local support from employees of Cameco Fuel Manufacturing in Cobourg, Ontario. The meeting was held both in-person and online. Overall, there were a total of 112 participants, who came mainly from Canada and the U.S., but also from the UK, Japan, Switzerland, Germany, and India.

Keywords: Beryllium Health & Safety Committee (BHSC), Beryllium, Beryllium Oxide, Fusion Engineering, Irradiation Effects, Beryllide Intermetallic Compounds, Beryllium Fluoride, Beryl Ore, Bertrandite Ore, Plasma-Facing Materials, Neutron-Multiplier Materials, Health and Safety, Chronic Beryllium Disease (CBD), Beryllium Sensitization (BeS), Fusion Start-Ups, Molten Salt, FLiBe, FLiBe Purification, FLiBe Corrosivity, Molten Salt Reactors, Fission Test Reactors, Small Modular Reactors (SMR), Cameco Fuel Manufacturing, CANDU Power Reactors, Zirconium Fuel Bundles, Beryllium Braze Alloy, International Beryllium Workshop (BeWS)

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Table of Contents

Introduction & Post-Meeting Overview	5
BHSC 2025 Spring Meeting Agenda	6
BHSC Meetings & Symposia Sub-Committee	8
BHSC 2025 Spring Meeting Sponsor Organization	8
Day 1: Welcome & BHSC 2025 Spring Meeting Overview	9
Welcome and Spring Meeting Overview	9
<i>BHSC Chair R. CHRETIEN and Vice Chairs C.K. DORN & J. SOBIERAJ</i>	
Day 1: Technical Presentations	17
NNSA Oversight of the Chronic Beryllium Disease Prevention Program	17
<i>J. SOBIERAJ et al. (National Nuclear Security Administration, USA)</i>	
History of the BeYOND Industrial Forum and Invitation to BeYOND-XI	27
<i>A. GORAIEB (Karlsruhe Beryllium Handling Facility, Germany) et al.</i>	
A Pilot Study of Efficacy/Practicality using Genetic Testing to reduce Industrial BeS & CBD	35
<i>C. DUMAS (Materion Brush Inc., Ohio, USA) et al.</i>	
Sarcoidosis in Beryllium Exposed Workers: A Case-Case Study	60
<i>L. BARKER (National Jewish Health, Colorado, USA)</i>	
Requirements, Challenges & Decisions regarding Safe D&D of “Beryllium Facilities”	68
<i>B. WALKER (Safer Environment Ltd., England, UK) et al.</i>	
MiRESSO for the Stable Supply of Beryllium for Fusion Applications.....	77
<i>T. IMAI (MiRESSO Co. Ltd., Aomori, Japan)</i>	
FLiBe Handling and Procedures carried out at MIT for Nuclear Applications	91
<i>K.B. WOLLER (Massachusetts Institute of Technology, Massachusetts, USA)</i>	
Overview of the International Beryllium Workshop Series and Invitation to BeWS-17	111
<i>C.K. DORN (Be4FUSION LLC, California, USA) et al.</i>	
A Practitioner’s Guide to Beryllium Hazard Management.....	117
<i>D. FIELD (National Nuclear Security Administration, Washington, DC, USA) et al.</i>	
Day 1: Vendor Technical Presentation	125
Codeac Solutions Ltd., Code-Be Products, Chicago, Illinois, USA	125
<i>Dr. Melissa FREIDERICH, PhD; Tristan KENNELLY; and Lucas BENDO-WATSON</i>	
Day 2: Technical Presentation.....	130
Beryllium-Bearing Salt Purification and Characterization.....	130
<i>J. ZHANG et al. (Virginia Tech, Virginia, USA)</i>	

Day 2: BHSC Business Meeting	141
Led by Roland CHRETIEN, Chair and Josef SOBIERAJ & Chris DORN, Vice Chairs	141
<i>Business Meeting Minutes compiled by Jack BENNETT, BHSC Recording Secretary</i>	
BHSC 2025 Fall Meeting Announcement.....	145
<i>Chris QUINN-VAWTER (Sandia National Laboratories, New Mexico, USA)</i>	
Appendices	155
BHSC 2025 Spring Meeting Participants List.....	155
Meeting & Venue Photos.....	159

Introduction & Post-Meeting Overview

The Beryllium Health & Safety Committee (BHSC) 2025 Spring Meeting was held on 25-26 March 2025 at the Venture 13 Centre in Cobourg, Ontario, Canada. This meeting has been held annually as an in-person event from 1995-2019. Due to the pandemic, the Spring Meeting was not held from 2020-2022, and it was finally resumed again in 2023. There is also an annual Fall Meeting, and a larger BHSC Symposium that typically happens once every two or three years and most recently in October 2024.

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 it is accomplished through generation, collection, and dissemination of information to members and other interested parties.

The Spring 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 Cameco staff. Participants came mainly from Canada and the U.S., but also from the UK, Japan, Germany, Switzerland, and India. Some key aspects to this year's meeting:

- Run in a hybrid format with both in-person and online attendees and presenters
- Once again highlighted beryllium molten salt (FLiBe) as an up-and-coming product form
- Featured presentations from industry, academia, and government facilities in many Be areas
- Updated members on status of the revised *Practitioner's Guide to Be Hazard Management*
- Presented a leadership succession ceremony as BHSC Chair changed for the first time since 2019
- Included tours of the Cameco Fuel Manufacturing facilities in Cobourg and Port Hope

The meeting was comprised of 13 presentations, including introductory remarks by the BHSC and Cameco senior leadership; updates and beryllium worker protection program activities from the U.S. Department of Energy and the NNSA; histories of the BeYOND and International Beryllium Workshop (BeWS) series; a pilot study on genetic testing; a case-case study on sarcoidosis in Be-exposed workers; an investigation into decommissioning Be-contaminated facilities; introduction to a new producer of primary beryllium in Japan; status of colorimetric Be detection; Be research activities for fusion and fission energy, including FLiBe molten salt; and status on the revision of the aforementioned Beryllium Practitioner's Guide, a critically important BHSC activity that is now well underway. 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 it was announced that the BHSC 2025 Fall Meeting would be held from 18-19 November 2025 at Sandia National Labs in Albuquerque, New Mexico.

The final BHSC 2025 Spring Meeting agenda is included near the beginning of this document to introduce the abstracts and presentations that follow. A list of people and organizations represented at the Meeting may 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

April 2025

BHSC 2025 Spring 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 Be4FUSION, Jack BENNETT of Lawrence Livermore National Lab, Julie FOWLER of the NNSA, as well as BHSC Chair Roland CHRETIEN. Local support from Cameco staff in Cobourg was provided by Victoria ROBICHAUD, Crystal RODDY, and Chris KNOX at the meeting.

AGENDA – Beryllium Health and Safety Committee Meeting 25-26 March 2025 – Hosted by Cameco, Cobourg, Ontario, Canada Also available virtually; links to be provided

All times listed below are Eastern Daylight Time (EDT)

Day 1 – Tuesday, 25 March 2025

Venture 13 Conference Room ([Town of Cobourg](#))

Time (EDT)	Activity	Task Lead/ Speaker
<i>Morning (EDT) – available via webinar</i>		
08:30	Meet and Greet	Robichaud, Roddy
09:00	BHSC Welcome and Overview	Chretien, Dorn, Sobieraj
09:15	Cameco Leadership Remarks	Robichaud, Roddy, Jensen
09:30	NNSA Oversight of the Chronic Beryllium Disease Prevention Program	Sobieraj et al.
10:00	<i>Group Picture / Catered Break (Sponsored by Cameco)</i>	
10:30	History of the BeYOND Series & Invitation to BeYOND-XI	Goraieb et al.
11:00	Pilot Study on Genetic Testing to Reduce BeS & CBD	Dumas et al.
11:30	Sarcoidosis in Beryllium Exposed Workers: A Case-Case Study	Barker et al.
12:00	<i>Lunch (Sponsored by Cameco)</i>	
<i>Afternoon (EDT) – available via webinar</i>		
13:00	Requirements, Challenges, and Decisions regarding Safe D&D of Beryllium Facilities	Walker and Holden
13:30	MiRESSO for Stable Supply of Be for Fusion Applications	Imai et al.
14:00	FLiBe Handling and Procedures Carried Out at MIT for Nuclear Applications	Woller et al.
14:30	<i>Break</i>	
14:50	History of the Int’l Be Workshop Series & Invitation to BeWS-17	Dorn et al.
15:20	Codeac Beryllium Colorimetric Technology	Freiderich and Kennelly
15:50	<i>Break</i>	
16:00	Update on Revision to “A Practitioner’s Guide to Beryllium Hazard Management”	Adams et al.
16:30	Wrap-up	Chretien, Dorn, Sobieraj
18:00	No-Host Social: The Mill Restaurant and Golf Course	Robichaud

Day 2 – Wednesday, 26 March 2025

Venture 13 Conference Room ([Town of Cobourg](#))

Time (EDT)	Activity	Task Lead/ Speaker
<i>Morning (EDT) – available via webinar</i>		
08:30	Meet and Greet	Robichaud, Roddy
09:00	Second-day Agenda Review	Chretien, Dorn, Sobieraj
09:05	Be-Bearing Salt Purification and Characterization	Zhang et al.
09:35	<i>Catered Break (Sponsored by Cameco)</i>	
09:50	BHSC Business Meeting	Board Members
10:25	Subcommittee Breakout Sessions	Members
10:50	Reports from Subcommittee Breakouts	S/C Chairs
11:10	<i>Break</i>	
11:20	Reflections by the Outgoing BHSC Chair & Vision of the Incoming BHSC Chair	Chretien / Dorn
11:35	Opportunities to Serve/ BHSC Succession Planning	Field, Sobieraj
11:45	BHSC Fall Meeting Announcement	Quinn-Vawter, Pass
11:50	Wrap-Up	Chretien, Dorn, Sobieraj
12:00	<i>Lunch (Sponsored by Cameco)</i>	
<i>Afternoon (EDT) – Tours for In-Person Attendees</i>		
13:00	Cameco Tour Presentation	Jensen
13:30	Tour – Cameco Cobourg Facility	Robichaud, Roddy
15:00	Tour – Cameco Port Hope Facility	Robichaud, Roddy
17:00	<i>Adjourn (End of Day)</i>	
End of Day 2		

(Note: BHSC Board meeting: Monday, 24 March 2025)

BHSC Meetings & Symposia Sub-Committee

Name	Position	Organization
Josef SOBIERAJ	Chair	National Nuclear Security Administration
April BROWN	Website Pages including Links Meeting Participant Registration & Coordination Post-Meeting Survey	US Department of Energy Office of Worker Safety & Health Policy
Chris DORN	Communications, Program, Logo Design, and Meeting Minutes	Be4FUSION LLC Rockland Resources Ltd.
Julie FOWLER Dan JENSEN	Meeting Participant Registration & Coordination	National Nuclear Security Administration
Gary GRIFFIN	Special Advisor & Vendor Liaison Past Sub-Committee Chair	GEG Consulting LLC

BHSC 2025 Spring Meeting Sponsor Organization

The organizers of the BHSC 2025 Spring Meeting would like to thank our generous sponsor for their support of the event:



Powering a secure energy future

	Cameco Fuel Manufacturing Cobourg & Port Hope Ontario, Canada	
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Day 1: Welcome & BHSC 2025 Spring Meeting Overview

Welcome and Spring Meeting Overview

BHSC Chair R. CHRETIEN and Vice Chairs C.K. DORN & J. SOBIERAJ

Welcome and BHSC 2025 Spring Meeting Overview

Roland CHRETIEN¹, Christopher DORN^{2,3}, and Josef SOBIERAJ⁴

¹*Edgewater Technical Associates, South Carolina, U.S.A.*

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

³*Rockland Resources Ltd., Vancouver, British Columbia, Canada*

⁴*National Nuclear Security Administration (NNSA), Amarillo, Texas, U.S.A.*

To open the 2025 Spring Meeting, the BHSC leadership put together a presentation, which covered the following material:

- Meetings & Symposia Attendance
 - Number of individuals
 - List of organizations represented
- Brief Overview of BHSC History
 - Mission and Vision
 - BHSC Historical Timeline
 - Implementation of Vision & Mission
 - International Symposia
 - Face-to-Face Meetings
 - Workshops and Other Events
 - Examples of Involvement: Publications & White Papers
- Theme for the 2024 International Symposium: “Extraction to Application”
 - Mining, Recycling & Disposal
 - Fabrication & Facilities
 - Application & Technology
 - Regulations & Health Impacts
- Meeting Minutes, Symposia Proceedings & Executive Summaries
- Executive Summaries: Research Gate Interest/Impact
- BHSC Meetings & Symposia Sub-Committee: Acknowledgements & Reflections

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Welcome to the BHSC 2025 Spring Meeting



Beryllium Health & Safety Committee 2025 Spring Meeting Welcome and Overview



Roland Chretien¹, BHSC Chair; Chris Dorn², BHSC Vice Chair;
Josef Sobieraj³, BHSC Vice Chair

25-26 March 2025 / Cobourg, Ontario, Canada



¹Edgewater Technical Associates, ²Be4FUSION LLC, ³National Nuclear Security Administration

	Spring Meeting Attendance (111 Registrants) Academia / Government / Industry (71 Orgs)		
ALS Environmental Argonne National Laboratory Ashley Analytical Associates ATI INC Atomic Weapons Establishment (UK) Battelle - Pacific NW National Laboratory Be4FUSION LLC. Brookhaven National Laboratory BWXT Nuclear Energy Canada, Inc. Cameco Corporation Cameco Fuel Manufacturing Catavba Corporations Codeac Solutions Commonwealth Fusion Systems Conseil Européen pour la Recherche Nucléaire Department of Veteran Affairs DOE - Office of Enterprise Assessments DOE - Office of Environment, Health, Safety, and Security DOE - Idaho Field Office DOE Office of Fossil Energy and Carbon Management DOE - Office of Safety and Security, Safety Division DOE - Office of Science Edgewater Technical Associates Force Health Protection, CFHS HQ	General Atomics General Dynamics Mission Systems Hanford Site Help By hand LLC HMIS Idaho National Laboratory Infrastructure Health & Safety Association Kansas City National Security Campus Karlsruhe Beryllium Handling Facility (GVT GmbH & Co.KG) Katmai Diversified Services Lawrence Livermore National Laboratory Los Alamos National Laboratory Massachusetts Institute of Technology Materion Brush Inc. Materion corporation Michigan State University MiRESSO Co. Ltd. National Institutes for Quantum and Radiological Science and Technology, Japan Nevada National Security Site - Mission Support and Test Services, LLC. Mitsui & Co; LTD N3B BWXT National Jewish Health NA-ESH HQ Worker Safety and Health NNSA Kansas City Field Office NNSA Livermore Field Office	NNSA Los Alamos Field Office NNSA Nevada Field Office NNSA Pantex Field Office NNSA Sandia Field Office NNSA Savannah River Field Office NNSA Y-12 Field Office Oak Ridge Institute for Science and Education Oak Ridge National Laboratory ORAU/ORISE/DOE Ctr Pacific Northwest National Laboratory Pantex Plant - PanTeXas Deterrence Rockland Resources Ltd. Safer Environment Ltd. Sandia National Laboratories Savannah River National Laboratory UCOR, LLC University of Pennsylvania University of San Francisco US Army Corps of Engineers UT-Battelle/Oak Ridge National Laboratory Virginia Tech University Xcimer Energy Y-12 National Security Complex - CNS	3





Brief Overview of BHSC History

4



VISION

The BHSC is committed to promoting activities/efforts that will help to understand and prevent Be-induced conditions and illnesses, including Be sensitization (BeS) and chronic beryllium disease (CBD), that may be caused or exacerbated by workplace exposure to beryllium.

MISSION

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

5



1960s	1997	1999	2007	2009	2010	2016	2016	2017
National Labs - Be Awareness Training	DOE DP Be Safety Policy	DOE "Be Rule," 10 CFR 850	DOE WSHP, 10 CFR 851	ACGIH Be TLV lowered	DOE issues RFI, 10 CFR 850	OSHA issues Be Rule, 29 CFR 1024 & DOE issues revised NOPR, 10 CFR 850	BHSC Website established	5th Int'l Symposium, and first held in Las Vegas

Beryllium Health and Safety Committee Timeline



6



Implementation of Vision & Mission



International Symposia: offered every 3 – 5 years to encourage experts and non-experts alike to participate in discussions and exchange of information to assist the collective group, and those outside the BHSC, to understand and prevent beryllium-induced conditions and illnesses caused or exacerbated by workplace exposure to beryllium.

1st - 2002; 2nd - 2005; 3rd - 2008; 4th - 2012; 5th - 2017; 6th - 2020/2021 (cancelled); 6th - 2024

Face-to-Face meetings: offered approximately twice a year for BHSC membership to participate in discussions and exchange of information on current issues impacting Beryllium safety and health.

*1995 – 2024**

* a few “face-to face” meetings were actually via Webinar or Teams due to COVID travel restrictions.

7



Implementation of Vision & Mission



Workshops and Other Events

- Data Reporting Task Force workshop at LLNL,
- Inspection of Hanford CBDPP, Fall 2010 at LLNL
- Joint BHSC/EFCOG/DOE session with Dr. David Michaels, Spring 2009 at Washington, DC
- AIHC&E –
 - Provide Panel and Classroom Sessions (2016, 2017, 2018, 2019* (planned))
 - DOE IH meeting (annually) – provide updates on BHSC activities
- Attend Public Hearings – DOE Be Rule (2016); OSHA Be Rule (2016)

8



Implementation of Vision & Mission



Examples of Involvement:

Publications

- A Practitioner's Guide to Beryllium Hazard Management – late 2018
 - Beryllium in soil (Agrawal et al., ES&T, 2008)
 - Special issue of JOEH, December 2009, with 11 papers
 - Beryllium: Environmental Analysis and Monitoring, (Brisson et al., RSC Publ., 2009)
 - BeO Round Robin Study (Oatts et al., JEM, 2012)

White papers

- CBD Prevention: Controlling Exposure in Be Work Environment
- Data Reporting Task Force (two papers on reporting limits, uncensored data)
- Issues Concerning Wall Deposits
- Risk Communication (training modules)

9



THANK YOU!

10

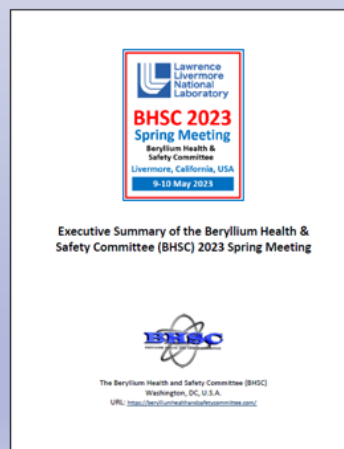


BHSC Meeting Minutes, Symposia Proceedings & Executive Summaries



Documenting What the BHSC Does

- Up to 2022, Slide Presentation Files Uploaded to Website
 - Only known to members and lacking in broader outreach
- First Iteration: 2023 Spring Meeting
 - Open call for papers and requested abstracts
 - Published Exec Summary and Meeting Minutes
- Executive Summaries
 - Abstracts and general info about the meetings
 - Free, open access through self-publication on Research Gate
- Meeting Minutes & Symposia Proceedings
 - Complete event content: abstracts, slides, photos, attendees, etc.
 - Available at no cost to paid members through the BHSC website
- Individual Presentations as Excerpts Available on Request
- How Can BHSC Members Help?
 - Create a profile on Research Gate and post your work
 - Access BHSC publications on RG and recommend and/or cite them in your work



11



BHSC Executive Summaries: Research Gate Interest/ Impact



Research Interest
Score: 4.2
Reads: 373

Attendees: 40 In-Person
48 Virtual
88 Total



Research Interest
Score: 6.4
Reads: 458

Attendees: 72 In-Person
49 Virtual
121 Total



Research Interest
Score: 6.2
Reads: 356

Attendees: 45 In-Person
55 Virtual
100 Total



Research Interest
Score: 2.7
Reads: 169

Attendees: 98 In-Person
Virtual (N/A)
98 Total

Note: 'Reads' updated weekly by Research Gate with readers from many countries.

12



THANK YOU!

13



BHSC Meetings & Symposia Sub-Committee: Acknowledgements and Reflections



Ad Hoc Planning Team

- Acknowledgements:  (Wave when your name is called) 
 - **Cameco Organization** (Amazing Hosts)
 - Wes Adams, Lisa Barker, Jack Bennett, April Brown, Roland Chretien, Chris Dorn, Julie Fowler, Greg Heldt, Dan Jensen, **Victoria Robichaud**, **Crystal Roddy**, Josef Sobieraj, Beth Walker (and Others).
- Planning began ~6 months ago.
- Forecast interest and Attendance
- Agenda Review

14

Day 1: Technical Presentations

NNSA Oversight of the Chronic Beryllium Disease Prevention Program

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

National Nuclear Security Administration Oversight of the Chronic Beryllium Disease Prevention Program

Josef A. SOBIERAJ¹, Wesley ADAMS², Michael BROWN³, Sybil CHANDLER⁴,
Kul GARG⁵, Daniel JENSEN⁶, James JONIEC⁷, Matthew PEEK⁸, and Joseph VOLZA⁹

National Nuclear Security Administration, U.S.A.:

¹*NA-ESH-23 Worker Safety and Health Division*

²*Los Alamos Field Office, Los Alamos, New Mexico*

³*Y-12 Field Office, Oak Ridge, Tennessee*

⁴*Kansas City Field Office, Kansas City, Missouri*

⁵*Livermore Field Office, Livermore, California*

⁶*Nevada Field Office, Las Vegas, Nevada*

⁷*Savannah River Field Office, Aiken, South Carolina*

⁸*Pantex Field Office*

⁹*Sandia Field Office, Albuquerque, New Mexico*

The United States Department of Energy (U.S. DOE) promulgated Title 10 Code of Federal Regulations Part 850 – Chronic Beryllium Disease Prevention Program (10 CFR 850) for establishment of a chronic beryllium disease prevention program (CBDPP) that supplements and is deemed an integral part of the worker safety and health program.

The National Nuclear Security Administration (NNSA) was established by Congress in 2000 and is a semi-autonomous agency within the U.S. DOE that protects our nation by designing and delivering a safe, secure, reliable, and effective U.S. nuclear stockpile; forging solutions that enable global security and stability through nonproliferation, counterproliferation, and emergency response; providing nuclear propulsion to power a global U.S. Navy; and leveraging transformative technologies to address emerging challenges.

The NNSA has eight government-owned, contractor operated (GOCO) sites and facilities including: Kansas City National Security Campus, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Nevada National Security Complex, Pantex Plant, Sandia National Laboratory, Savannah River Site, and Y-12 National Security Complex. For these sites and facilities, the managing and operating (M&O) contractor develops and implements a CBDPP with the federal site beryllium program managers providing first-line federal oversight.

In addition, the NNSA formally established a Beryllium Safety Functional Area Lead (SFAL) headquarters position that guides and supports the NNSA sites and which reports to the NNSA Cognizant Secretarial Officer for Safety on a quarterly basis.

In this presentation, we will describe the interaction between contractor and federal employees with respect to the DOE governance and management framework for effective partnering by stakeholders. In addition, this presentation will share criteria and attributes templates and performance measures that have been developed for consistent beryllium program assessment by sites and facilities. Finally, the presenters will share best practices and challenges for implementing this model.

Corresponding Author:

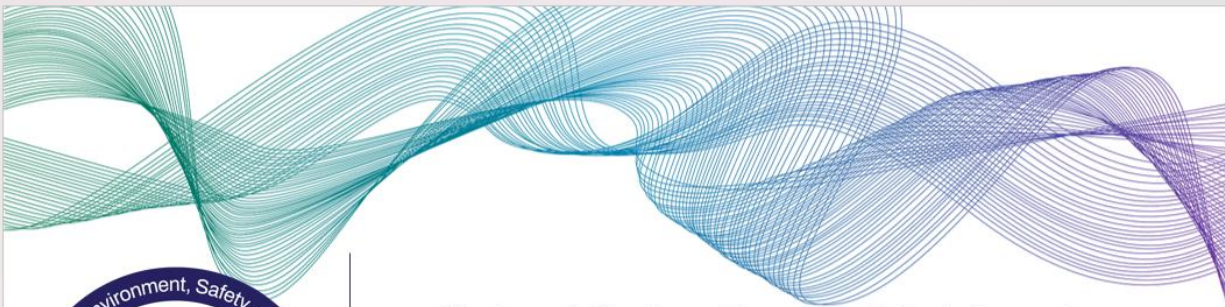
Dr. Josef A. SOBIERAJ, PhD

National Nuclear Security Administration

NA-ESH-23 Worker Safety and Health Division

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URL: [National Nuclear Security Administration | Department of Energy](#)



National Nuclear Security Administration Oversight of the Chronic Beryllium Disease Prevention Program (CBDPP)

Josef Sobieraj, Wesley Adams, Michael Brown, Sybil Chandler, Kul Garg, Daniel Jensen, James Joniec, Matthew Peek, Joseph Volza

Beryllium Health and Safety Committee,
Spring Meeting, March 25, 2025

INNOVATE. COLLABORATE. DELIVER.



National Nuclear Security Administration

National Nuclear Security Administration (NNSA) was established by Congress in 2000 and is a semi-autonomous agency within the U.S. Dept. of Energy (DOE)

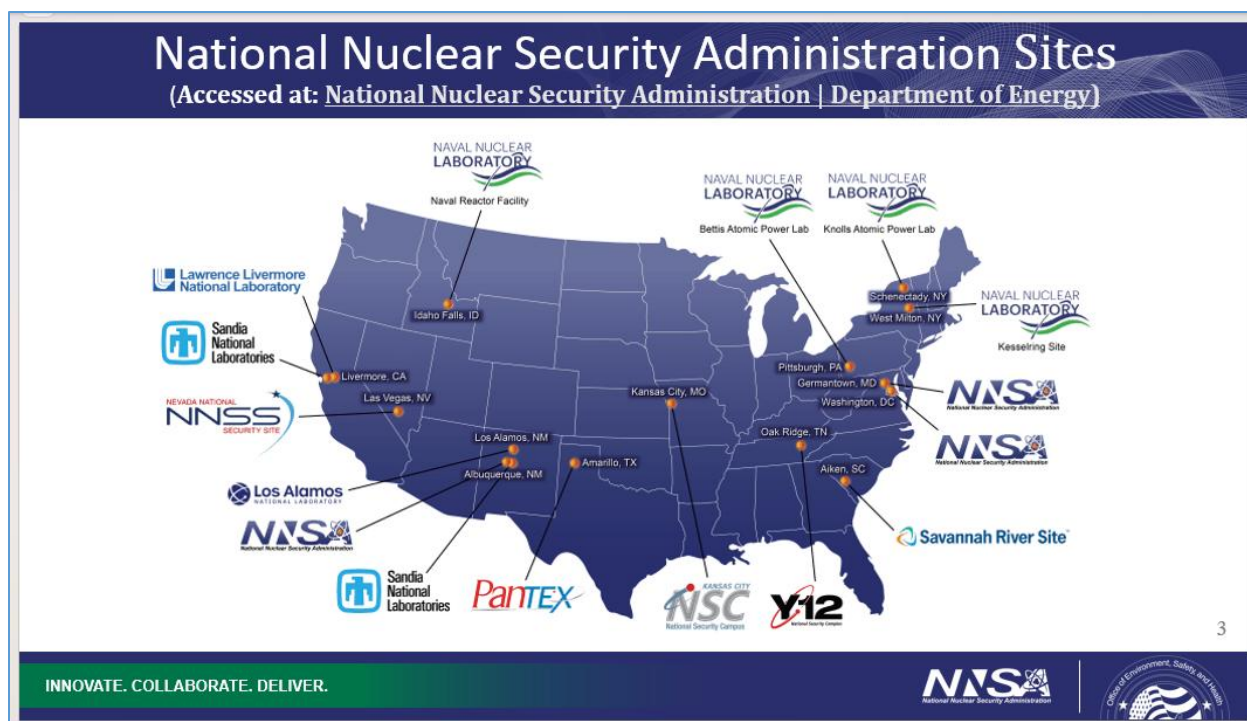
- Protects our nation by designing and delivering a safe, secure, reliable, and effective U.S. nuclear stockpile;
- Forges solutions that enable global security and stability through nonproliferation, counterproliferation, and emergency response;
- Provides nuclear propulsion to power a global U.S. Navy; and
- Leverages transformative technologies to address emerging challenges.

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

2

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CONTEXT: Workers Potentially Exposed to Beryllium








US OSHA: Estimates 62,000 US workers exposed to beryllium in the United States; 50,500 workers in General Industry and approximately 11,500 Construction and Shipyard workers.
[Source: [OSHA's Rulemaking to Protect Workers from Beryllium Exposure | Occupational Safety and Health Administration](#), dated 8/28/2020]

US DOE: Cohort of 56,784 workers within the active reporting sites who have worked for DOE and are tracked through the Beryllium-Associated Worker Registry (BAWR).
[Source: [Data Metrics & Results, Beryllium-Associated Worker Registry Dashboard \(through 2023\)](#)]

NNSA: Subset of US DOE with cohort of 23,956 workers within the active reporting sites tracked through the Beryllium-Associated Worker Registry (BAWR). (Source: ORISE Operations Manager, Health Studies, reported 3/03/2025)

Europe: Carcinogen Exposure (CAREX) database estimates 67,000 Europeans are exposed to beryllium in the workplace. (Source: Kauppinen et al., 2000)

United Kingdom: UK Health and Safety Executive estimates 500 – 1,000 workers in the UK are exposed to beryllium. (Source: HSE RR873 Research Report, 2011)

Canada: Carcinogen Exposure (CAREX) database estimates 3,800 Canadians are exposed to beryllium in the workplace. (Source: [Beryllium - Occupational Exposures - CAREX Canada](#), 2016)

4

INNOVATE. COLLABORATE. DELIVER.

NNSA
National Nuclear Security Administration

10 CFR Part 850, Chronic Beryllium Disease Prevention Program (CBDPP)

Final Rule Promulgated - December 8, 1999

§ 850.1 Scope

- Establish a comprehensive Chronic Beryllium Disease Prevention Program (CBDPP)
 - Integrated into existing worker safety and health program
 - 10 CFR 851, *Worker Safety and Health Program*

5

INNOVATE. COLLABORATE. DELIVER.



10 CFR Part 850 CBDPP: Specific Program Elements

Subpart C Specific Program Requirements

- § 850.20 Baseline beryllium inventory.
- § 850.21 Hazard assessment.
- § 850.22 Permissible exposure limit.
- § 850.23 Action level.
- § 850.24 Exposure monitoring.
- § 850.25 Exposure reduction and minimization.
- § 850.26 Regulated areas.
- § 850.27 Hygiene facilities and practices.
- § 850.28 Respiratory protection.
- § 850.29 Protective clothing and equipment.
- § 850.30 Housekeeping.
- § 850.31 Release criteria.
- § 850.32 Waste disposal.
- § 850.33 Beryllium emergencies.
- § 850.34 Medical surveillance.
- § 850.35 Medical removal.
- § 850.36 Medical consent.
- § 850.37 Training and counseling.
- § 850.38 Warning signs and labels.
- § 850.39 Recordkeeping and use of information.
- § 850.40 Performance feedback.

- 10 CFR 850 identifies twenty-one specific Program Elements;
- Program Elements are compliance-based and performance-based;
- NNSA implements a unique oversight model for assessing the CBDPP at NNSA Sites.

(Note: BHSC conducted a comparative analysis of international Beryllium program elements in the upcoming BHSC *Practitioner's Guide to Beryllium Hazard Management*, 2nd Ed.)

6

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Federal Line Management Oversight of DOE Nuclear Facilities (DOE G 226.1-2A)

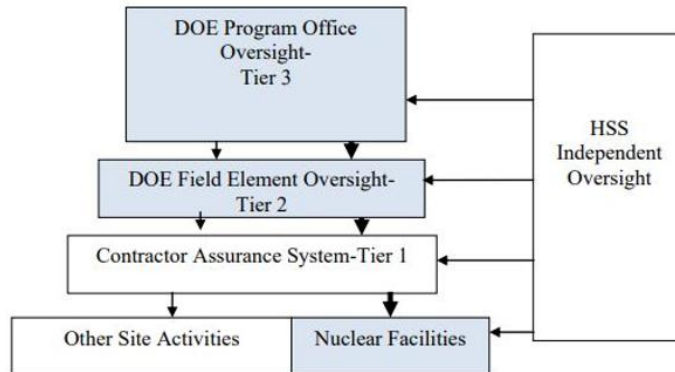


Figure 1. DOE's Multi-Tiered Approach to Safety Oversight

7

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NNSA HQ Safety Functional Area Leads

NA-ESH Standard Operating Procedure



Number	NA-ESH-20.005
Title	NA-ESH-20 Safety Functional Area Lead (SFAL) Standard Operating Procedure (SOP)
Revision	1.0
Effective Date	05/07/2024
Review Date	05/07/2027

Purpose: To establish and formalize the responsibilities for the Office of Safety (NA-ESH-20) SFALs to ensure the NNSA Cognizant Secretarial Officer for Safety (CSO) has situational awareness of ESHQ effectiveness and understanding of enterprise level risks.

SFALs: *Beryllium Safety*, Electrical Safety, Explosives Safety, Fire Protection, Nuclear Criticality Safety, Quality Assurance, Radiation Protection, Safety Basis, Worker Safety & Health

8

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NNSA Beryllium SFAL Programmatic Oversight (Quarterly / Semi-Annual Reporting)

Quarterly Reporting:

- Beryllium SFAL provides formal briefing to the NNSA Cognizant Secretarial Officer (CSO) for Safety and Senior Management Team (**Tier 3 Oversight**);
- Provide updates to the Beryllium SFAL for inclusion in the report to the CSO for Safety (**Tiers 2/3 Oversight**);
- Federal Site Beryllium POCs interface with M&O Beryllium POC for quarterly updates (**Tiers 1/2 Oversight**).

Semi-Annual Reporting:

- NNSA Sites must semi-annually transmit an electronic registry of beryllium-associated workers [§ 850.39 (h)] (**Tiers 1/2 Oversight**);
- NNSA Beryllium SFAL routinely contacts BAWR program manager for information on beryllium sensitization (BeS) and chronic beryllium disease (CBD) cases at NNSA Sites (**Tier 3 Oversight**).

9

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NNSA Beryllium SFAL Programmatic Oversight (Annual and Ad Hoc Reporting)

Annual Reporting:

- Beryllium SFAL and HQ Site POCs evaluate Site performance of CBDPP as one element of overall Contractor Performance Evaluation Process (**Tier 3 Oversight**);
- Federal Site Beryllium POCs annually develop Site Integrated Assessment Plan (SIAP) based on risk and consequence scoring to determine level of rigor in assessing contractor CBDPP (**Tier 2 Oversight**);
- M&O Contractor annually reports CBDPP status and determines level of rigor in assessing CBDPP as part of overall Contractor Assurance System (**Tier 1 Oversight**).

Ad Hoc Reporting:

- Contractor submits CBDPP update to the appropriate Head of DOE Field Element for review and approval whenever a significant change/addition or change in contractors occurs. (**Tiers 1/2 Oversight**);
- Significant event occurs exceeding reporting thresholds or new operations or challenges arise requiring discussion and oversight (**Tiers 1/2/3 Oversight**);
- Other (e.g., For Cause/Programmatic External Assessments, etc.).

10

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NNSA's Evolving CBDPP Oversight Tools (Beryllium Checkerboard Ratings)

Beryllium Checkerboard

Rev 1

Site: _____ Fiscal Year: _____ Trimester: _____

1. Safety Management System Implementation, Integration with Chronic Beryllium Disease Prevention Program (CBOPP) and execution

Does the CBOPP as implemented by the M&O continually drive a culture of improved Be safety performance through SPOMCs/CAS and use of high-quality quantifiable metrics, is fully integrated with the SMSO, QA, EMS, WPA&C, and other site M&O management processes?

- **Poor** – non-existent
- **Marginal** – improvement to CBOPP is not based on analysis or trending of SPOMCs and CAS. Change is infrequent (i.e., contract change or directed by Field Office)
- **Meets** – improvement to CBOPP is compliance or standards-based (i.e., contract change; significant change in Operations) but is not always driven by trending of SPOMCs and CAS. Integration with SM is improving but not yet thorough. Integration with EMS and QAP is lacking. Integration with WPA&C processes is improving. Issues management program/assessment processes improving; corrective actions somewhat slow to close. Integration with SPOMCs/CAS improving but needs attention to integrate quality metrics.
- **Exceeds** – improvement to CBOPP processes is largely driven by compliance (i.e., contract change or significant change in Ops) with some basis in performance trends (i.e., SPOMCs and trending of CAS). M&O is striving to improve use of performance metrics. Integration of SMS, EMS, and QAP with CBOPP is improving but not yet thorough. M&O is striving for third-party certifications of safety related programs with at least one system audited/certified by third parties. Integration with WPA&C processes is improving but not yet thorough. Issues management program and assessment processes are complete/fully up to date; link to SPOMCs and CAS; managed with very good quality metrics.
- **Significantly Exceeds** – improvement to CBOPP processes is largely performance-based predicated on thorough and frequent analysis of high-quality quantifiable metrics and trending of CAS/SPOMCs performance throughout the performance cycle (e.g., monthly, trimester, annually). SMS, EMS, QAP are thoroughly integrated with CBOPP; audited/certified by third parties. CBOPP supports and is fully integrated with WPA&C processes. Issues management program and assessment processes are complete/fully up to date; link to SPOMCs and CAS; well-maintained and managed with high-quality quantifiable metrics. Considered "benchmark" or close to benchmark in most respects consistently pursues excellence.

2. CBDPP administration and support

a. How often does the site M&O update the CBDPP including implementing policies and procedures. Approved by Field Office?

- **Poor** – non-existent
- **Marginal** – infrequent; contract change
- **Meets** – somewhat frequent – contract change; significant change in the Ops
- **Exceeds** – periodically based on trending; contract change; significant change in the Ops
- **Significantly Exceeds** – annually; CBOPP performance trending/analysis drives change

b. Is there a designated and competent CBDPP Lead?

- **Poor** – non-existent
- **Marginal** – designated; not CH; little training or experience
- **Meets** – designated; CH; some training or experience
- **Exceeds** – designated; CH; well-qualified/competent; significant Be experience
- **Significantly Exceeds** – designated; CH; well-qualified/competent; sought after by peers

c. How well does the M&O maintain CBDPP-related records (data, reports, medical, etc.)?

- **Poor** – records missing or incomplete
- **Marginal** – some records missing; not accessible by stakeholders
- **Meets** – records mostly accurate/complete; restricted access to IH, Medical, WPA&C
- **Exceeds** – records accurate/complete; easily accessible via site's IT system to vested stakeholders (e.g., Be workers/supervisors, IH, safety, medical, WPA&C)
- **Significantly Exceeds** – records accurate/complete; include data analysis and trending; easily accessible via site's IT system to all stakeholders

d. How well does the M&O support DOE/NNSA sponsored CBDPP intercommunication, training and outreach efforts (e.g., BFOOD INOPS, BFO&C, JOWCO (Be Safety), AINCE (DGE meeting))?

Checkerboard Template:

- Template with **established criteria and attributes** to support adjectival ratings (**Tiers 1/2 Oversight**);
- Template established **consistent reporting** criteria for NNSA Sites (**Tier 3 Oversight**).

Template Program Elements:

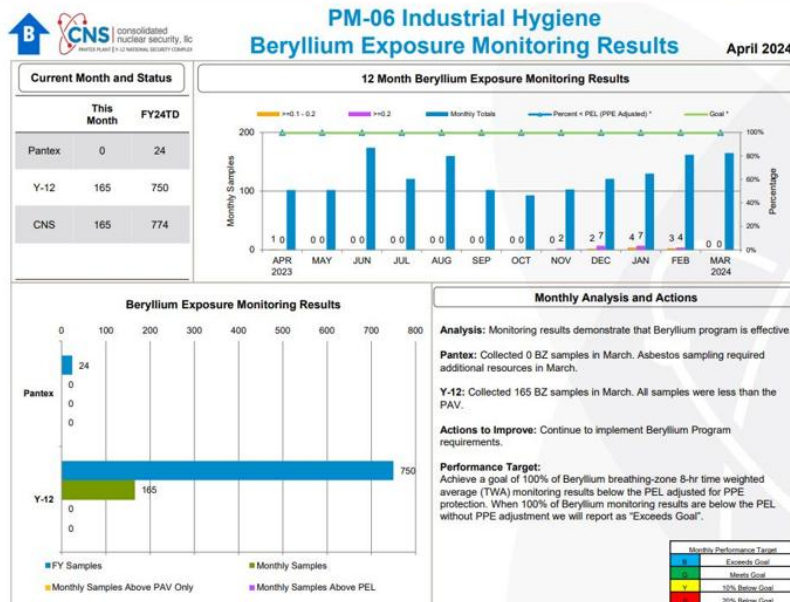
1. Safety Management System Implementation
2. CBDPP Administration and Support
3. Be Baseline Inventory/Hazard ID/Exposure Monitoring
4. Safety Expectations/Communication
5. Minimization and Reduction of Be Hazards / Feedback and Improvement
6. Be Training
7. Be Medical Surveillance

11

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Safety Performance Objectives, Measures and Commitments



Monthly Performance Measure:

- Evidence of implementation of sampling program.
- Sampling results validate adequacy of process controls in space and time.
- Any elevated sampling results quickly identified so appropriate resources can address issues.

12



NNSA Oversight Initiatives for Continual Improvement

- Continue to develop and mature performance measures and metrics for assessing the CBDPP (*i.e.*, SPOMCs).
- Improve partnering of Contractors and Feds at all Tiers by timely sharing of information, best practices, benchmarking, and challenges.
 - Consider implementing successful model used by the SPOMC Working Group
 - Align these meetings with the quarterly SFAL briefings to Leadership
- Additional ideas.

13

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NNSA Beryllium Federal Points of Contact (Meet the Team)

Josef Sobieraj, *NA-ESH-23 Worker Safety and Health Division*

Wesley Adams, *Los Alamos Field Office*

Michael Brown, *Y-12 Field Office*

Sybil Chandler, *Kansas City Field Office*

Kul Garg, *Livermore Field Office*

Daniel Jensen, *Nevada Field Office*

James Joniec, *Savannah River Field Office*

Matthew Peek, *Pantex Field Office*

Joseph Volza, *Sandia Field Office*

14

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BHSC Oversight Discussion

Topics for Consideration

- Additional Thoughts/Comments from NNSA Federal/Contractor POCs
- Discuss Oversight Models for other DOE Organizations
- Discuss Oversight for Industry and Research Organizations

15

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History of the BeYOND Industrial Forum and Invitation to BeYOND-XI

A. GORAIEB (Karlsruhe Beryllium Handling Facility, Germany) et al.

History of the BeYOND Industrial Forum and Invitation to BeYOND-XI

Aniceto GORAIEB¹ and Christopher DORN²

¹*Karlsruhe Beryllium Handling Facility (KBHF), Eggenstein-Leopoldshafen, Germany*

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

The BeYOND Industrial Forum was first held in 2009, co-founded by Aniceto Goraieb of the Karlsruhe Beryllium Handling Facility (KBHF) and Chris Dorn, then working for Brush Wellman Inc. in the U.S. The name BeYOND is an acronym, which stands for “Beryllium Opportunities for New Developments.”

The reason for holding another beryllium-in-fusion-type event in addition to the IEA International Workshop on Beryllium Technology (BeWS) was that it would have a different focus. BeYOND was created with the idea of more emphasis on strengthening the connection between the beryllium research community and the beryllium industry, an aspect not always satisfied by the BeWS. Since BeYOND-V in 2013, the workshop has generally also placed more emphasis on beryllium health and safety than typically found in the BeWS.

After trying various timing relative to other conferences, it evolved that the BeYOND workshops would take place on alternate years from the BeWS and normally held in conjunction with the SOFT Conference (Symposium on Fusion Technology), which is always held in Europe. Meetings to date:

- BeYOND-I: Karlsruhe, Germany, 2009
- BeYOND-II: Porto, Portugal, 2010
- BeYOND-III: Karlsruhe, Germany, 2011
- BeYOND-IV: Karlsruhe, Germany, 2012
- BeYOND-V: Barcelona, Spain, 2013
- BeYOND-VI: San Sebastian, Spain, 2014
- BeYOND-VII: Berlin, Germany, 2016
- BeYOND-VIII: Karlsruhe, Germany, 2018
- BeYOND-IX: Karlsruhe, Germany, 2022
- BeYOND-X: Oxford, England, UK, 2023

Nowadays, as the driving force in the fusion industry moves from government research institutes to private enterprises, it is the commercial companies that will determine the timeframe for achieving a successful, scalable fusion machine. If the realization of that first machine is to succeed, it is clear that collaboration between the traditional institutes and the commercial companies must happen,

and that need for working together goes well beyond just what is happening with beryllium. Everyone needs to start thinking on a broader and bigger scale.

In June 2023, BeYOND co-founder Aniceto Goraieb participated as a panelist in a satellite session at the Symposium on Fusion Energy (SOFE), which was his original brainchild. That session, which was titled “Next Steps to Global Fusion Partnerships,” discussed the opportunities in private-public partnership (PPP) in the fusion energy industry, and it was ultimately supported by Kyoto Fusioneering in the UK, and the Fusion Industry Association (FIA) in the U.S. The presentations and discussion during that session emphasized not only the importance of partnerships to accelerate the development of fusion, but they also showed how many different pathways exist and are already being used for collaboration and partnership.

Based on this experience at SOFE, coupled with the large-scale changes in the fusion industry, it seems that now is the time to change the purpose of the BeYOND Industrial Forum. Up to now, BeYOND has been focused on fostering partnerships between government labs and industry exclusively for beryllium-related research, but the vision for the future is to significantly broaden the scope of those partnerships. Now, the critical path for accelerating the success of fusion lies in the promise of the aforementioned public-private partnerships, and those PPPs need to cover all areas of fusion where technology transfers are needed and not just those that involve beryllium.

The presentation concludes with an invitation to participate in BeYOND-XI, scheduled for 12 September 2025 in Karlsruhe, Germany, with a new agenda focused on global fusion partnerships, and with particular emphasis on building supply chains for fusion-critical materials. The event theme is “From Laboratory Scale to Pilot Production and beyond....”

Corresponding Author:

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URL: <https://www.fusion-for-future.de/>

LET'S CATCH THE STAR

**RESEARCH
ON BEHALF
OF MANKIND**

**History of the
BeYOND Industrial
Forum & Invitation
to BeYOND-XI**

Aniceto Goraieb, KBHF GmbH
Chris Dorn, Be4FUSION LLC



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www.fusion-for-future.de



**BHSC 2025
Spring Meeting**
Beryllium Health &
Safety Committee
Cobourg, Ontario, Canada
25-26 March 2025

BHSC 2025 Spring Meeting
Cobourg, Ontario, Canada
25 March 2025



Presentation Outline

- Founding of BeYOND
 - Workshop Concept
 - Program Focus
 - Sponsors & Partners
- History of the Events
 - Initially Held Annually
 - Transition to Every 2 Years
- Changes in the Fusion Industry
 - Traditional Structure (1980s-2010s)
 - New Landscape (starting late 2010s)
- Need for Public-Private Partnerships
- Invitation to BeYOND-XI





We came a long way through fusion history

- The Start-Up GVT was established 1993
 - Specialized in Solid Breeder Blanket Design
 - Material design, testing & pilot production
 - Work performed on FLiBe, as well
- Non-Profit Organization founded 2000
 - “Fusion for Future” by Mankindproject e.V.
 - Events for children and adults
 - Science, industry, politics and the public
- KBHF, a Spin-In at KIT established 2009
 - Private infrastructure for Blanket handling
 - Public-Private-Partnership on KIT Campus
 - Transfer company science to industry
- BeYOND started the same year



25-26 March 2025

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Founding of BeYOND

- Workshop Concept
 - Link Research Centers to Industry
 - Greater Emphasis on Industrial Issues
 - Scale-Up from Lab to Production
 - Technology Transfer
 - Environmental, Health & Safety (EH&S)
- Starting the Series
 - Partnership: KBHF & Brush Wellman
 - Funding from KIT & Industry Partners
- Evolution of the Program
 - Even-Number Years (opposite BeWS)
 - Timing Coordinated with SOFT
 - Mostly Held in Karlsruhe, Germany



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History of the Events

- BeYOND-I: Karlsruhe, Germany, 2009
- BeYOND-II: Porto, Portugal, 2010
- BeYOND-III: Karlsruhe, Germany, 2011
- BeYOND-IV: Karlsruhe, Germany, 2012
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- BeYOND-IX: Karlsruhe, Germany, 2022
- BeYOND-X: Oxford, England, UK, 2023



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Next Steps to Global Fusion Partnerships

- First time in June 2023, at SOFE
 - Symposium on Fusion Engineering in Oxford
 - A brainchild of the BeYOND founders
 - Supported by Kyoto Fusioneering (KF) in UK
 - Also, by Fusion Industry Association (FIA, USA)
 - Organized with the help of UKAEA
 - Discussed the opportunities of PPPs
 - Showed the importance of partnerships to accelerate fusion
 - Many different pathways already exist and are used for this purpose
 - Synergies play a significant role to get ready in time (1 or 2 decades?)
 - Non-Profit Organizations could be an additional key to the success



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Mankindproject e.V. has now been restarted

- **Communication**
 - To keep the public informed
 - Connecting Engineers and Visioneers
 - Bridging between science & Industry
 - Student programs for junior stuff
- **Event management**
 - Support of BeYOND
 - Historical venues to catch up with science
- **Co-Financing of research programs**
 - Crowd Funding
 - Organization of charity events
 - Tax refunds for donations



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Merging the concepts at BeYOND-XI

- **Global Fusion Partnerships (GFP) need:**
 - New interested and qualified staff
 - Technology Transfer (TT) options
 - Partners that enable the possibility of synergies
 - Public and political support
- **BeYOND-GFP could help with:**
 - Short-Term TT:
 - Finding Technology near state-of-the-art
 - Mid-Term TT:
 - Create research partnerships, train students
 - Long-Term TT:
 - Indirect technology transfer back to science labs
- **The Non-profit Organization's role would be:**
 - Crowd Funding, State Funding
 - Organization of charity events
 - Tax credits or offsets for donations



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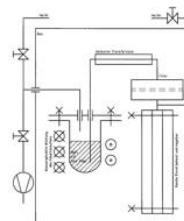
State of the Art and beyond

- Near-Term State of the Art:
 - The Solid Breeder Concept at KIT
 - Ulba is producing our Be-Ti material concept
 - KALOS pilot production facility running at KIT
 - Mass production will be available, soon!
 - The concept is already qualified for fusion
- Mid-Term Technology Transfer:
 - The Molten Salt (FLiBe) Concept
 - Mass production has already begun
 - Until now only data for fission available (1960s)
 - Has to be qualified for fusion application, now!
- Long-Term Technology Transfer:
 - Liquid-Metal Concepts for the Breeder Blanket
 - MHD Effects cause difficulties in compact machines
 - Coatings have to prove their long-term stability

Helium-cooled pebble bed blanket design of DEMO



2 17.10.2023 Dr. Ramel Gass Institute for Applied Materials - Applied Materials Physics



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You are Invited to Participate in BeYOND-XI!

- Program: *"From Laboratory Scale to Pilot Production and beyond..."*
 - Needed for Critical Fusion Materials
 - Beryllium & Beryllide Intermetallics
 - Lithium Ceramics
 - Molten Salts (FLiBe, FLiNaK, etc.)
- Global Fusion Partnerships need:
 - New interested and qualified staff
 - Technology Transfer options
 - Partners that enable synergies
 - Public and political support
- BeYOND-XI: Networking Opportunities



25-26 March 2025

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Thank You Very Much for Your Attention!



www.fusion-for-future.de

Aniceto Goraieb, KBHF GmbH



Be⁴FUSION

Specialty Materials & Business Consulting

<https://be4fusion.com/>

Chris Dorn, Be4FUSION LLC

A Pilot Study of Efficacy/Practicality using Genetic Testing to reduce Industrial BeS & CBD
C. DUMAS (Materion Brush Inc., Ohio, USA) et al.

A Pilot Study of Efficacy/Practicality using Genetic Testing to reduce Industrial Beryllium Sensitization & Chronic Beryllium Disease

Constantine DUMAS¹, Kenneth ROSENMAN², Dimitri MONOS³,
Gregory HELDT¹, and Michael KENT¹

¹*Materion Brush Inc, Elmore, Ohio, USA*

²*Michigan State University, East Lansing, Michigan, USA*

³*University of Pennsylvania, Philadelphia, Pennsylvania, USA*

Recent NIOSH studies (published in 2016) of Materion beryllium workers have provided a wealth of information concerning genetic risks for Beryllium Sensitization (BeS) and Chronic Beryllium Disease (CBD).

We have subsequently performed genetic case studies on Materion employees that developed BeS or CBD over the past two decades. The cost benefit of mass screenings that would have been required to prevent these cases, using current genetic knowledge, was analyzed. A strictly empirical approach was compared to a more mechanistic analysis applying HLA-DPB1 (HLA = human leukocyte antigen) electronegativity information.

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

A pilot study of efficacy/practicality using genetic testing to reduce industrial beryllium sensitization and chronic beryllium disease.

Constantine Dumas¹, Kenneth Rosenman², Dimitri Monos³,
Gregory Heldt¹, and Michael Kent¹

BHSC Meeting, Spring 2025

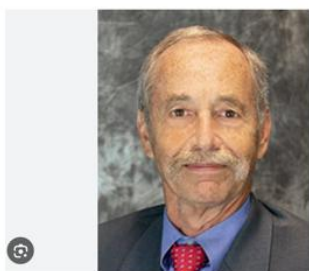


¹Materion Brush Inc, Elmore, OH, USA

²Michigan State University, East Lansing, MI, USA

³University of Pennsylvania, Philadelphia, PA, USA

March 25, 2025
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Occupational and Environmental Medicine | MSU

Professor
Rosenman, MD



CHOP Research Institut...
Dimitrios S. Monos | C...

Professor
Monos, PhD

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Asclepius and Hygeia

The Greeks had two gods of health



Therapy
Ασκληπίος



Prevention
Ἑγεία

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Delta, Utah



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Why would we consider the possibility that genetics could influence susceptibility to chronic beryllium disease?

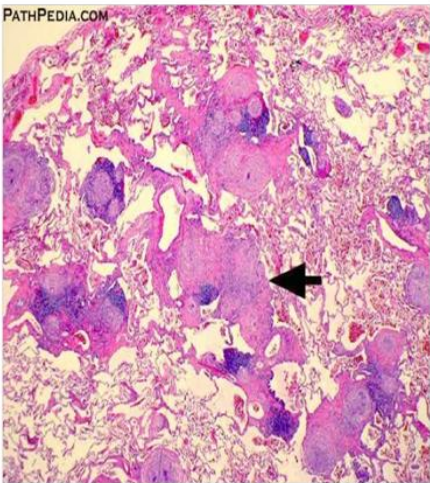
▶ **What is the pathophysiology of chronic beryllium disease?**

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PATHPEDIA.COM

[CHRONIC PULMONARY BERYLLOSIIS]. The histopathologic findings of chronic berylliosis are identical to those of sarcoidosis. Both are characterized by non-necrotizing granulomata distributed in the parenchyma (arrow) and along the lymphatic routes. Although the findings are non-specific, the constellation of histologic findings along with history of chronic exposure to beryllium metal dust or its compounds suggests the diagnosis.

MATERION

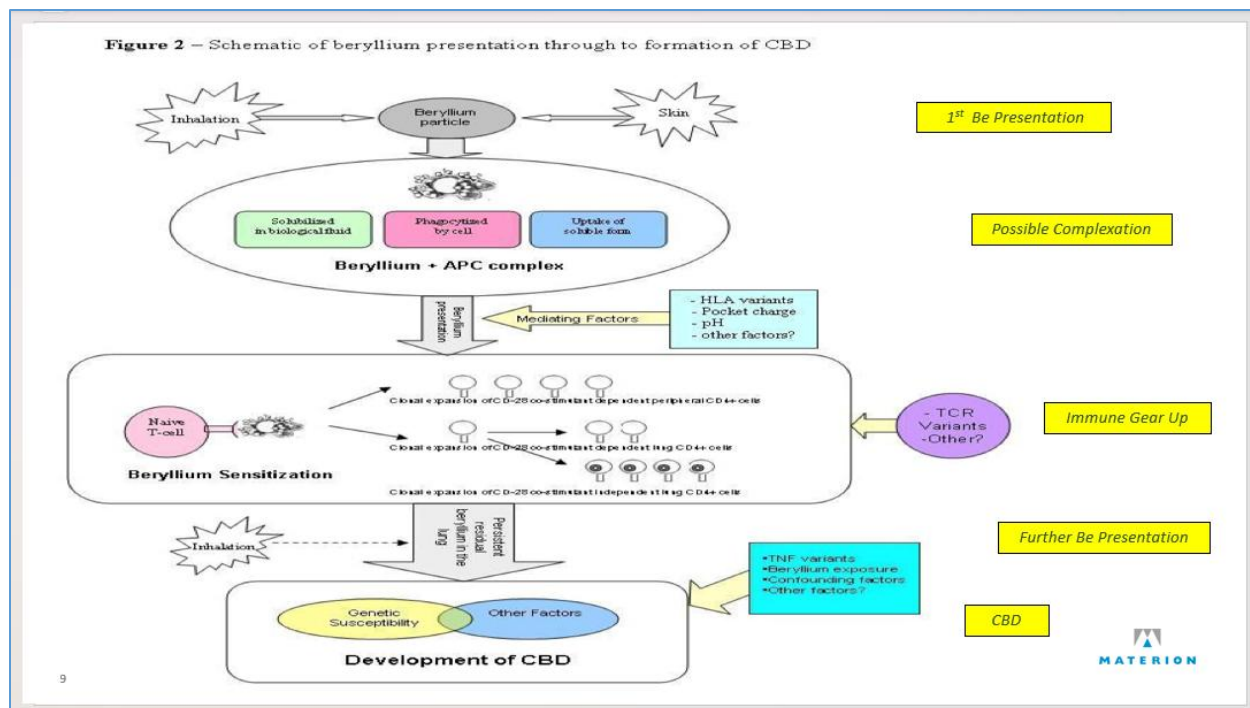
How Much is $0.2\mu\text{g}/\text{m}^3$?

One packet of sweetener in the air volume of the Superdome

- Weight of 1 packet of sweetener = $1\text{ g} = 1,000,000\text{ }\mu\text{g}$
- Volume of the Superdome = $3,500,000\text{ m}^3$

$$\frac{1,000,000\text{ }\mu\text{g}}{3,500,000\text{ m}^3} = 0.29\mu\text{g}/\text{m}^3$$





How does the immune system work?

humoral immunity?

macrophages?

antigens?

antibodies?

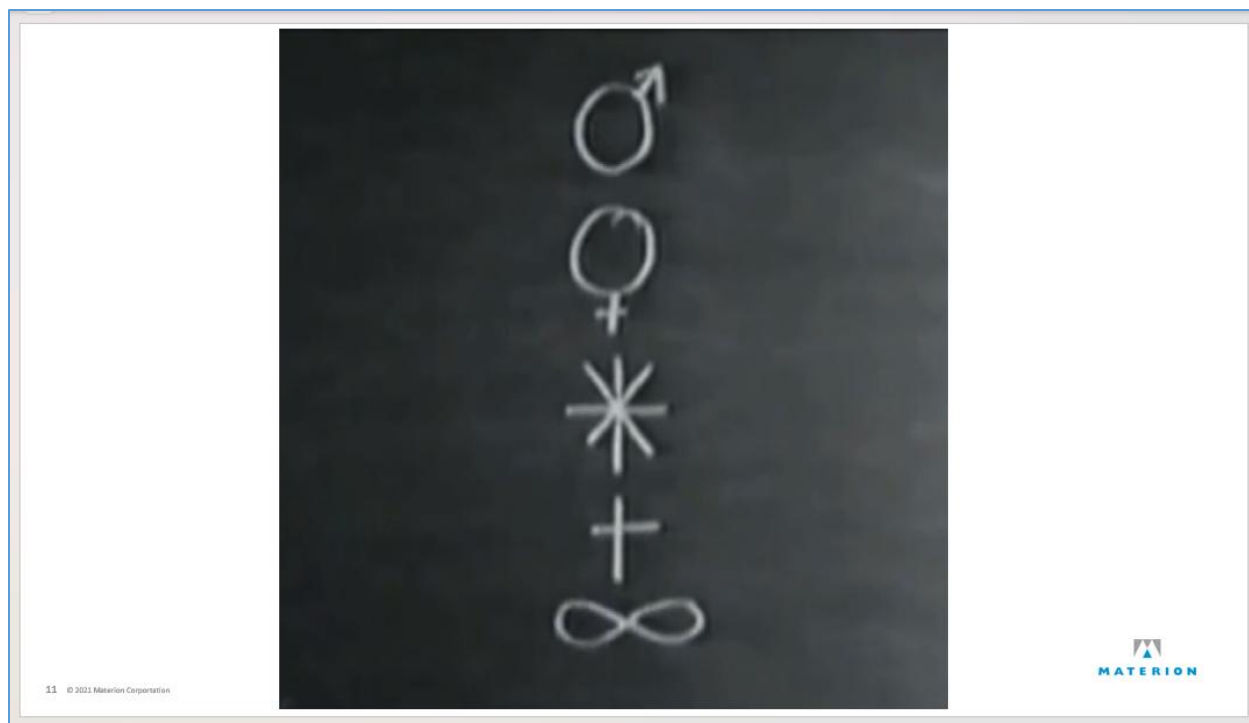
B cells?

T cells?

cytokines?

cellular immunity?

immunoglobulins?

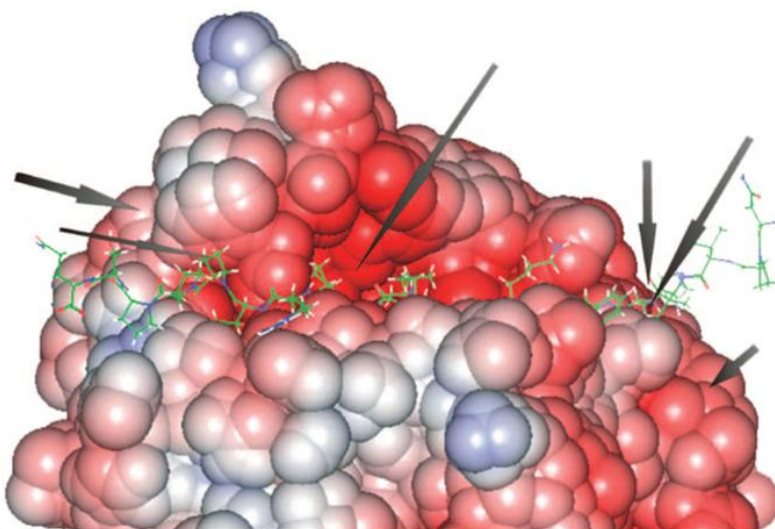


MCMLXI to MCMLXVI

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Major Histocompatibility Complex (MHC) Class II protein molecule (friend or foe?)



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Torre pendente di Pisa



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Chronic beryllium disease (genetics)

- ▶ On chromosome 6, HLA-DPB1 codes for:
- ▶ MHC II (i.e. the antigen detector)

Luca Richeldi and Cesare Saltini, University of Modena 1993, identified the CBD-associated gene marker HLA DPGLu69



- ▶ **In 1993 we learned** - If glutamic acid is coded at position 69 of that protein molecule, the risk of beryllium sensitization and CBD is increased. 1/3rd of the population carry the Glu69 marker.

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NIOSH did a study with Materion.....why?

Chronic beryllium disease (CBD) has a well-characterized immunologic mechanism requiring cell-mediated sensitization to the metal antigen. Beryllium sensitization (BeS) is affected by both exposure and genetic characteristics. Since 1993, six research groups, studying a number of beryllium-exposed populations, have confirmed that workers with a glutamic acid (E) in the 69th position of the Human Leukocyte Antigen (HLA)-DPB1 molecule, involved in antigen presentation, have increased susceptibility for BeS and CBD.¹⁻¹⁰ However, this supra-allelic *E69* marker of genetic risk is present in more than one-third of the U.S. population and far exceeds the prevalence of BeS and CBD in worker populations. For those reasons, *E69* genetic testing was not pursued as a good predictor of who might develop CBD in a beryllium workplace,¹¹ especially in light of concerns for employment and insurance discrimination.

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J Occup Environ Med. 2016 September ; 58(9): 855–860. doi:10.1097/JOM.0000000000000805.

Research to Practice Implications of High-Risk Genotypes for Beryllium Sensitization and Disease

Kathleen Kreiss, MD, Ethan D. Fechter-Leggett, DVM, Erin C. McCanlies, PhD, Christine R. Schuler, PhD, and Ainsley Weston, PhD
Respiratory Health Division (Drs Kreiss, Fechter-Leggett, Schuler [former affiliation], Weston), Health Effects Laboratory Division (Drs McCanlies, Weston [former affiliation]), and Division of Safety Research, National Institute for Occupational Safety and Health, Morgantown, West Virginia (Dr Schuler)

Abstract

Objective—Beryllium workers may better understand their genetic susceptibility to chronic beryllium disease (CBD) expressed as population-based prevalence, rather than odds ratios from case-control studies.

Methods—We calculated CBD prevalences from allele-specific DNA sequences of 853 workers for *Human Leukocyte Antigen (HLA)-DPB1* genotypes and groups characterized by number of *E69*-containing alleles and by calculated surface electronegativity of HLA-DPB1.

Results—Of 18 groups of at least 10 workers with specific genotypes, CBD prevalence was highest, 72.7%, for the *HLA-DPB1*02:01:02/DPB1*17:01* genotype. Population-based grouped genotypes with two *E69* alleles wherein one allele had –9 surface charge had a beryllium sensitization (BeS) of 52.6% and a CBD prevalence of 42.1%.

Conclusions—The high CBD and BeS prevalences associated with –9-charged *E69* alleles and two *E69*s suggest that workers may benefit from knowing their genetic susceptibility in deciding whether to avoid future beryllium exposure.

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In addition to position 69, what is the entire protein molecule?

Recent NIOSH research improves the predictive value of genetic screening by considering chain locations in addition to glu69 that affect electronegativity

Kreiss K, Fechter-Leggett E, McCanlies EC, Schuler CR, Weston A. Research to Practice Implications of High-Risk Genotypes for Beryllium Sensitization and Disease. JOEM. 2016;58(9):855-860.

TABLE 2. Percent Prevalence of CBD and Total BeS by Genotype for 18 Groups of At Least 10 Persons With Identical HLA-DPB1 Genotype (66.8% of the Genotyped Population), With Specification of Number of E69 Alleles and Number of Alleles With Negative 9 Electronegativity for Each Genotype, in a Population of 853 Genotyped Beryllium Workers

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*04:01/*10:01	1	1	40.0	53.3	1.8
*02:01:02/*02:01:02	2	0	33.3	52.4	2.5
*02:01:02/*04:02	1	0	27.8	38.9	2.1
*02:01:02/*03:01:01	1	0	16.7	38.9	2.1
*02:01:02/*04:01	1	0	12.0	22.0	11.7
*03:01:01/*05:01	0	0	10.0	20.0	1.2
*04:01/*05:01	0	0	10.0	20.0	1.2
*01:01:01/*02:01:02	1	0	10.0	10.0	1.2
*04:01/*04:01	0	0	3.1	5.5	15.0
*01:01:01/*04:01	0	0	3.1	3.1	3.8
*04:01/*04:02	0	0	2.6	6.4	9.1
*03:01:01/*04:01	0	0	2.0	4.1	5.7
*04:01/*11:01:01	0	0	0.0	6.7	1.8
*03:01:01/*04:02	0	0	0.0	0.0	2.1
*01:01:01/*03:01:01	0	0	0.0	0.0	1.6
*04:01/*13:01	1	0	0.0	0.0	1.4
*03:01:01/*03:01:01	0	0	0.0	0.0	1.3

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Chronic beryllium disease (genetics)

HLA-DPB1 Genotype	Number of E69 Alleles	Number of -9 Charged Alleles	CBD % Prevalence	Total BeS % Prevalence	Percentage of Genotyped Population
*02:01:02/*17:01	2	1	72.7	72.7	1.3
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*02:01:02/*04:02	1	0	27.8	38.9	2.1

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Should we implement testing based on the NIOSH findings and warn the top few rows?

► G.I.N.A.

- Genetic Information Non-discrimination Act (2008)

► Would workers be motivated to stop Be employment?

- Do they leave when beryllium blood sensitized?

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Are workers currently advised to leave if sensitized to Be?

An Official American Thoracic Society Statement:

Diagnosis and Management of Beryllium Sensitivity and Chronic Beryllium Disease

John R. Balmes, Jerrold L. Abraham, Raed A. Dweik, Elizabeth Fireman, Andrew P. Fontenot, Lisa A. Maier,

Joachim Muller-Quernheim, Gaston Ostiguy, Lewis D. Pepper, Cesare Saltini, Christine R. Schuler, Tim K. Takaro,

and Paul F. Wambach; on behalf of the ATS Ad Hoc Committee on Beryllium Sensitivity and Chronic Beryllium Disease, June 2014

“Based on the limited evidence about determinants of progression, **it seems prudent for workers with BeS to avoid all future occupational exposures to beryllium**, even though wage and job loss can occur when a worker with BeS is medically precluded from further exposure to beryllium.”

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Would this data be persuasive?

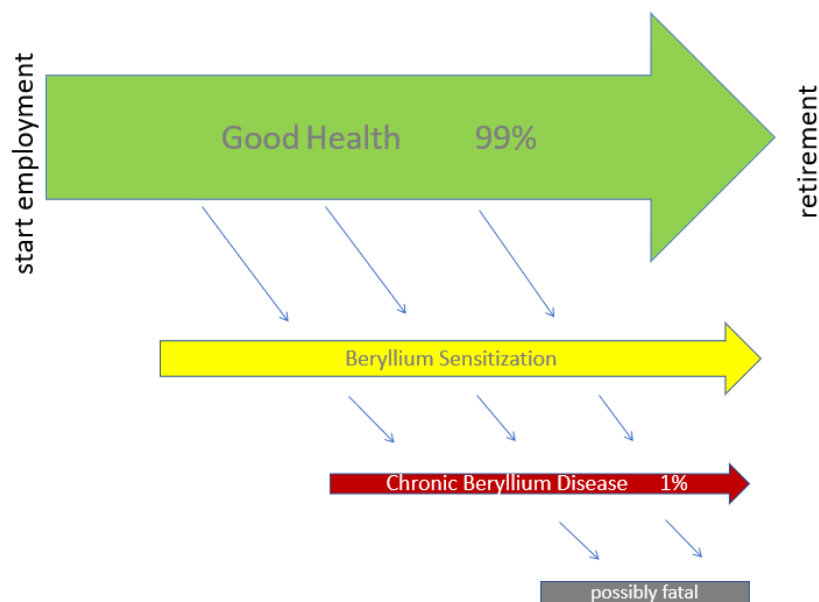
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*01:01:01/*02:01:02	1	0	10.0	10.0	1.2
*04:01/*04:01	0	0	3.1	5.5	15.0
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24

Is this relevant in the respirator era?

Recent NIOSH research improves the predictive value of genetic screening by considering chain locations in addition to glu69 that affect electronegativity

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*04:01/*13:01	1	0	0.0	0.0	1.4
*03:01:01/*03:01:01	0	0	0.0	0.0	1.3

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Hypothesis?

- Possibly, the less exposed modern (post 2001 in respirators) BeS/CBD cases are just highly genetically susceptible
- If yes, genetic testing may become more practical?
 - All cases might be precisely polarized to the top few rows of the NIOSH table?

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Is this relevant in the respirator era?

Recent NIOSH research improves the predictive value of genetic screening by considering chain locations in addition to glu69 that affect electronegativity

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*04:01/*13:01	1	0	0.0	0.0	1.4
*03:01:01/*03:01:01	0	0	0.0	0.0	1.3

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Study design

- ▶ Genetically test the **modern** era (in respirator) BeS/CBD cases
- ▶ Are they more polarized to the top row?
- ▶ Then, determine how well a genetic surveillance program would have prevented cases.

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Materion – Michigan State University Genetics Study

- ▶ Tested DNA of 41 BeS and 15 CBD modern Materion workers
- ▶ Then, simulated utility for these, had we tested and applied NIOSH study knowledge

<i>HLA-DPB1</i> Genotype	Number of E69 Alleles	Number of -9 Charged Alleles	CBD % Prevalence	Total BeS % Prevalence	Percentage of Genotyped Population
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Materion – Michigan State University Genetics Study

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- ▶ Applying the *first* NIOSH row alone,
 - ▶ zero BeS and zero CBD cases
- ▶ Applying the *second* NIOSH row alone,
 - ▶ 1 BeS and zero CBD
- ▶ Applying the *third* NIOSH row alone,
 - ▶ 2 BeS and zero CBD
- ▶ Applying the *fourth* NIOSH row alone,
 - ▶ 5 BeS and 1 CBD

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Therefore, what would have been the utility of implementing a genetics program based on the NIOSH table empirically?

- ▶ Consider testing and alerting the top 4 rows
 - ▶ estimate these represent 7.7% of the tested population
- ▶ If had tested all new hires since 2001
 - ▶ estimate a tested population of 2,200 workers
- ▶ Testing cost
 - ▶ $2,200 \times \$800 = \$1,760,000$

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Therefore, what would have been the utility of implementing a genetics program based on the NIOSH table **empirically**?

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- ▶ consider testing and alerting the top 4 rows
 - ▶ 169 new hires would have been alerted
- ▶ Ifall 169 left,
 - ▶ potentially **saved 1 CBD case (out of 15) and 8 BeS cases (out of 41)**
- ▶ at a **cost of \$1,760,000** and 160 left unnecessarily

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DISCUSSION of GENETIC TESTING (empirically)

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Empirical vs mechanistic approach



What about: Calgary? Regina? Windsor?
Lethbridge? Quebec City? London?
Cobourg? Kingston?.....

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RECALL:

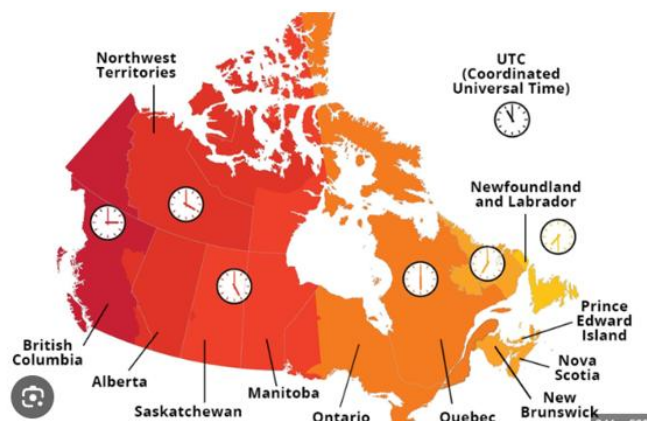
The NIOSH table only showed 2/3rds of the people tested.

1/3 unreliable data

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Empirical vs mechanistic approach



Mechanistic knowledge allows broader categorization

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Now, what would have been the utility of implementing a genetics program based on the NIOSH table **mechanistically**?

HLA-DPB1 Genotype	Number of E69 Alleles	Number of -9 Charged Alleles	CBD % Prevalence	Total BeS % Prevalence	Percentage of Genotyped Population
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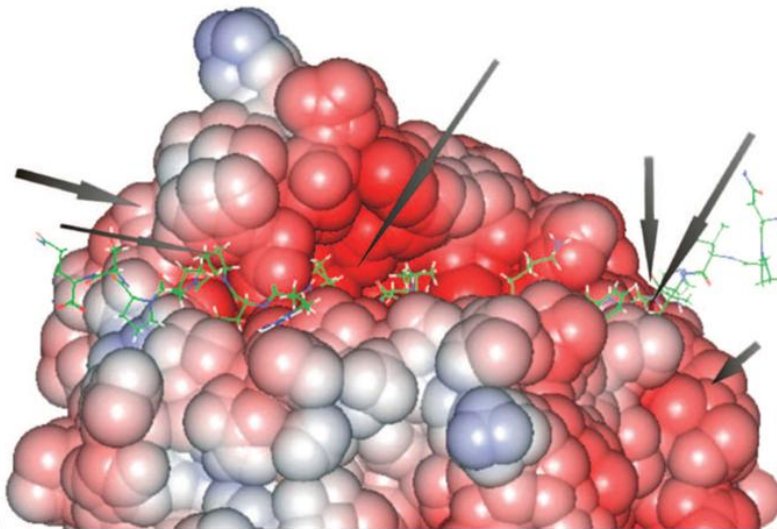
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HLA-DPB1 (antigen detector)



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Now, what would have been the utility of implementing a genetics program based on the NIOSH table **mechanistically**?

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- ▶ Consider testing and alerting all -9 genotypes on a mechanistic assumption
 - ▶ even the ones not shown in the NIOSH table
 - ▶ unknown exact population, but at least 68 new hires would have been alerted
- ▶ **If**all 68+ left,
 - ▶ potentially **saved 5 CBD cases (out of 15) and 11 BeS (out of 41)**
- ▶ at a **cost of \$1,760,000** and 52+ left unnecessarily

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DISCUSSION of GENETIC TESTING (mechanistically)

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ONGOING GENETICS RESEARCH?

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Materion – Michigan State University Genetics Study

- ▶ additional scientific understanding would make testing more practical
- ▶ are there any other DNA markers we can investigate?

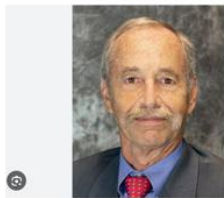
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Materion – Michigan State University Genetics Study

exciting finding.....

- ▶ a new DNA marker affecting *expression* (*promotion or suppression*) that is predictive in progression from BeS to CBD (Dr. Monos at University of Pennsylvania)



Professor
Rosenman, MD

Occupational and Environmental Medicine | MSU



Professor
Monos, PhD

CHOP Research Institut...
Dimitrios S. Monos | C...



Sarcoidosis in Beryllium Exposed Workers: A Case-Case Study
L. BARKER (National Jewish Health, Colorado, USA)

Sarcoidosis in Beryllium Exposed Workers: A Case-Case Study

Lisa BARKER

National Jewish Health, Denver, Colorado, USA

Despite the utility of the beryllium lymphocyte proliferation test (BeLPT), distinguishing sarcoidosis, a disease of unknown etiology, from chronic beryllium disease (CBD) has long posed a diagnostic challenge. It is unclear if beryllium-exposed sarcoidosis cases (Be-exp-Sarc) are clinically distinct from CBD, or are misdiagnosed cases of CBD.

We performed a case-case study of 40 beryllium-exposed individuals diagnosed with Be-exp-Sarc compared to 40 frequency-matched CBD cases. We compared demographics, exposure, clinical, physical, and radiographic characteristics and HLA-DBPI E69 genotype.

CBD was defined based on confirmed BeS, as demonstrated by 2 or more abnormal peripheral BeLPTs, 1 abnormal plus at least 1 borderline BeLPT, or an abnormal bronchoalveolar lavage (BAL) BeLPT plus biopsy evidence of granulomatous inflammation or an abnormal BAL BeLPT and lymphocytosis ($\geq 15\%$ lymphocytes).

Be-exp-Sarc was defined based on a compatible clinical picture, biopsy-confirmed granulomatous inflammation and exclusion of other potential granuloma-inducing diseases or demonstration of Lofgren's syndrome with negative blood and/or BAL BeLPT results, negative AFB and fungal stains and cultures obtained at the time of bronchoscopy, and no alternative granulomatous lung disease, such as hypersensitivity pneumonitis, was diagnosed in our occupational and environmental lung disease specialty clinic.

Results of this case-case study are presented and conclusions drawn where possible.

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Sarcoidosis in Beryllium Exposed Workers: A case-case study

Lisa Barker, PMP, MPH

March 25, 2025

BHSC 2025 Spring Meeting, CAMECO Fuel Mfg., Cobourg, Ontario



BACKGROUND

Despite the utility of the beryllium lymphocyte proliferation test (BeLPT), distinguishing sarcoidosis, a disease of unknown etiology, from chronic beryllium disease (CBD) has long posed a diagnostic challenge. It is unclear if beryllium-exposed sarcoidosis cases (Be-exp-Sarc) are clinically distinct from CBD, or are misdiagnosed cases of CBD.



RATES OF DISEASE

CBD

- Risk of beryllium sensitization (BeS) and CBD are increased in genetically predisposed workers exposed to beryllium
- Within exposed workforces, the observed prevalence of BeS and CBD has ranged from < 1 to 16%.
- Percentage of workers with CBD among those with BeS increases with higher beryllium exposure.

3



RATES OF DISEASE

Sarcoidosis

- The estimated prevalence of sarcoidosis in the United States is at least 48 per 100,000.⁸
- Increased risk of sarcoidosis observed in different occupational & environmental exposures, including metal exposure and military
- WTC responders are at increased risk with 6-year incidence after 911 of 192 per 100,000 WTC responders, greater risk in black responders

4



WHAT'S THE SAME

- CBD and sarcoidosis are histopathologically indistinguishable
- Both are characterized by major histocompatibility complex (MHC) class II restricted antigen presentation
 - CBD (HLA)-DPB1 Glu 69 (E69) *also BeS
 - Sarcoidosis HLA-DRB1
- CBD and sarcoidosis share similar differential expression of pathogenic genes and pathways

5



WHAT'S DIFFERENT

- Organs involved, extrapulmonary involvement common in sarcoidosis
- BeLPT response, both blood and lavage
- Seedahmed et al, Found <1% of veterans with sarcoidosis have ever received a BeLPT

6



RESEARCH QUESTION

Hypothesized that Be-exp-Sarc differs from CBD based on clinical and exposure characteristics, as well as by HLA-DPB1 E69 carriage.

7



Methods

We performed a case-case study of 40 beryllium-exposed individuals diagnosed with Be-exp-Sarc compared to 40 frequency-matched CBD cases. We compared demographics, exposure, clinical, physical, and radiographic characteristics and HLA DBPI E69 genotype.

8



Case Definitions:

CBD was defined based on confirmed BeS, as demonstrated by 2 or more abnormal peripheral BeLPTs, 1 abnormal plus at least 1 borderline BeLPT, or an abnormal bronchoalveolar lavage (BAL) BeLPT plus biopsy evidence of granulomatous inflammation or an abnormal BAL BeLPT and lymphocytosis ($\geq 15\%$ lymphocytes).

Be-exp-Sarc was defined based on a compatible clinical picture, biopsy-confirmed granulomatous inflammation and exclusion of other potential granuloma-inducing diseases or demonstration of Lofgren's syndrome with negative blood and/or BAL BeLPT results, negative AFB and fungal stains and cultures obtained at the time of bronchoscopy, and no alternative granulomatous lung disease, such as hypersensitivity pneumonitis, was diagnosed in our occupational and environmental lung disease specialty clinic.

9



DATA COMPARED

- Clinical Data from diagnostic evaluation
- Exposure Data –work hx, exposure estimates
- HLA-DPB1 Genotyping
- JMP15
- Categorical outcomes – chi square analysis
- Continuous variables – Students T (para) Wilcoxon rank sum (non)

10



RESULTS

Demographics

Characteristic	Be-exp-Sarc	CBD	p-value
Age (mean years)	47	52	0.03
Race: NH/H/AA* (%)	85%/10%/3%	85%/15%/0%	0.37
Gender (% male)	88%	90%	0.72
Smoker: N/F/C** (%)	70%/20%/10%	58%/37%/5%	0.19
Beryllium exposure (years)	12.7 (1-42)	17.5 (1-37)	0.06
Cumulative Be exposure	1.36 (0.03-12.5)	2.10 (0.01-20.0)	0.36

* NH/H/AA: NonHispanic White/Hispanic/African American

** N/F/C: Never smoker/Former smoker/Current smoker

11



RESULTS

Parameter	Be-exp-Sarc	CBD	p-value
DIAGNOSTIC FINDINGS			
Granulomas on biopsy	94.9%	83%	0.01
BAL BeLPT peak SI (SD)	1.5 (1.02)	25.7 (58.1)	0.02
BAL Lymphocytes (%) (range)	18% (1-68%)	28% (21-80%)	0.02
PHYSIOLOGY			
Total Lung Capacity (%pred)	100%	106%	0.025
FEV1 (% pred)	84%	88%	0.22
FEV1/FVC ratio	78%	76%	0.25
DLCO (%pred)	80%	88%	0.04
VO2 max (L/min)	1.81	2.06	0.027
A-a gradient at max exercise	19	18	0.67
RADIOGRAPHIC IMAGING			
Parenchymal abnormalities	77%	24%	<0.001
Mediastinal adenopathy	70%	21%	<0.001
Scadding-like Stage 0	7%	67%	<0.001
Scadding-like Stage 1	17%	10%	0.48
Scadding-like Stage 2	50%	8%	<0.001
Scadding-like Stage 3	20%	11%	0.29
Scadding-like Stage 4	7%	3%	0.44

Clinical Characteristics

12

RESULTS

HLA-DPBI E69 Carriage in Be-exp-Sarc and CBD

E69 Carriage	Be-exp-Sarc	CBD	p-value
E69 negative	47.0% (16)	7.7% (n=3)	<0.001
E69 heterozygous	50.0% (17)	66.7% (n=27)	0.15
E69 homozygous	3.0% (n=1)	25.6% (n=10)	0.004
Any E69 Non*02 allele	23.5% (n=8)	53.8% (n=21)	0.008
E69 Non*02 allele heterozygous	23.5% (n=8)	48.7% (n=19)	0.02
E69 Non*02 allele homozygous	0	5.1% (n=2)	0.18

13

CONCLUSIONS

The only absolute distinguishing features:

- Lack of confirmed beryllium sensitization in Be-exp-Sarc
- Lack of extra-thoracic manifestations in CBD

These findings suggest that Be-exp-Sarc may be distinct from CBD, and beryllium or some other workplace exposure may possibly play an as yet to be defined etiologic role

14

Requirements, Challenges & Decisions regarding Safe D&D of “Beryllium Facilities”
B. WALKER (Safer Environment Ltd., England, UK) et al.

Requirements, Challenges, and Decisions regarding Safe D&D of “Beryllium Facilities”

Beth WALKER¹ and Vern HOLDEN²

¹*Safer Environment Ltd., Bristol, England, UK*

²*UCOR LLC, Oak Ridge, Tennessee, USA*

There are complex requirements and challenges involving the safe decontamination, decommissioning, and demolition (D&D) of beryllium facilities, as they are also commonly contaminated with plutonium, uranium, and a wide array of toxic industrial chemicals and substances including asbestos, lead, mercury and others.

Because, across the globe, many facilities are only just coming to the end of their life cycle, decisions are made to either decontaminate facilities to their pre-beryllium status for safe occupation or to demolish these facilities in accordance with safe and healthy work practices. The D&D of beryllium facilities is not widely published and only a few organizations have experience with these activities, although as more facilities come to the end of their working life and more beryllium facilities are built and will eventually need decommissioning, this experience is valuable to those who may need to decommission in the future.

This presentation discusses the lack of a recognized definition as to what constitutes a “Beryllium Facility” globally with most countries requiring a risk assessment to establish the level of potential exposure to beryllium for the worker, the public, or the environment. A beryllium facility can be an industrial building where beryllium-containing materials are processed, used, or handled in a manner that may expose people to beryllium but can also be an outdoor range in which high-energy operations such as detonations are planned and executed.

In all cases, there are important decisions for the safe D&D of these beryllium facilities with respect to the worker, the public, and the environment. Finally, the authors share best practices and lessons learned regarding D&D of beryllium facilities based on work experiences and information obtained from a literature review of published studies.

Corresponding Author:

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Health, Safety, and Environment Consultant

Safer Environment Limited

EMAIL: saferenvironmentltd@gmail.com

Organization URL: www.saferenvironmentltd.com

Requirements, Challenges, and Decisions regarding safe D&D of ‘Beryllium Facilities’

Beth Walker¹ and Vern Holden²

Presented March 25, 2025

Beryllium Health & Safety Committee (BHSC) 2025 Spring Meeting

¹Safer Environment Ltd., Bristol, England, U.K., ²UCOR LLC, Oak Ridge, TN, USA

Background

Many facilities across the globe are only just coming to the end of their life cycle;

Decisions made to either decontaminate facilities to their pre-beryllium status for safe occupation or to demolish these facilities in accordance with safe and healthy work practices;

The D&D of beryllium facilities is not widely published and relatively few organisations have experience with these activities;

As more facilities come to the end of their working life and more beryllium facilities are built and will eventually need decommissioning, D&D Best Practices and Lessons Learned are valuable.

2



Definitions of the 'D's

Deactivate – process of placing a facility in a low-risk state with minimum surveillance and maintenance requirements.

Decommissioning – process of officially taking a facility or equipment out of use.

Demolition - process of tearing down existing structures to make way for new construction or to remove hazardous or obsolete buildings.

Decontamination – process of removing dangerous substances from something.

Using an excavator with a hydraulic claw as workers spray water to control dust ([Deactivation & Decommissioning \(D&D\) | Department of Energy](#))

3

D&D Link: [Deactivation & Decommissioning \(D&D\) | Department of Energy](#)

What is a Beryllium Facility?



BEST PRACTICE: Hanford provides lists of current and past Beryllium Controlled Facilities (BCFs)
[Source - [Projects & Facilities - Hanford Site](#)]

Sutton, M., Bibby, R.K., Eppich, G.R., Lee, S., Lindvall, R.E., Wilson, K., Esser, B.K. (2012). Evaluation of historical Beryllium abundance in soils, airborne particulates and facilities at Lawrence Livermore National Laboratory. *Science of the Total Environment*, 437, 373-383.

Sutton et al. (2012) compared beryllium contamination of facilities at Lawrence Livermore National Laboratory that machined, handled and stored beryllium since the 1950s to facilities involving outdoor testing of beryllium-containing components performed at LLNL's Site 300 facility.

LAWRENCE LIVERMORE NATIONAL LAB SITE 300
(SOURCE - [Site 300 | The Center for Land Use Interpretation](#))



4

Hanford Link: [Projects & Facilities - Hanford Site](#)

LLNL Link: [Site 300 | The Center for Land Use Interpretation](#)

D&D Health and Safety Concerns



Demolition is a hazardous activity and comes with many physical safety hazards as well as health hazards.

Some of these include:

- Hazardous dust
- Hazardous leachate
- Unstable infrastructure and associated risks
- Hazardous waste
- Heavy plant

The list goes on.....

And that is before we even look at beryllium risk.

5

D&D Health and Safety Concerns

Published study on workers at a DOE nuclear weapons facility during the process of decontamination and decommissioning:

- Population of 2,221 workers;
- 19 workers (0.8%) were beryllium sensitized based on two or more abnormal beryllium lymphocyte proliferation tests; and
- 2 workers were diagnosed with chronic beryllium disease.

Source

Sackett, H.M., Maier, L.A., Silveira, L., Mroz, M.M., Ogden, L.G., Murphy, J.R., Newman, L.S. (2004). Beryllium medical surveillance at a former nuclear weapons facility during cleanup operations. *Journal of occupational and environmental medicine*, 46(9), 953-61.

6

Beryllium + Other Hazards

Beryllium facilities commonly contaminated with other hazardous agents including:

- Radiological: plutonium, uranium, and others.
- Industrial: asbestos, lead, mercury, silica, and others.
- D&d hierarchy of controls tailored to individual and collective hazards.



7

D&D Requirements

- Each project will be different and will require a full assessment of risk prior to undertaking any works.
- The aim must be to remediate to pre-operation conditions.
- Techniques employed should be decided based on the risk level, the intended use of the facility in the future and the surrounding environment.
- In a perfect world, to remove all beryllium risk, the building would be demolished, but in reality, other methods may need to be used .
- Any residual risk must be communicated to any future building occupier.

8



Decontaminate versus Decommission

Decontamination:

- Less intrusive works required.
- May need soil and water sampling and information passed to next user
- Potentially areas will be omitted, such as roof voids and duct work/pipe work.

Beryllium manufacturing facility in UK and beryllium fabricator facility in California employed this method.

Decommission:

- This will be much more intrusive and usually include a full strip or demolition.
- May need soil and water sampling and remediation
- Less concern for future risk.

Beryllium contaminated legacy test reactor in oak ridge employed this method

9



What about Outdoor “Facilities”?

Decontamination:

- Characterize native soils prior to operations (*i.e.*, Background).
- Excavate contaminated soils to pre-ops background levels.
- Decontaminate any structures.

Decommission:

- Containments/barriers/postings and PPE as appropriate.
- Loss of operational area.

10



Beryllium D&D Best Practices What to Consider pre-start

- Understand the final use for the facility.
- Look at similar projects where possible.
- Take baseline samples including prevalent air samples.
- Decontaminate and remove items that can be safely cleaned.
- Segregate areas by level of suspected contamination and decontamination accordingly.
- Consider the need for negative pressure during the clean

11

Beryllium D&D Best Practices

What to Consider pre-start

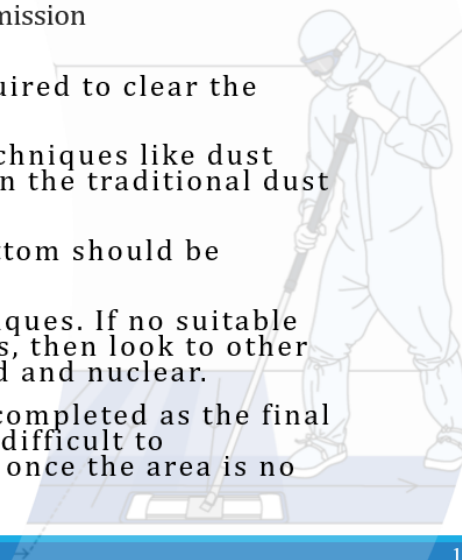
- Identify correct PPE and RPE requirements.
- Establish decontamination areas and robust cleaning practices.
- Consider decontamination of personnel.
- Consider power requirements
- Be prepared to clean the building ventilation system.
- Each decommission project used hepa filter vacuums in some capacity.
- Dust suppression is very important to ensure the applicable beryllium limits are not exceeded.

12

Beryllium D&D Best Practices

What to Consider for the decontamination/decommission

- If demolition, a decontamination is required to clear the facility.
- A controlled demolition is essential. Techniques like dust suppression and dismantling rather than the traditional dust raising demolition is required.
- If decontamination only, then top to bottom should be considered.
- Use established decontamination techniques. If no suitable techniques can be found in past projects, then look to other similar industries such as asbestos, lead and nuclear.
- Encapsulation of areas may need to be completed as the final step. This is to prevent areas that were difficult to decontaminate free releasing beryllium once the area is no longer occupied.

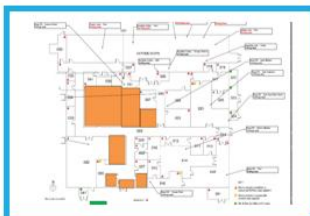


13

Beryllium D&D Best Practices

Use established methods such as:

- PPE
- Enclosures
- Negative pressure
- Signage
- Wipe and cleaning methods
- Sample regime
- Training



14

Beryllium D&D Lessons Learned

- The biggest lesson learnt from all case studies reviewed was to speak to stakeholders and establish:
 - Expectations- pre, during and post project
 - Methods available and best practices- look at case studies.
 - Ensure 'gateways' are in place to review the project, this can be captured by reviews, sampling and ground, soil water and air surveys
- Understand the project well and who the main stakeholders are.
- Be prepared for delays and setbacks, until beryllium remediation projects are commonplace, the project may come across unexpected events.
- Have a good contingency plan!
- Have a glass of wine ready for the last day!

15



A Practitioner's Guide to Beryllium Hazard Management **Chapter 12: Case Studies Involving Decontamination,** **Decommissioning, and Demolition of Beryllium Facilities**

New Chapter in *"A Practitioner's Guide to Beryllium Hazard Management"*

Sneak preview of this chapter with anticipated publishing date in 2025

16

MiRESSO for the Stable Supply of Beryllium for Fusion Applications

T. IMAI (MiRESSO Co. Ltd., Aomori, Japan)

MiRESSO for the Stable Supply of Beryllium for Fusion Applications

Tomoaki IMAI and Masaru NAKAMICHI

MiRESSO Co. Ltd., Misawa, Aomori, JAPAN

To create fusion energy by D-T reaction, large quantities of beryllium are essential. Tritium, as fuel, is self-produced in the blanket covering the plasma during operation. Beryllium is needed for the blanket as it multiplies neutrons and produces more Tritium. Fusion reactors require between 350 and 500 metric tons of beryllium, depending on the blanket design. This represents a significant quantity for the beryllium market, as the current total global production is only approximately 300 metric tons per year, most of which goes into copper-alloy production.

Therefore, to secure a stable supply of beryllium for fusion applications, we established MiRESSO Co. Ltd. based on a new beryllium refining technology. In traditional processes of beryllium dissolution from beryl, high-temperature treatment at 2000°C is required. Beryl ore, which is often collected as a byproduct of mining gemstones such as emerald and aquamarine, is extremely stable from the viewpoint of thermal and chemical properties. In conventional processes for beryllium dissolution, fritting by melting and quenching, as well as sulfation roasting, all of which are high-cost processes, are necessary.

Alternatively, MiRESSO offers a novel process with the promise of significant cost reduction. MiRESSO has established a low-energy dissolution at a temperature of 300°C. This process is a combination of a base fusion method for dissolution of insoluble substances and microwave heating.

MiRESSO will produce and sell beryllium and its compounds, which are required for fusion reactors as neutron multiplier, armor, windows, functional alloys, etc. For early realization of commercially viable fusion energy, MiRESSO will develop and offer a stable source of supply for all beryllium products to meet the requirements from customers in a variety of end-use markets.

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MiRESSO Co. Ltd.

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URL: <https://miresso.co.jp/en/>



MiRESSO

MiRESSO for the Stable Supply of Beryllium for Fusion Applications

T. IMAI and M. NAKAMICHI

BHSC 2025 Spring Meeting
Cobourg, Ontario, Canada

25 March 2025

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BHSC 2025
Spring Meeting
Beryllium Health & Safety Committee
Cobourg, Ontario, Canada
25-26 March 2025



MiRESSO

Table of Contents

- 1. About MiRESSO**
2. Beryllium Market Situation
3. The value we can offer in the refining process
4. Safety Management
5. Our Business Plan
6. Funding & Contracts



2

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1. About MiRESSO



Company Profile

About MiRESSO

(Mineral Refining and Recycling System Society)



CEO	■ Masaru Nakamichi, Ph.D. (Previous job: Group Leader in the Breeding Functional Materials Development Group, QST)
Head Office	■ Misawa, Aomori, Japan
Start-up	■ May, 2023
Business Outline	■ Production and sales of Beryllium ■ Licensing & consultation for energy saving and CO₂ emission reduction of refining and recycling process with high temperatures

Contribution to social and economic security by stably securing mineral resources

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About QST

(National Institutes for Quantum Science and Technology)



Organization	■ One of eight organizations charged of Ministry of Education, Culture, Sports, Science and Technology (MEXT) in Japan ■ Through R&D related to quantum science and technology, QST create and provide new value and contribute to society to a sustainable future economically and ecologically.
Support from QST	■ MiRESSO is the 1st certified startup company by QST in the fusion energy. ■ MiRESSO can receive benefits from QST, such as patent licensing and facility rental. < Image of fusion reactor > 



Be 4
Beryllium

3

1. About MiRESSO



Meet the Team



President & CEO
Masaru Nakamichi
Former job: Group Leader, Breeding Functional Materials Development Group, QST.



**CSO (Chief Strategy Officer)
Head of Business Development**
Tomoaki Imai (Tom)
Former Job: Trading & Asset Management of Energy Commodities in ITOCHU Corporation.



4

1. About MiRESSO

MiRESSO

Fusion: Large Quantities of Beryllium are Essential

Fusion Reaction

Deuterium + Tritium → Helium + Neutron

Plasma

• : Proton

Neutron Multiplier (Be)

1 piece → 2 pieces

Increased to two

Tritium Breeder (Li)

Fuel Production

Helium + Tritium

Fusion Reactor

Blanket

Be

Li

- Tritium as fuel is self-produced in the blanket covering the plasma during operation.
- **Beryllium (Be)** is essential for the blanket, as it multiplies neutrons and produces more Tritium.
- **Fusion reactors require 350~500 tons** of Be, a huge quantity for Be market.

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5

1. About MiRESSO

MiRESSO

Our Target

Short-term	Mid-term	Long-term
■ Production and sales of Beryllium and its compounds (e.g. metal, alloy, hydroxide, oxide, other compounds) ■ Consultation and technology licensing for thermal utilization process with high temperatures	■ Stably securing and supplying mineral resources for early realization of fusion energy ■ Contribution to energy saving and CO₂ reduction for thermal utilization process with high temperatures	■ Contribution to carbon neutrality : ➢ Energy resources by implementation in society of fusion energy ➢ Thermal utilization process by environmental affinity technology

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6



Table of Contents

1. About MiRESSO
- 2. Beryllium Market Situation**
3. The value we can offer in the refining process
4. Safety Management
5. Our Business Plan
6. Funding & Contracts

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7

2. Beryllium Market Situation



Trends in the US & Global Beryllium Markets

Salient Statistics—United States:

	2020	2021	2022	2023	2024*
Production, mine shipments	165	175	175	185	180
Imports for consumption ¹	48	49	39	25	20
Exports ²	25	30	61	68	30
Shipments from Government stockpile ³	3	7	9	NA	NA
Consumption:					
Apparent ⁴	196	196	187	144	170
Reported, ore	170	170	170	180	180
Price, annual average unit value, beryllium-copper master alloy, ⁵ dollars per kilogram of contained beryllium	620	680	660	1,400	1,500

Source:
USGS Mineral
Commodity
Summaries 2025

■ US Geological Survey Report Observations

- Overall production trends are up over the last five years, so the Be market is clearly growing
- Price of Be contained in Cu-Be Master Alloy more than doubled from 2022 to 2023, so cost of beryllium seems to be going up just when lower prices would be expected

■ Main Challenges to Increasing Beryllium Production

- High-Temperature Refining: **High operating expense** for ore dissolution at 2,000°C
- Safety Management: **High capital expense** for safe handling of specific chemical substances

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8

Table of Contents

1. About MiRESSO
2. Beryllium Market Situation
- 3. The value we can offer in the refining process**
4. Safety Management
5. Our Business Plan
6. Funding & Contracts

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9

3. The value we can offer in the refining process

Conventional Processes Require High Treatment Temperatures



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10

3. The value we can offer in the refining process

MiRESSO has Established a Low-Energy Dissolution Method

Our innovative process

Beryllium ore (beryl)

Base + Microwave Heating (300°C • Normal Press.)

Acid dissolution (Room Temp. • Normal Press.)

Separating & Refining

Products (Be & compounds)

Cost Reduction!

Microwave Heating at 300°C

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11

3. The value we can offer in the refining process

Beryllium ore dissolution by our innovative process

綠柱石 ($\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$)

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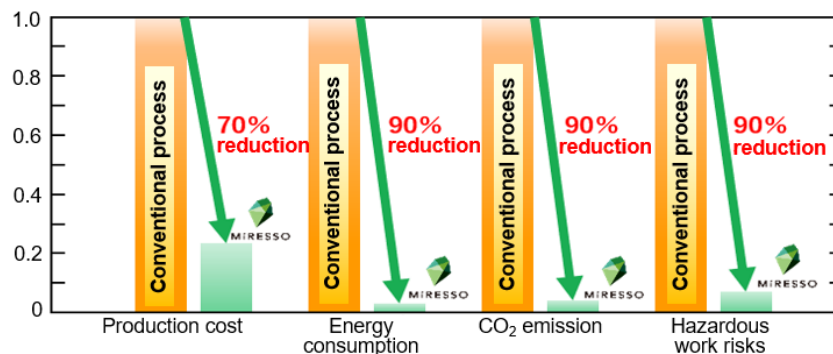
12

3. The value we can offer in the refining process

Achieving both cost reduction and environmental advantages compared to conventional process of Be ore (Beryl) dissolution.



Comparison of conventional Beryl dissolution process with our innovative process:
two-step heating at 2,000 and 250 °C → only one heating by microwave at 300 °C



"Our technology has a positive impact on society in terms of sustainability."

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13

Table of Contents



1. About MiRESSO
2. Beryllium Market Situation
3. The value we can offer in the refining process
- 4. Safety Management**
5. Our Business Plan
6. Funding & Contracts

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14

4. Safety Management



Safety management in Japan (1)

Legislation and the governing ministry

- The requirements to develop beryllium health and safety programs for Japan come from **the administrative government agency of the Ministry of Health, Labor and Welfare**.
- Beryllium and its alloys (> 3 wt.% Be) are defined as specified chemical substances. Beryllium safety handling is provided in detail in the ordinance on prevention of hazards due to specified chemical substances based on the **Industrial Safety and Health Act**.
- Business operators need a **manufacturing license issued by the Minister of Health, Labor and Welfare**.

Operation

- The Industrial Safety and Health Act stipulates that **business operators have to appoint an operations supervisor**, and this supervisor should instruct and guide the workers.
- In order to prevent health problems, it is important to ensure that three kinds of occupational health management such as "**working environment management**," "**work management**," and "**health management**" should be performed, as well as to educate workers.
- It is essential to **remove hazards in the workplace** and to **take measures of risk reduction** based on the results of these assessments.

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15

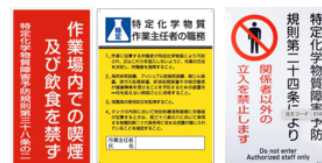
4. Safety Management



Safety management in Japan (2)

Beryllium area designations

- It is stipulated that **workplaces** of manufacturing and handling of beryllium **have to be isolated from other workplaces**.
- In the case of handling of beryllium with a powdery or particulate state, **protection equipment including ventilation system** should be installed.



Medical enrollment and surveillance

- Workers are required to undergo **a periodic health examination for beryllium twice a year**, and business operators are obligated to keep the results of the health examination for **30 years**.
- It is mandatory to include medical/work history, symptoms questionnaire, physical examination, skin symptoms, chest radiograph, pulmonary function test (VC: Vital Capacity), and others.

Airborne monitoring

- The administrative control level of beryllium is 0.001mg/m³. The business operators are required to carry out **the quantitative risk assessment** by comparison with these values such as 0.001mg/m³ as the administrative control level, 0.002mg/m³ as the TLVs recommended by the Japan Society for Occupational Health, and 0.00005mg/m³ as the TLVs recommended by the ACGIH.

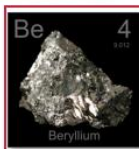
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16

4. Safety Management



Low-Temperature Processing Reduces Risk & Safety Costs



- Risk of severe functional impairment if dust enters the lungs
- Installation of enclosures or local exhaust ventilation systems is necessary

Conventional Refining Technology

- **Open System Process** by High-Temperature Treatment
- Safety Management of **High-Temperature Treatment**
- Safety Management for **Dust Protection**

MiRESSO's Refining Technology

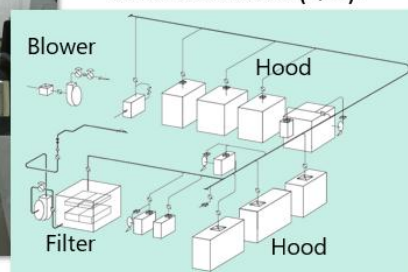
- **Closed System Process** by Low-Temperature Treatment
- **Risk Reduction in Safety** by Low-Temperature Treatment
- **Cost Reduction** with Dust Protection Measures at Low Temperatures

Safety management of beryllium



◀ Actual Safety Work Scene

▼ Ex. of Local Exhaust Equipment for Dust Protection (QST):



Achieving Low Risk and Low Cost with Low-Temperature Processing

17

Table of Contents



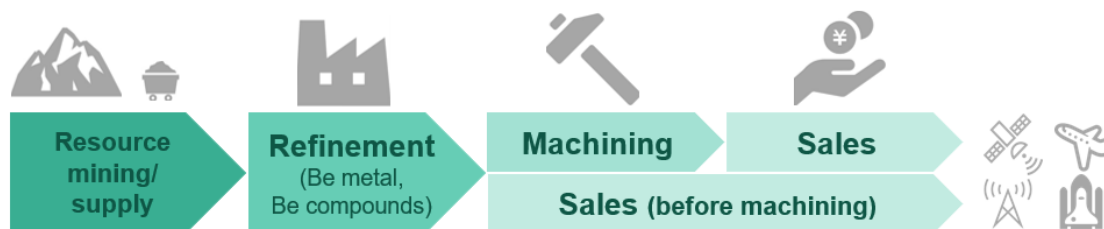
1. About MiRESSO
2. Beryllium Market Situation
3. The value we can offer in the refining process
4. Safety Management
- 5. Our Business Plan**
6. Funding & Contracts

18

5. Our Business Plan



Establishment of supply chain for Beryllium



- Resource : Procurement prospects of Be ore* from the pegmatite mine.
- Refining : Under construction of pilot plant targeting operation in 2027.
- Manufacturing : Establishment of original fabrication techniques for fusion.
- Sales : Development of customers in Japan and overseas.



*Beryl (Be) and spodumene (Li) deposits are one of pegmatite (cooled magma).

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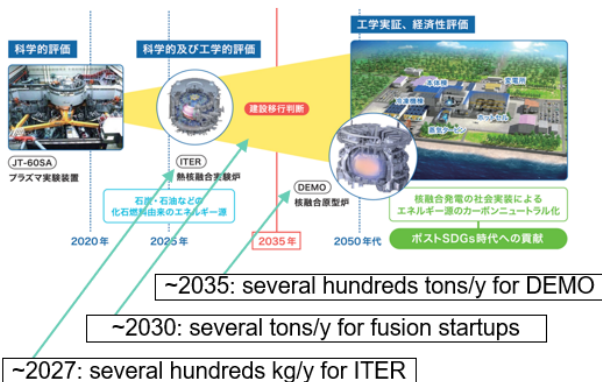
19

4. Our Business Plan

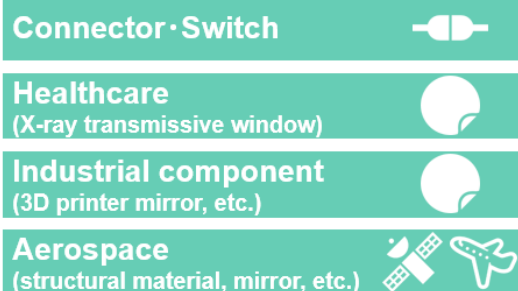


Sales to existing Be market before supplying for fusion.

Timeline of Fusion Energy



Be related products · Expected sales destination



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20

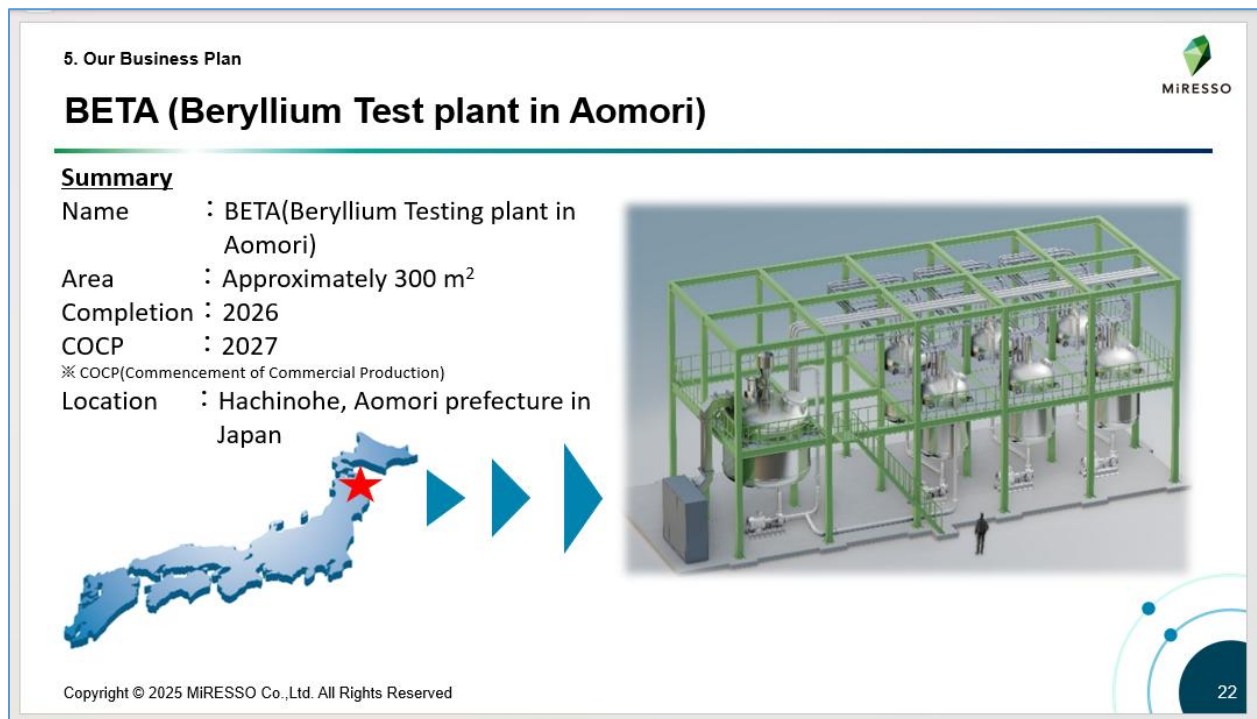
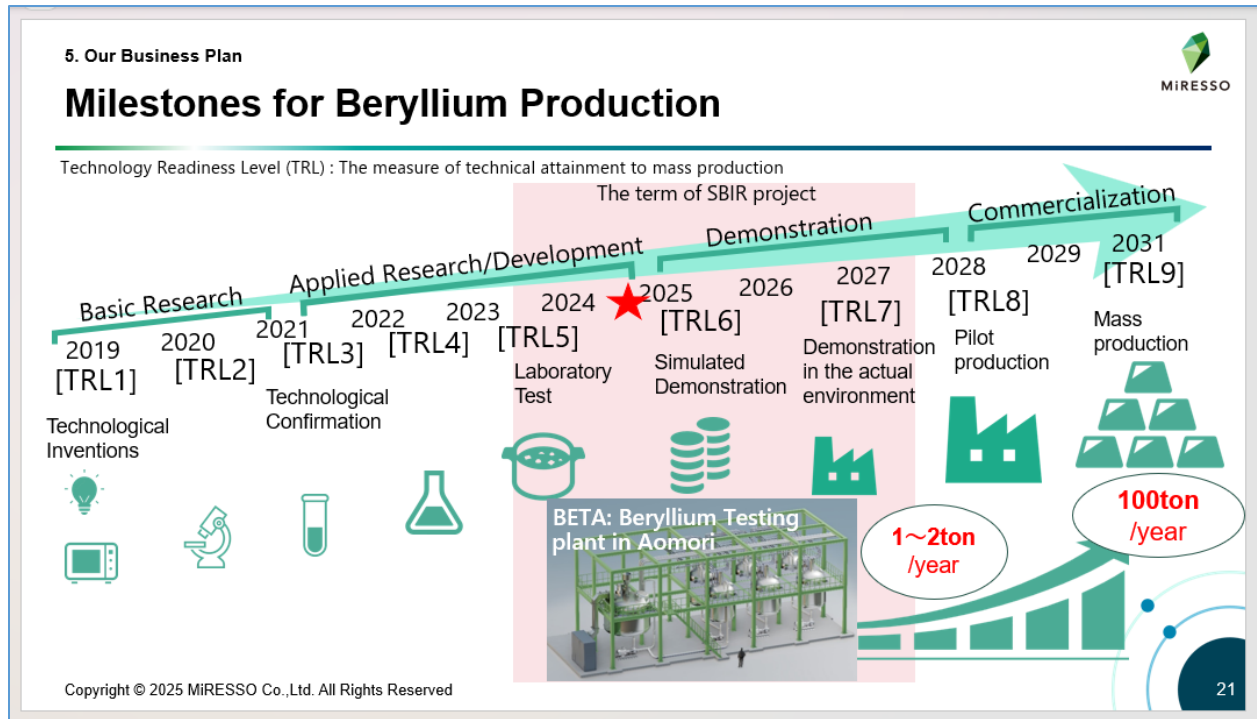




Table of Contents

1. About MiRESSO
2. Beryllium Market Situation
3. The value we can offer in the refining process
4. Safety Management
5. Our Business Plan
- 6. Funding & Contracts**

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23

6. Funding & Contracts



Funding

**1st Round : Univ. Tokyo
Innovation Platform Co., Ltd.**



1stRound

- Selected as a support recipient for the 9th "1stRound" which is one of Japan's largest incubation programs spanning fourteen leading universities.
- Receiving up to approx. **USD 70k** (10 million yen) in non-equity funding without limits on how the funds are used.
- Support for development tools and facilities such as cloud resources and offices.

SBIR in MEXT Japan
(Small Business Innovation Research)



Ministry of Education, Culture, Sports, Science
and Technology (MEXT)

SBIR Project (Phase 3)

Fusion Energy Field

(Business theme: Verification of Fusion technologies forward to
Fusion Demonstration Reactor (DEMO), etc.)

- Selected for approx. **USD 13mil** (2 billion yen) subsidy with the business theme "Verification of low-temperature refining technology for stably securing beryllium resources for fusion reactors".

We have raised approx. **USD 1.7mil** (0.25 billion yen)
from Japanese companies in March 2024.



三井住友海上キャピタル

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24

6. Funding & Contracts



Comprehensive Business Alliance Agreement with PAMCO

- ✓ MiRESSO and PAMCO (Pacific Metals Co., Ltd) signed a Comprehensive Business Alliance Agreement on 25th October 2024.



- ✓ What is PAMCO?

Overview of the Company	
Name	Pacific Metals Co., Ltd.
Established	December 1. 1949
Annual Sales	34,095 million yen (FY2022)
No. of employees	422 (FY 2022)
Capital	13,900 million yen (FY2019)
Business Item	Ferronickel Ferronickel Slag
Note	Listed on the Tokyo Prime Market



(Pictured on left: Masayuki Aoyama, President and Representative Director, PACIFIC METALS;
Right: Masaru Nakamichi, Chairman and CEO, MiRESSO)

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25



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Mineral Refining and Recycling System Society

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26

FLiBe Handling and Procedures carried out at MIT for Nuclear Applications

K.B. WOLLER (Massachusetts Institute of Technology, Massachusetts, USA)

FLiBe Handling and Procedures carried out at MIT for Nuclear Applications

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Jim DOUGHTY², Nikola GOLES¹, Yina HUANG³, Andy KAHLIL²,
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²*Environment, Health, and Safety Office, MIT, Cambridge, Massachusetts, USA*

³*Nuclear Reactor Lab, MIT, Cambridge, Massachusetts, USA*

FLiBe is under study at MIT for both fission and fusion energy applications. There were several experiments in the past carried out at the MIT Nuclear Reactor Lab of irradiating small volumes of salt with the MIT Reactor. Additional experiments on salt irradiation in a fusion neutron energy spectrum are also being planned, and at larger scale. Additional experiments with FLiBe are being conducted to better understand the composition, compatibility, and hydrogen transport properties to inform further development of FLiBe components and systems for fusion energy.

The scale of experiments and measurements ranges from tens of mg for static corrosion testing to 1000kg for irradiation testing. The large mass range requires a varied approach for practices when planning and carrying out these experiments. Tests at low mass (<5kg) so far have been carried out in gloveboxes and fume hoods dedicated to FLiBe, but the current spaces are insufficient for the experiments planned for volumes greater than 5kg. To support the setup and execution of these larger scale experiments, MIT is constructing a roughly 700-square-foot lab space to consolidate FLiBe experiments and facilitate the handling of industry quantities of FLiBe for forced flow loop experiments and fusion blanket component testing.

This presentation will provide an update on the lab progress along with various notes of experience from procedures carried out with FLiBe for experiments including general lab and personnel surveillance and safety.

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URL: www.psfc.mit.edu

FLiBe handling and fusion research at MIT PSFC

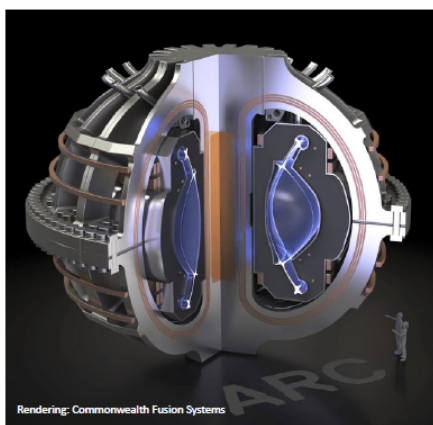
Kevin B. Woller, kbwoller@mit.edu

March 25, 2025

On behalf of the FLiBe researchers and Environment, Health, and Safety Office at MIT



FLiBe for tritium breeding blankets



- Maximize solid angle coverage of fusion core to optimize tritium breeding and radiation shielding
- Molten salt interaction with magnetic fields lower compared to liquid metals
- Liquid breeder pump out for maintenance cycles
- Online chemistry control to address corrosion and tritium speciation (T_2 , HT over TF)
- Tritium has low solubility in molten salts, easing extraction
- Take advantage of good thermal physical properties for high power density concepts, efficient thermal cycle

The Liquid Immersion Blanket (LIB) concept addresses the market drive for faster, smaller, more efficient fusion energy



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2

Current areas of FLiBe research at the PSFC

1. Tritium breeding testing
 - a. Ventilation safety, broader Be work plan development
2. Static Corrosion
 - a. Salt dispensing and containment
3. Compositional Analysis development
 - a. Sampling and Extraction from Glovebox, digestion development
4. Hydrogenic transport property measurement
 - a. Vapor migration consideration and release safety

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Current areas of FLiBe research at the PSFC

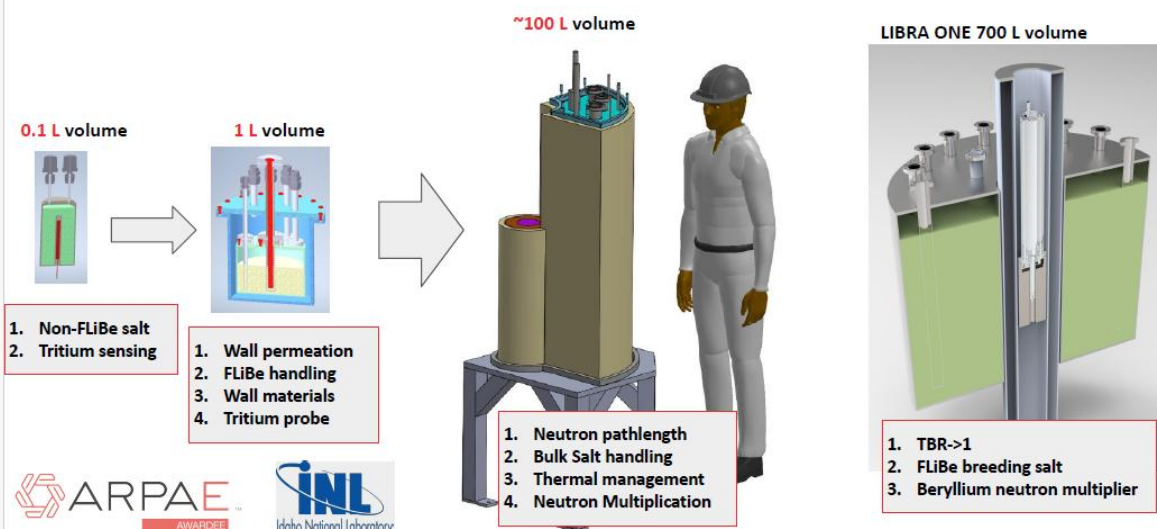
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4

Progression to Full-scale LIB tech: Build A Better Yield (BABY), LIBRA Pi, LIBRA ONE

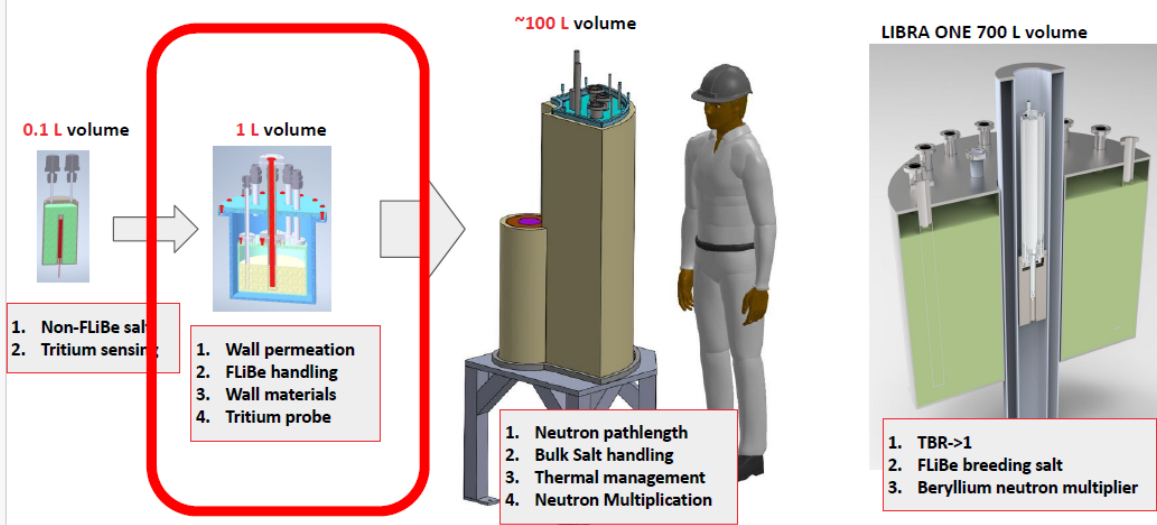


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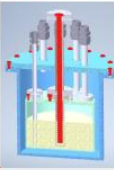


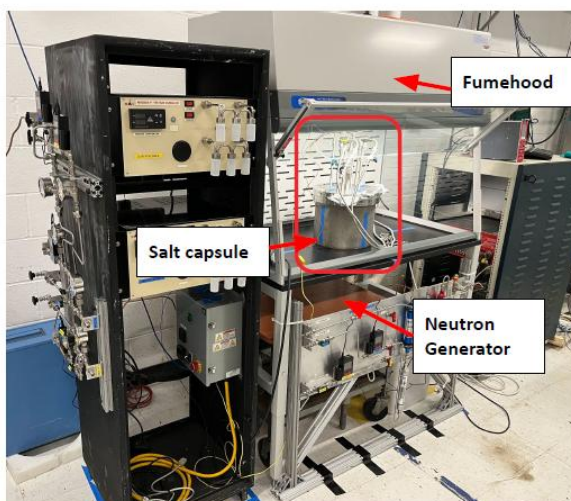
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6

Tritium breeding experiments under development for FLiBe

- 1 L volume
- 
1. Initial tests with surrogate salt, CLiF, indicate the enclosure is too restrictive
 2. Moving towards walk-in fumehood for FLiBe testing



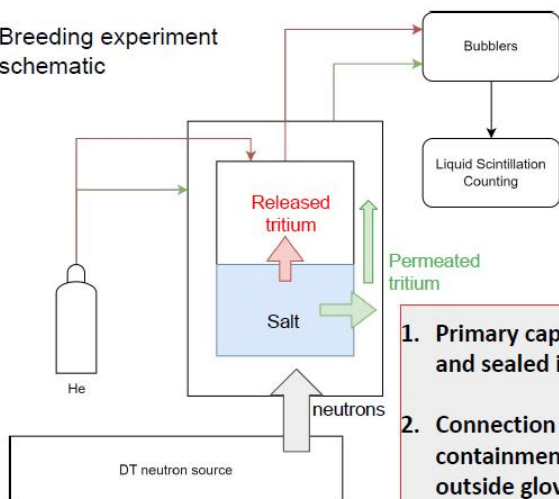
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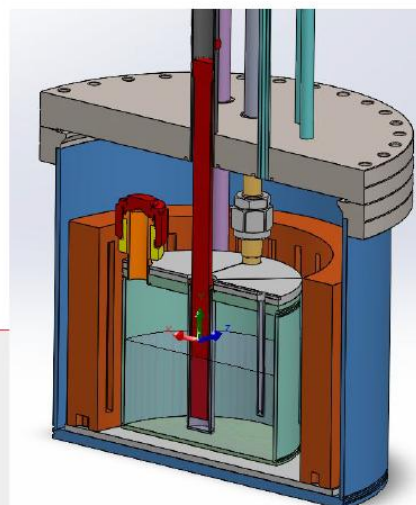
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Surrogate salt experiments inform planning for FLiBe test

Breeding experiment schematic



1. Primary capsule is filled and sealed in glovebox
2. Connection to secondary containment lid performed outside glovebox



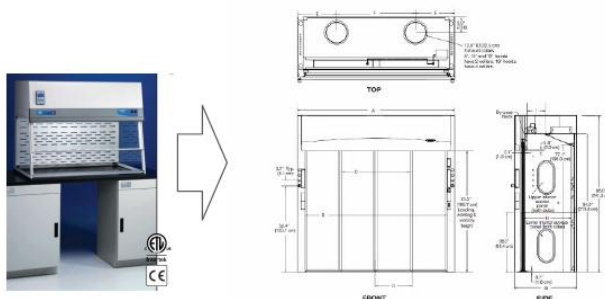
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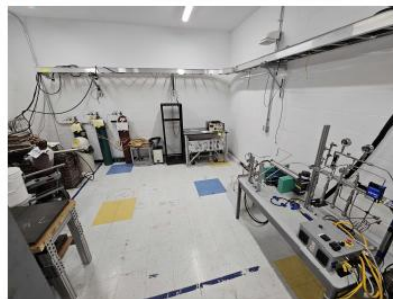
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Surrogate salt experiments inform planning for FLiBe test

Table Top ductless to ducted walk-in fumehood



Radiation Vault penetrations for supply and exhaust



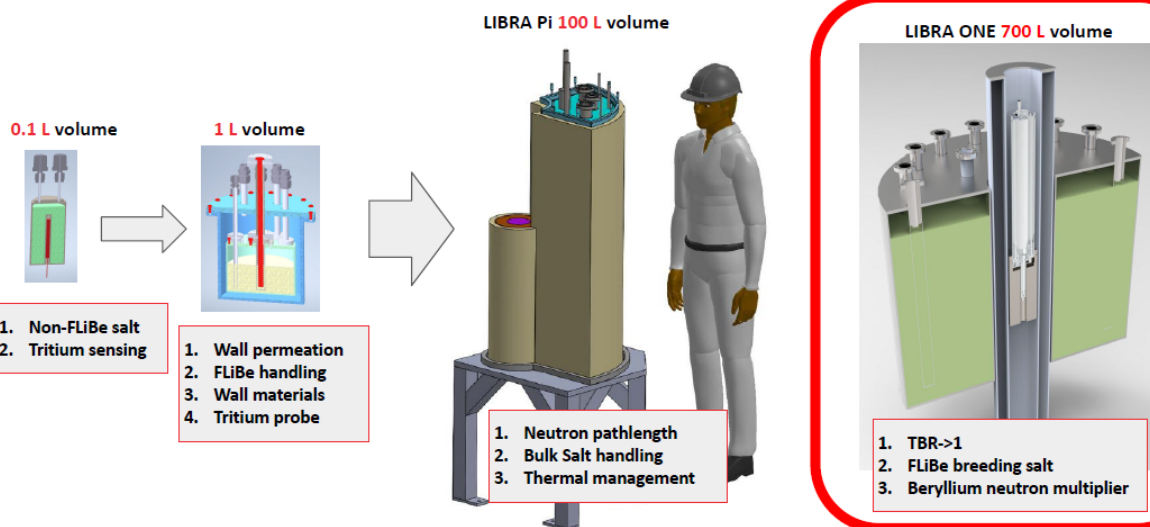
Walk-in fumehood, gas flow planning, and safety procedures under development to facilitate FLiBe test without low to no Be migration.

-> HEPA filter for Be capture, halide gas neutralization and capture

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Progression to Full-scale LIB tech: Build A Better Yield (BABY), LIBRA Pi, LIBRA ONE



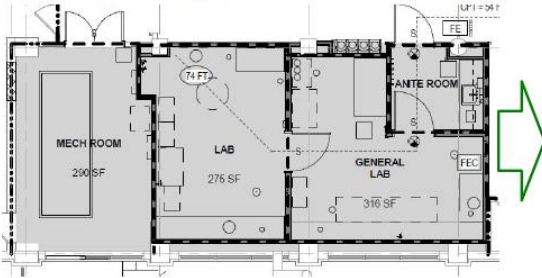
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MIT Salt Lab under construction for large-scale FLiBe handling

FLiBe Lab design



FLiBe Lab start of demolition Dec. '24,
Completion expected July '25



As of February 4, drywall going up in April

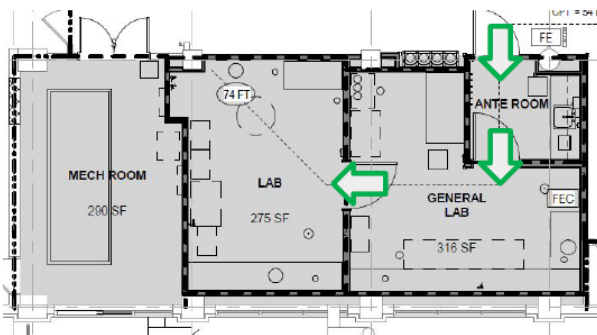
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MIT Salt Lab under construction for large-scale FLiBe handling

Salt Lab design



Used for FLiBe

Cascaded negative pressure lab spaces from
common hallway to interior lab space.

1. Anteroom 2. Air Shower 3. General Lab 4. High
risk Lab

Materion graciously provided lab design review

Intention is to mirror the Beryllium Worker
Protection for the production and handling of
FLiBe, presented by Materion at BHSC 2023
Spring Meeting

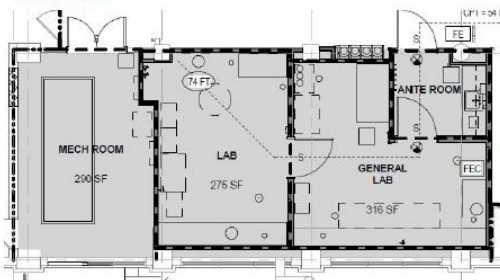
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12

MIT Salt Lab under construction for large-scale FLiBe handling

Salt Lab



FLiBe Lab plans

- Handle FLiBe and Be-containing salts at industrial scales
- FLiBe loop operation and sensor testing

Experiments on:

- Electrochemistry
- Compositional analysis
- Hydrogen transport
- Hydrogen (tritium) extraction

Future directions:

- Alternative salt chemistries for Fusion
- Thermosiphon development for compact thermal convection corrosion experiments

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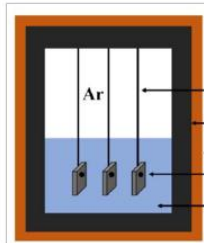
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14

Static Corrosion testing in FLiBe, Weiyue Zhou, TMS 2024

How much oxygen are we talking about?

A completely sealed
(welded) crucible



Depends on the
cover gas volume

Is this too low?

Open to glove box
atmosphere



0.1 – 10 ppm

Is this range OK?

Running a UHP argon
cover gas through an
autoclave



>10 ppm

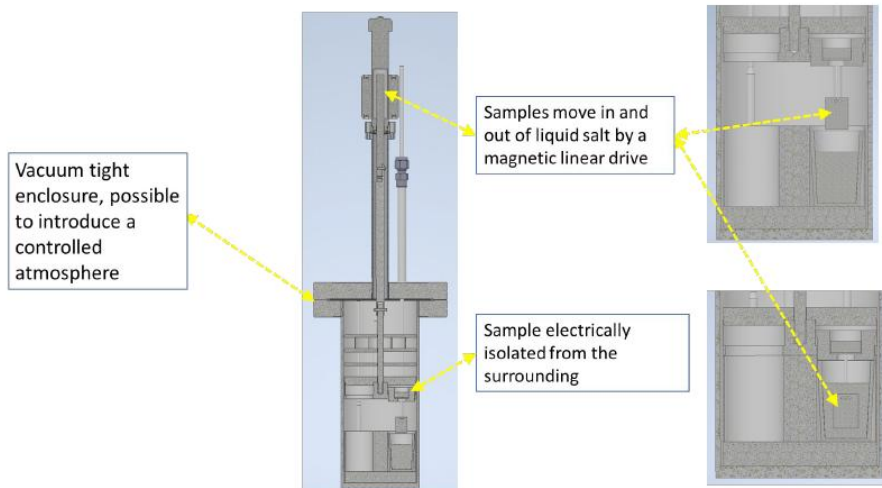
Is this too much?

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Static Corrosion testing design for FLiBe, Weiyue Zhou, TMS 2024



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16

Static Corrosion testing design for FLiBe, Weiye Zhou, TMS 2024

- FLiNaK in Glassy Carbon Crucibles
- Samples suspended by nickel wire on BN spacers
- Additional thermal reflection plates
- Sealed and heated up by a clamshell furnace



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17

Static Corrosion test, Weiye Zhou, TMS 2024

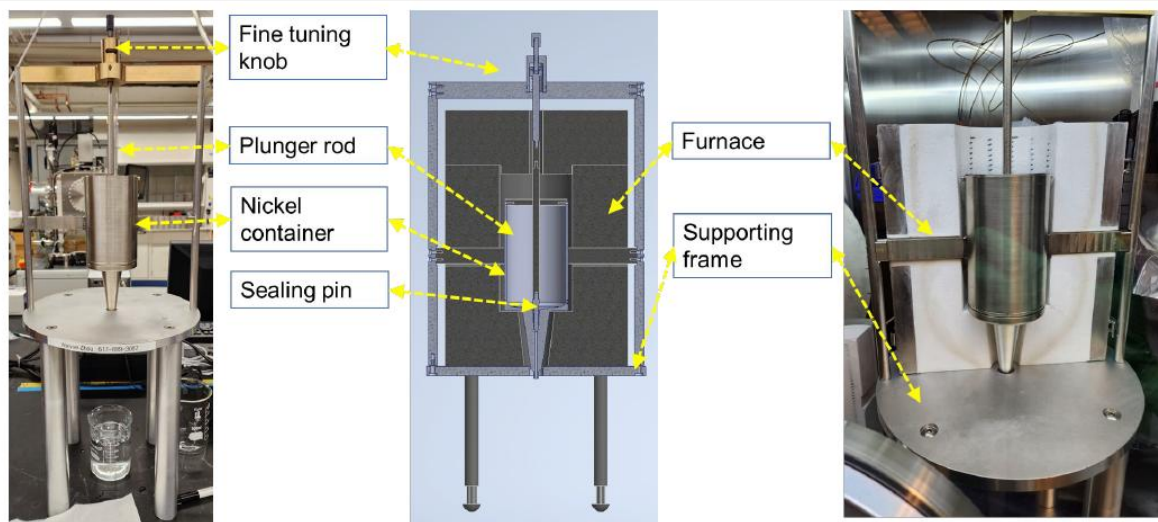
- FLiNaK in Glassy Carbon Crucibles
- Samples suspended by nickel wire
- Sealed and heated up by a clamshell furnace



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18

Salt Dispensing for FLiBe, Weiyue Zhou, TMS 2024

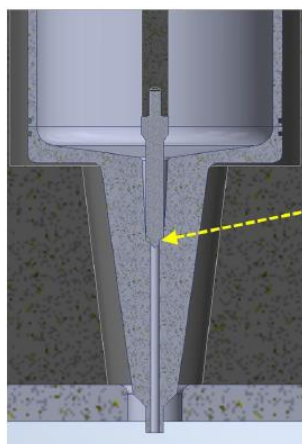


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19

Salt Dispensing for FLiBe, Weiyue Zhou, TMS 2024



Sealing is achieved
by a small force

Flow is controlled
by varying cross-
sectional area

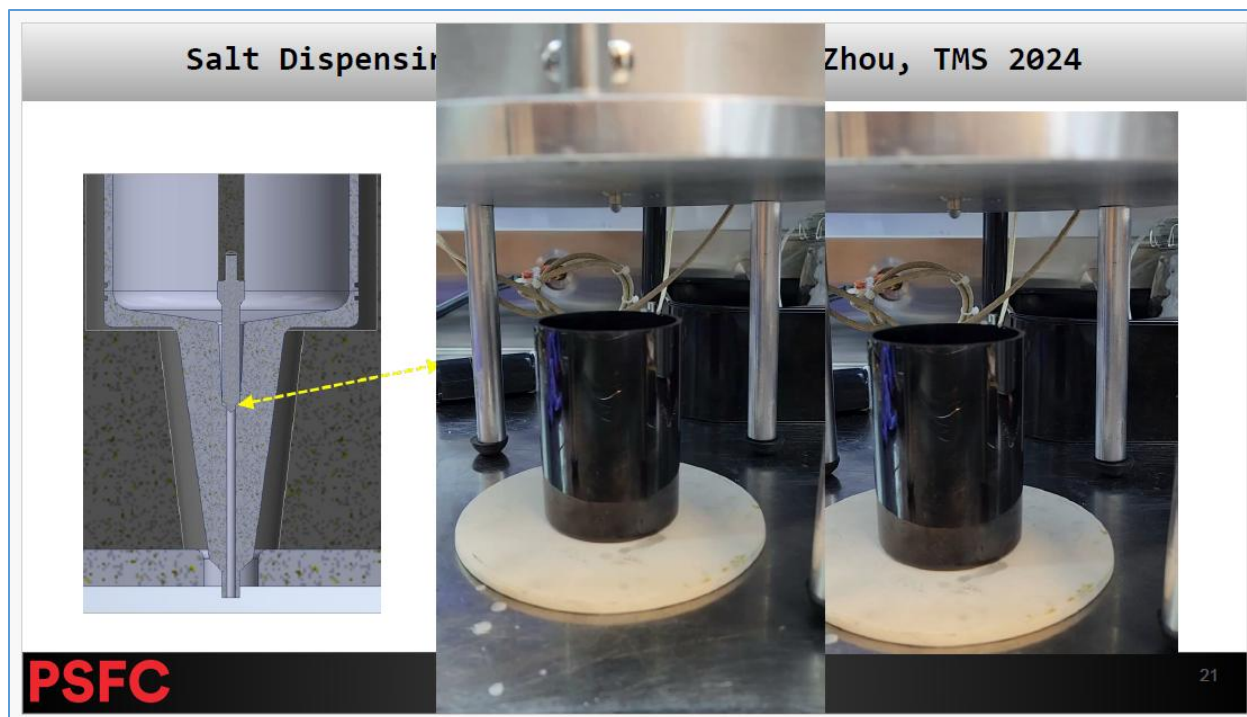
Each droplet of
FLiNaK is 0.22 ~
0.23 g



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20



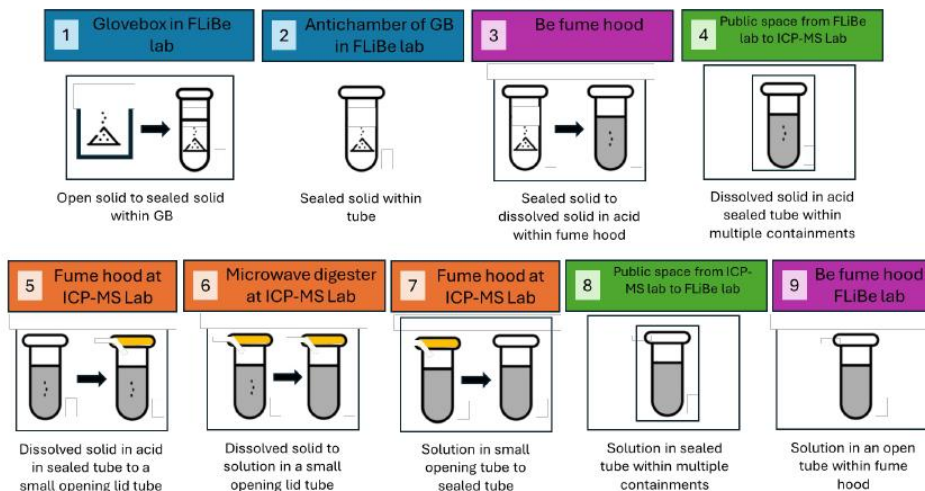
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ICP-MS FLiBe analysis, SOP development, Nayoung Kim & Weiyue Zhou

GB = Glovebox

Locations of operation



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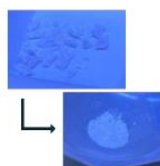
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ICP-MS FLiBe analysis, SOP development, Nayoung Kim & Weiyue Zhou

1. Glovebox in FLiBe lab

- Grinding of salts**
 - Glovebag inside the glovebox -> Be-contaminated waste
- Transferring salt into the tubes**
 - Inserting the spatula to the bottom of the tubes -> Minimizes salt residue on the walls
- Sealing the tubes**
 - With rubber stoppers and tape
 - Good sealing
- Swiping the tubes for BeFinder (future work)**



Good sealing of the stopper even without taping

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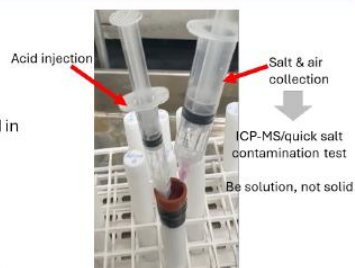
24

ICP-MS FLiBe analysis, SOP development, Nayoung Kim & Weiyue Zhou

3. Be fume hood

1. Acid injection

- Use a stainless steel needle to poke two holes
- Use a 2 ml syringe with a plastic needle to inject acid
- Fill up a 5 ml syringe with a plastic needle with 2 ml of water
- Inject the acid while air and possible solid FLiBe salts are collected in the 5 ml syringe (See the video)
- Concerns
 - Are the stainless steel needles also Be-contaminated?
 - How should the holes be sealed?
- Gently shake/tilt the tube to get the salt residues from the wall (No severe leakage observed in preliminary experiment)



2. Digestion

- Leave it in the cabinet of the Be fume hood?

3. Packaging for transfer

- 1st with a plastic bag
- 2nd with a lockable carrier



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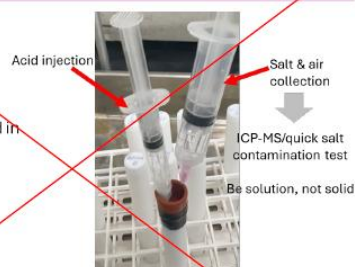
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ICP-MS FLiBe analysis, SOP development, Nayoung Kim & Weiyue Zhou

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ICP-MS FLiBe analysis, SOP development, Nayoung Kim & Weiyue Zhou

4. Public space from FLiBe Lab to ICP-MS Lab

1. Packaging for transfer

- 1st with a plastic bag
- 2nd with a lockable carrier



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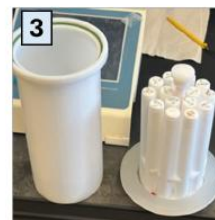
27

ICP-MS FLiBe analysis, SOP development, Nayoung Kim & Weiyue Zhou

5. Fume hood at ICP-MS Lab

1. Change of lids

- Salts are dissolved in the acid (with naked eyes)
- From rubber stopper to PTFE stopper for digestion
- Collect the rubber stopper in a water bottle?



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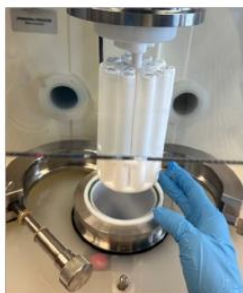
28

ICP-MS FLiBe analysis, SOP development, Nayoung Kim & Weiyue Zhou

6. Microwave digester at ICP-MS Lab

1. Microwave digestion

- Small-opening lid tubes are placed in the chamber.
- Microwave-digested at 230C for 15 min.



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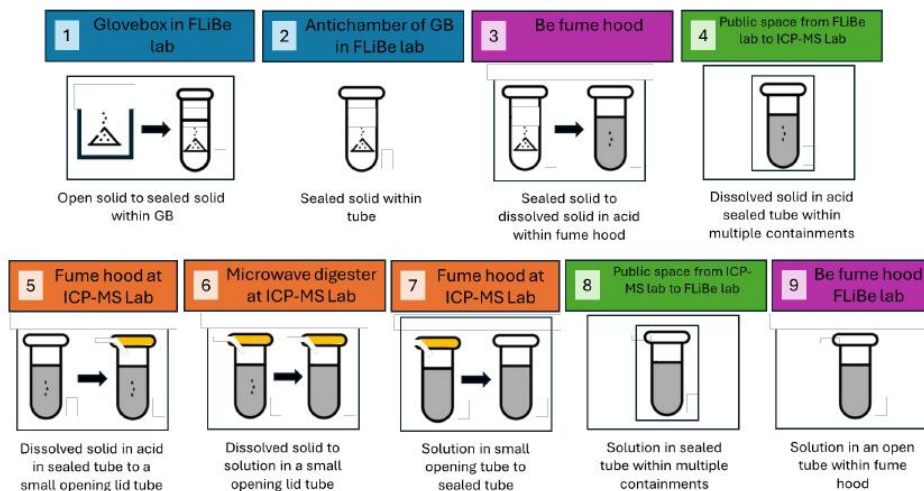
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29

ICP-MS FLiBe analysis, SOP development, Nayoung Kim & Weiyue Zhou

GB = Glovebox

Locations of operation



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30

Current areas of FLiBe research at the PSFC

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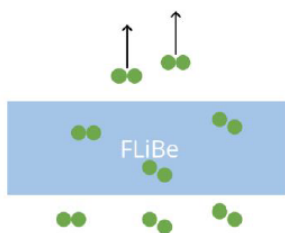
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31

Hydrogen transport measurements, Abhishek Saraswat, Weiyue Zhou, Remi Delaporte-Mathurin

Experiment principle

1. Impose partial pressure of H on one side
2. H permeates through the salt
3. Measure the desorption flux on the other side



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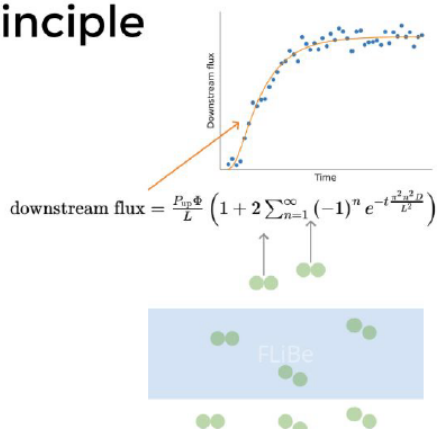
32

Hydrogen transport measurements, Abhishek Saraswat, Weiyue Zhou, Remi Delaporte-Mathurin

Experiment principle

1. Impose partial pressure of H on one side
2. H permeates through the salt
3. Measure the desorption flux on the other side
4. Fit with the master curve to identify Φ and D
5. Repeat for different temperature

<700C



$$\text{downstream flux} = \frac{P_{\text{up}} \Phi}{L} \left(1 + 2 \sum_{n=1}^{\infty} (-1)^n e^{-t \frac{2n^2 D}{L^2}} \right)$$

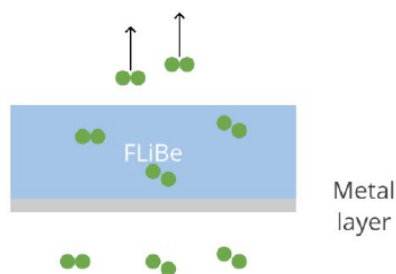
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Hydrogen transport measurements, Abhishek Saraswat, Weiyue Zhou, Remi Delaporte-Mathurin

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Hydrogen transport measurements, Abhishek Saraswat, Weiyue Zhou, Remi Delaporte-Mathurin

Ni200 permeation vessel

Downstream tubes (19.05 mm ID) for Ar sweep (planned for FLiBe feed)

Upstream tubes for H₂ injection and exhaust

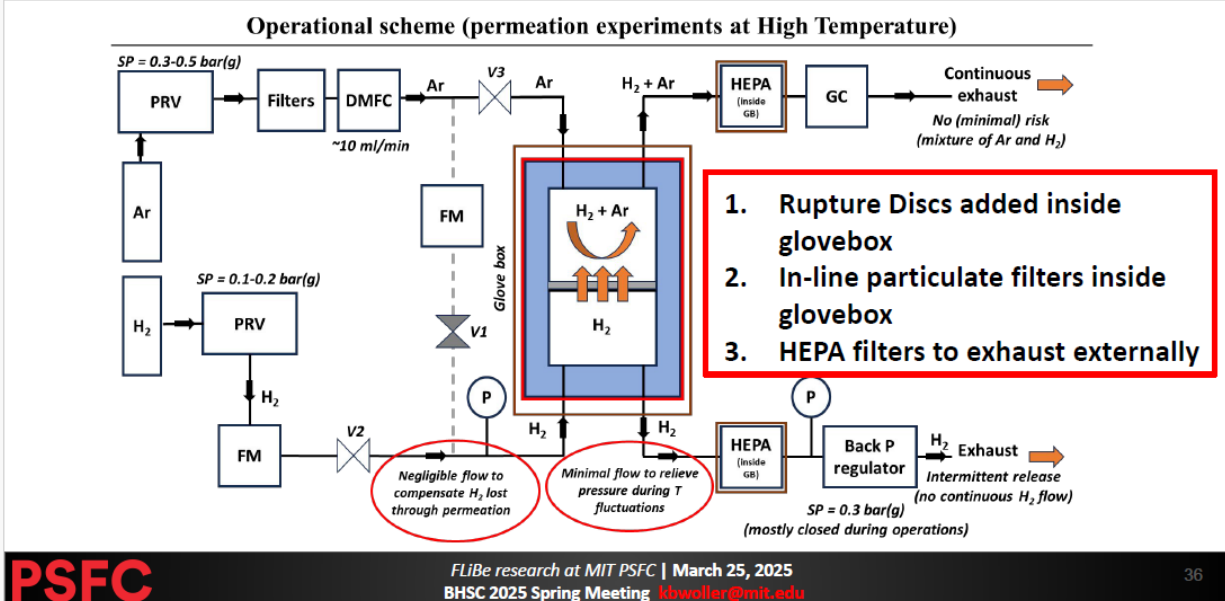
FLiBe casting for insertion down large ID tubes

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Hydrogen transport property measurements, Abhishek Saraswat, Weiyue Zhou, Remi Delaporte-Mathurin



PPE Donning/Doffing, Be Work Plan, Be monitoring and Surveillance development, lead by Weiyue Zhou



Be Safe!

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37

Overview of the International Beryllium Workshop Series and Invitation to BeWS-17
C.K. DORN (Be4FUSION LLC, California, USA) et al.

Overview of the International Beryllium Workshop (BeWS) Series and Invitation to BeWS-17

Christopher DORN¹ and Aniceto GORAIEB²

¹*Be4FUSION LLC, Upland, California, U.S.A.*

²*Karlsruhe Beryllium Handling Facility (KBHF), Eggenstein-Leopoldshafen, Germany*

In the technical field of beryllium, especially for fusion and fission applications, the longest established conference series for sharing information and best practices is the International Workshop on Beryllium Technology (BeWS). These events normally take place in odd-numbered years and tend to be held in conjunction with a larger technical conference such as the ICFRM (International Conference on Fusion Reactor Materials) or the ISFNT (International Symposium on Fusion Nuclear Technology).

The BeWS series is an outgrowth of a meeting of fusion and beryllium technical specialists who first gathered at the Idaho National Laboratory in 1989. The group met again, and after the ICFRM-5 in 1991, the organizers decided to ask the IEA (International Energy Agency in France) to sponsor the Beryllium Workshop as an ongoing series.

Since then, as part of the IEA program, the Beryllium Workshop has generally taken place once every two years, although there have been a couple of instances when the sequence was interrupted, most recently for the global pandemic in 2021. Technical areas of interest for presentations at the Beryllium Workshops nowadays have expanded to include the following:

- Production, forming, and joining
- Chemical compatibility and corrosion
- Irradiation effects, including changes in microstructure and properties
- Composition control and characterization
- Modeling and experimental validation of irradiation defects
- Thermal and mechanical properties
- Monitoring, disposal, and recycling
- High heat flux performance
- Applications for beryllide intermetallic compounds
- Beryllium-containing molten salts, such as FLiBe, FLiNaBe, etc.
- Environmental, health, and safety (EH&S) issues

At this point, the 17th International Workshop on Beryllium Technology (BeWS-17) is planned for 6-8 October 2025, to be held on the Uji Campus of Kyoto University in Kyoto, Japan. This year's BeWS event will be a joint session with the 22nd International Workshop on Ceramic Breeder Blanket Interactions (CBBI-22). Both workshops are satellite meetings of ICFRM-22, which will be held in Shizuoka, Japan from 28 September through 3 October 2025.

Corresponding Author:

Mr. Chris DORN, Be4FUSION LLC

BeWS International Organizing Committee (IOC)

EMAIL: chris.dorn@be4fusion.com

Event URL: [First Announcement of BeWS-17 Kyoto University Oct-2025](#)

Beryllium Health & Safety Committee 2025 Spring Meeting



Be₄FUSION



**Overview of the International
Beryllium Workshop Series (BeWS)
and
An Invitation to BeWS-17**

Chris DORN¹ and Aniceto GORAIEB²

¹Be₄FUSION LLC, California, U.S.A.

²KBHF GmbH, Germany

25 March 2025

Cameco Fuel Manufacturing • Cobourg, Ontario, Canada

Presentation Outline

- Introduction & Overview
 - Challenges to Address
 - Precursor Genesis Meeting
- International Beryllium Workshop
 - An Initial Meeting as a Trial
 - Establishing the Recurring Series
 - Sponsorship & Related Conferences
- An Invitation to BeWS-17 in Japan
 - Chair & Organizing Committee
 - Joint Workshop with Ceramic Breeders
 - Scope & Planned Technical Agenda
 - Location Notes (Venue & Local Sights)
- Summary & Key Dates



Be₄FUSION – Specialty Materials & Business Consulting

Introduction & Overview

- Technical Challenges
 - JET Beryllium Tiles Just Installed
 - Need for Material Property Data, Especially after Irradiation
 - Beryllium Material Forms
 - Uranium Content in Beryllium
- Precursor Meeting Genesis
 - JAERI: Japan Fusion Mission
 - Sep-1989 at Idaho National Lab
- Be Technology Workshop
 - 1991 Satellite to ICFRM
 - Idea for Series Event



The four founders of the Beryllium Workshop series

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3

The Beryllium Workshop Series

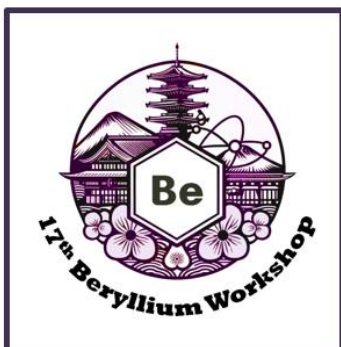
- Workshop Genesis
 - Japan Fusion Mission
 - Sep-1989 at Idaho NL
- Be Technology Workshop
 - 1991 Satellite to ICFRM
 - Idea for Series Event
- Founding the Series
 - FZK, INL, JAERI, KZ Univ.
 - Apply for IEA Sponsorship
- IEA Series Established
 - Odd-Numbered Years
 - Satellite of ICFRM or ISFNT

Meeting	Year	Attendees	Papers	Institutions	Location
BeWS-0	1991	42	12	12	Clearwater Beach, FL, USA
BeWS-1	1993	52	20	23	Karlsruhe, Germany
BeWS-2	1995	45	37	26	Jackson Lake Lodge, WY, USA
BeWS-3	1997	68	38	38	Mito, Japan
BeWS-4	1999	69	38	41	Karlsruhe, Germany
BeWS-5	2001	46	27	31	Moscow, Russia
BeWS-6	2003	54	49	48	Miyazaki, Japan
BeWS-7	2005	45	27	33	Santa Barbara, CA, USA
BeWS-8	2007	56	22	27	Lisbon, Portugal
BeWS-9	2009	?	16	24	Almaty, Kazakhstan
BeWS-10	2012	64	30	28	Karlsruhe, Germany
BeWS-11	2013	41	35	20	Barcelona, Spain
BeWS-12	2015	44	30	44	Jeju, South Korea
BeWS-13	2017	35	29	46	Chiba, Japan
BeWS-14	2019	49	33	32	Long Beach, California, USA
BeWS-15	2022	52	22	?	Karlsruhe, Germany

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4

An Invitation to the BeWS-17



- 17th International Workshop on Beryllium Technology (BeWS-17)
 - 6-8 October 2025 in Kyoto, Japan
 - Joint workshop with CBBI-22 (Ceramic Breeder Blanket Interactions workshop)
 - After the International Conference on Fusion Reactor Materials (ICFRM-22)

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5

BeWS-17: Scope, Technical Agenda & More

- BeWS-17 Chair
 - Dr. Jae-Hwan KIM of QST in Japan
- BeWS International Org Committee
 - Includes representatives from the EU, UK, Russia, Kazakhstan & North America
- Workshop Scope
 - Objective: share results of Be research and technology development
 - Beryllium use in both fission and fusion
- Participation Fee: €200 (EUR)
- Sponsorships Available from \$650 (USD)



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BeWS-17: Planned Technical Program

- Presentations are Requested in these Areas
 - Production, forming, and joining
 - Chemical compatibility and corrosion
 - Irradiation effects - Neutron, He, and H-Isotopes
 - Microstructural evolution
 - Mechanical and physical property degradation
 - Composition control and characterization
 - Modeling and experimental validation of irradiation defects in HCP (Hexagonal Close-Pack Crystal Structure) materials
 - Thermal and mechanical properties
 - Monitoring, disposal, and recycling
 - High heat flux performance
 - Beryllide intermetallic compound applications
 - Molten salts, FLiBe
 - Health and safety issues

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BeWS-17: Location Notes



- Workshop Venue
 - Kyoto University
 - Obaku Plaza on Uji Campus
- Uji City
 - Located between Kyoto & Nara
 - Kyoto & Nara former capitals
 - Uji developed as cultural center
- Cultural Sites
 - Byodoin Temple
 - Ujigami Shrine (oldest in Japan)

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8

Summary & Key Dates

- The Beryllium Workshop Series
 - Long history with origins dating back to 1989
 - BeWS Series since 1993 and under IEA Auspices
- BeWS-17 Key Dates
 - Abstracts Due & Registration Opens: **02-May**
 - Notification of Abstract Acceptance: **06-Jun**
 - Late Registration Applies: **10-Aug**
 - Final Program Published: **31-Aug**
 - Workshop: **06 to 08-Oct**
 - Conference Dinner: **06-Oct**
 - BeWS Site Tour (including KF FLiBe Lab): **08-Oct**
 - Final Papers Due for Publication: **31-Oct**



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9



Welcome to Be₄FUSION
Specialty Materials &
Business Consulting

TEL +1-510-415-9747

Be₄FUSION

<https://be4fusion.com/>

Proven Experience

With 30 years in the beryllium and specialty materials business, we offer unmatched expertise on high-performance materials for demanding applications in fusion, fission, and opto-mechanical systems.

Global Reach

In addition to technical expertise, we also have more than 25 years of international business experience, working with customers on six continents around the world.

Challenge Us!

Bring us your most difficult materials design and business management challenges, and find out for yourself how we are able to use our extensive resources and abilities to help make you successful!

A Practitioner's Guide to Beryllium Hazard Management

D. FIELD (National Nuclear Security Administration, Washington, DC, USA) et al.

Update on Revision to “A Practitioner’s Guide to Beryllium Hazard Management”

Wesley ADAMS¹, Roland CHRETIEN² and Christopher DORN³

¹*National Nuclear Security Administration, Los Alamos Field Office, USA*

²*Edgewater Technical Associates Southeast Regional Director, USA*

³*Be4FUSION LLC, Upland, California, USA*

The Beryllium Health and Safety Committee (BHSC) promotes activities and 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. The BHSC furthers its mission through meetings, symposia, and publications.

In this regard, the BHSC issued *A Practitioner’s Guide to Beryllium Hazard Management*, First Edition, dated February 2018, to provide a single information source that describes the history of beryllium disease, exposure levels and regulations, conduct of sampling, conduct of laboratory analysis, data evaluation, hierarchy of controls, release of equipment and items, training, risk communication, medical surveillance, recordkeeping requirements, and support references and websites.

The second edition of the Practitioner’s Guide is on schedule to be published in 2025 with more than forty experts in academia, government, and industry contributing to updates on the chapters in the first edition, as well as creating three new chapters including:

- Case Studies Involving Decontamination, Decommissioning, and Demolition of Beryllium Facilities
- Comparative Analysis of International Beryllium Health and Safety Programs
- FLiBe and other Beryllium Molten Salts

This presentation will highlight significant updates to existing chapters and key elements of new chapters.

Corresponding Author:

Wesley ADAMS

National Nuclear Security Administration

Los Alamos Field Office

EMAIL: Wesley.Adams@nnsa.doe.gov

Update on Revision to “A Practitioner’s Guide to Beryllium Hazard Management”

BHSC 2025 Spring Meeting

Wesley Adams¹, Roland Chretien², Christopher Dorn³

¹National Nuclear Security Administration, Los Alamos Field Office,

²Edgewater Technical Associates Southeast Regional Director, USA,

³Be4FUSION LLC, Upland, California, U.S.A.

Cobourg, Ontario, Canada

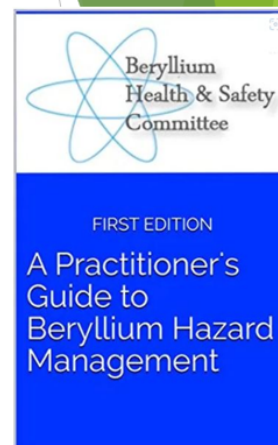
March 25, 2025

BHSC Mission:

- The Beryllium Health and Safety Committee (BHSC) promotes activities/efforts that help people better understand and prevent beryllium-induced conditions and illnesses, including Beryllium Sensitization (BeS) and Chronic Beryllium Disease (CBD). Such illnesses 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.

Practitioner's Guide: Filling a gap

- 'A Practitioner's Guide to Beryllium Hazard Management' fills a gap for beryllium practitioners including:
 - Engineers / Operators
 - Health professionals,
 - Safety professionals
 - Analytical Laboratories
 - Managers,
 - Union representatives,
 - Manufacturers / Vendors
 - Others.
- While briefer and more specific data sources are available on single subject areas, as are multi-volume compendia, *there was no current, up-to-date compilation of information* useful on a daily basis by the beryllium practitioner.



3

Updates since the 2024 Fall Symposium

Status of the 2nd Edition includes:

- Chapter Leads identified for each Chapter.
- >40 Chapter Contributors from Academia, Government, and Industry from around the world.
- Significant revisions to existing chapters including updated references.
- Three new chapters to fill additional gaps for the beryllium practitioner.

Note: Need for 2nd Edition based on regulatory changes and significant advances in beryllium safety and health since publication of the 1st Edition in 2018.

4

2nd Edition Practitioner's Guide: 'Table of Contents'

Chapter 2: The Background of Beryllium Disease (**Revised Title**);
Chapter 3: Development of Exposure Levels and Regulations
Chapter 4: Conduct of Sampling
Chapter 5: Conduct of Laboratory Analysis
Chapter 6: Data Evaluation and Related Topics
Chapter 7: Hierarchy of Controls
Chapter 8: Release of Equipment and Other Items
Chapter 9: Training
Chapter 10: Risk Communication
Chapter 11: Medical Surveillance
**Chapter 12: Case Studies Involving Decontamination, Decommissioning,
and Demolition of Beryllium Facilities**
**Chapter 13: Comparative Analysis of International Beryllium Health
and Safety Programs**
Chapter 14: FLiBe and other Beryllium Molten Salts
Chapter 15: Where to Go for Help

(Note: Red indicates New Chapter)

5

Chapter 2 and 3 Updated Highlights:

Chapter 2: The Background of Beryllium Disease

- ▶ Chapter Title changed to "Background of Beryllium Disease."
- ▶ More on development of beryllium Disease and health impacts.
- ▶ Additional information on beryllium and genetic predisposition.

Chapter 3: Development of Exposure Levels and Regulations

- ▶ Additional background and context from research studies.
- ▶ Updated citations and references.

6

Chapter 4 and 5 Updated Highlights:

Chapter 4: Conduct of Sampling

- ▶ The addition of colorimetric analysis in the initial risk characterization
- ▶ New section for Outdoor dispersal & contamination due to energetic events

Chapter 5: Conduct of Laboratory Analysis

- ▶ Reflects improvements in detection limits for the different analytical techniques.
- ▶ Clarification of confusing language.

7

Chapter 6 and 7 Updated Highlights:

Chapter 6: Data Evaluation and Related Topics

- ▶ Provides clarity throughout the chapter
- ▶ Added details of ASTM D8299, Using Metal Ratios in Soils to Distinguish between Anthropogenic and Natural Beryllium
- ▶ Updated References

Chapter 7: Hierarchy of Controls

- ▶ Provides clarity and context for implementing occupational safety hierarchy of controls for beryllium activities, operations, and facilities.
- ▶ Introduces the specialized hierarchy of controls and inherently safer designs established for nuclear facilities.
- ▶ Updated references.

8

Chapter 8 and 9 Updated Highlights:

Chapter 8: Release of Equipment and Other Items

- ▶ Expanded detail on cleaning methods and pros/cons
- ▶ Describes methodology for sampling and approval process and provides examples of labeling for release

Chapter 9: Training

- ▶ Additional background and context in the 'Introduction' section.
- ▶ Comparative analysis of international training program requirements
- ▶ Updated References

9

Chapter 10 and 11 Updated Highlights:

Chapter 10: Risk Communication

- ▶ Deemphasizes a purely DOE perspective and includes more information about workplace risk communication requirements, resources, and approaches from non-US entities.
- ▶ Recognizes that risk communication needs will be different depending on the facility, industry, and country, and so there is a heavier focus on discussing principles and theories behind risk communication, in addition to providing updated resources about communicating beryllium risk

Chapter 11: Medical Surveillance

- ▶ Updated Be LPT management algorithm
- ▶ Modified the table of contents to include more clinical information and provide a slightly better flow.

10

Chapter 12 and 13 New Information:

Chapter 12: Case Studies Involving D&D of Beryllium Facilities

- ▶ Describes the requirements and challenges involving the safe decontamination, decommissioning, and demolition (D&D) of beryllium facilities.
- ▶ Defines different types of beryllium facilities including traditional building structures as well as outdoor test ranges.
- ▶ Provides Best Practices and Lessons Learned for D&D activities.

Chapter 13: Comparative Analysis of Int'l Be H&S Programs

- ▶ Compares and summarizes the requirements for implementing beryllium programmatic areas in different countries.
- ▶ Describes tailoring of beryllium H&S requirements by different countries to the exposure risks for workers, the public, and the environment
- ▶ Provides context on the many factors leading to variability in beryllium health and safety requirements throughout the international community.

11

Chapter 14 and 15 New Information/Updates:

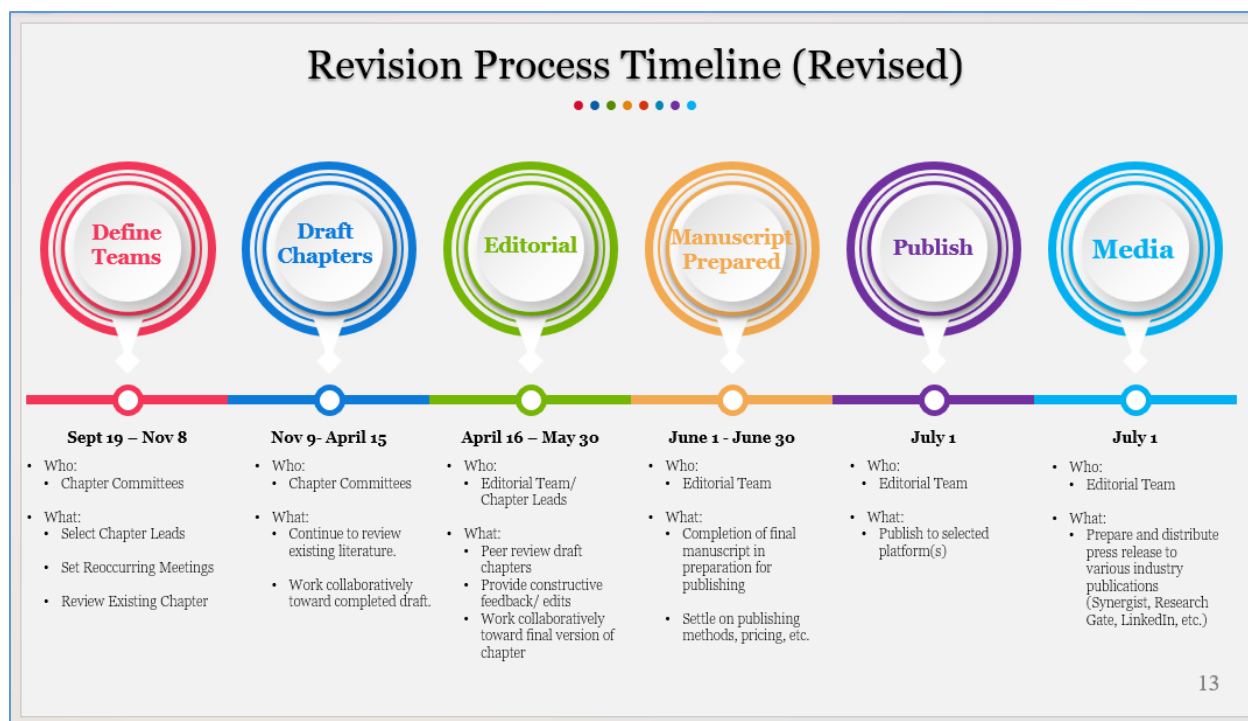
Chapter 14: FLiBe and Other Beryllium Molten Salts

- ▶ FLiBe usage is dominant in emergent nuclear technology and will be included as a new chapter in the Practitioner's Guide.
- ▶ The chapter will identify specific health and safety challenges associated with handling soluble forms of beryllium and provide worker protection models to help control risk.

Chapter 15: Where to Go for Help

- ▶ Identifies useful resources including organizations that actively meet and discuss beryllium-related matters, webpages for beryllium information, as well as references to beryllium-related publications.

12



Contributors (Partial Listing)

Wesley Adams	Cerys Gardner	Sara Pasqualoni
Eric Allred	Kul Garg	Tim Pickarski
Lisa Barker	Joanne Gill	Chris Quinn-Vawter
Isabel Bejar Alonso	Gary Griffin	Victoria Robichaud
Robert Brounstein	Greg Heldt	Crystal Roddy
April Brown	Jessica Helland	Josef Sobieraj
Kent Candee	Vern Holden	Laura Stacy
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Charles Davis	Tomoaki Imai	Seuri Taruru
Meghan Devine	Dan Jensen	Abbas Virji
Chris Dorn	Peggy Mroz	Beth Walker
Julie Fowler	Masaru Nakamichi	Zeke Wilmot
Melissa Freiderich	Greg Nichols	Shian Yada

A Complete Listing of Contributors/Affiliations
will be included in the Practitioner's Guide

14

Day 1: Vendor Technical Presentation

Codeac Solutions Ltd., Code-Be Products, Chicago, Illinois, USA

Dr. Melissa FREIDERICH, PhD; Tristan KENNELLY; and Lucas BENDO-WATSON



ONSITE COLORIMETRIC DETECTION OF BERYLLIUM

Beryllium Health and Safety Committee
2025 Spring Meeting

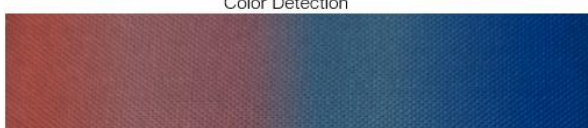


 www.codeacsolutions.com

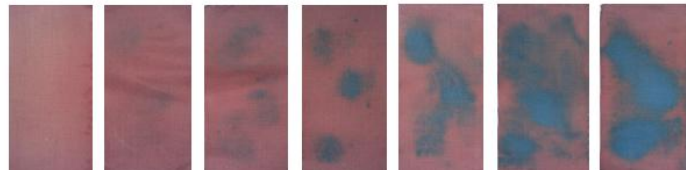
WHAT DOES CODEBE DO?

Rapid vivid blue color change when brought into contact with Beryllium.

Color Detection



No Detect Positive Detect



No Be 0.04 µg 0.1 µg 0.2 µg 0.6 µg 1 µg 2 µg

www.codeacsolutions.com



DETECTS BERYLLIUM

- Beryllium Metal
- Beryllium Oxide and/or Hydroxide
- Beryllium Nitrate
- Beryllium Sulphate
- Beryllium Copper Alloy

LIMIT OF DETECTION (LoD)

- CodeBe LoD a limit is ~0.04 µg per 100 cm²
- Can be adjusted

PRODUCT BENEFITS

- Fast, onsite results in under 2 minutes
- Easy to use with minimal training required
- Low-cost and accessible solution
- Quickly identifies contamination footprint
- Accurate detection at trace levels
- Requires no power or maintenance
- Tested on a broad range of field elements
- Overwhelming blue color reliably indicates beryllium, even with potential color changes from other substances

2

CODEBE IN ACTION



Wipe the area with suspected contamination

Detection of beryllium in applications such as; routine and incident response, housekeeping and diagnostic monitoring, control assessment, facility assessment, equipment release, bulk sampling including remediation effectiveness and waste characterization.

www.codeacsolutions.com

ADVANTAGES

- Pre-saturated or dry, ready to use straight from the packet
- Easy to use with minimal training required for all product types
- Provides onsite results in under 2 minutes, enabling real-time detection and decision making
- Low-cost and accessible solutions for contamination monitoring
- Simple, easy-to-interpret results for immediate identification of contamination
- Quickly identifies contamination footprint across various surfaces and air filters
- Accurately detects trace levels of contaminants, enhancing safety and operational efficiency
- Compatible with all common surfaces and air filter types
- No power or maintenance required, ideal for field use
- Samples can be sent for further quantification testing, such as ICP, if needed

3

UPCOMING PRODUCTS



ENVIRONMENTAL & BULK
SAMPLE TESTS



AIR MONITORING
SAMPLE TESTS
AVAILABLE TO TRIAL



OPTIONAL COLORIMETER



HUMAN DIAGNOSTIC

4

CODEBE TECHNOLOGY DEPLOYMENT



- We conducted successful field trials of CodeBe at CERN and Y-12 and have now released products for trial and evaluation for wider sectors and different applications
- ~30 large organisations.



Canada
2 Trials Underway

United States
Private sales

United States
Government sales

United States
19 Trials Underway

United Kingdom
4 Trials Underway

Europe
3 Trials Underway

Japan
2 Trials Scheduled

SECTORS

- Beryllium Mining, Production and Processing
- Beryllium manufacturing and use
- Nuclear power and fusion energy
- National security
- Medical device manufacturing
- Environmental and industrial remediation

APPLICATIONS

- Routine and incident response
- Housekeeping and diagnostic monitoring
- Control assessment
- Facility assessment
- Equipment release
- Bulk sampling
- Waste characterisation

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5

CODEBE USER FEEDBACK



- Fabrication with beryllium and industrial hygiene checks.

"We have proceeded with a systematic campaign of beryllium testing using wet and dry colorimetric wipes in our laboratories. The wipes have been measured after using ICP to check the detection level. The values have shown a full correlation between the presence of beryllium and the change of colour of the CodeBe wipes.

The wipes are easy to read and use and provide great reassurance to the workers that can have immediate feedback. It is a real ally to create a safety culture."

Isabel Bejar-Alonso, Senior Project Leader, CERN, Switzerland

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6



CODEBE USER FEEDBACK

- Manufacturing of beryllium based products and industrial hygiene facility checks.

"We have used the colorimetric wipes alongside the Ghost wipes/laboratory results to test the efficacy, broadly the CodeBe wipes matched what we were finding on the swabs, in the first round of tests. We found much better results from the impregnated CodeBe wipes, but we do not have any surfaces that we would need dry wipes, so this works much better for us.

We found the wipes easy to read and easy to use. I see them as being completely invaluable in the event of an incident. Giving the tools to understand the risk level immediately removes the need for worst case thinking.

They will also be valuable for those times when you need to demonstrate compliance of an area without having to wait for lab results (in the UK it is hard to get UKAS accreditation, so external labs are used with an average turnaround of 10-12 days).we will continue to use these wipes in areas we are testing with swabs and compare the results in a table to understand the efficacy."

Beth Walker, Safer Environment Limited, using the wipes at Novanta Technologies, Taunton.

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7



CODEBE USER FEEDBACK

- Machining and application of beryllium in nuclear and medical based applications with industrial hygiene control checks. Remediation sites with beryllium contamination.

"They got to my desk yesterday afternoon. I tried one this morning on some CuBe, freaking amazing--they work! I'm going to start setting up meetings with our deployed IH staff, we've got to start using this product across the lab. "

US National Laboratory

"The wipes performed great. We used the wet wipes as well as the dry wipes to confirm and our results were similar to other environmental testing we were doing in conjunction."

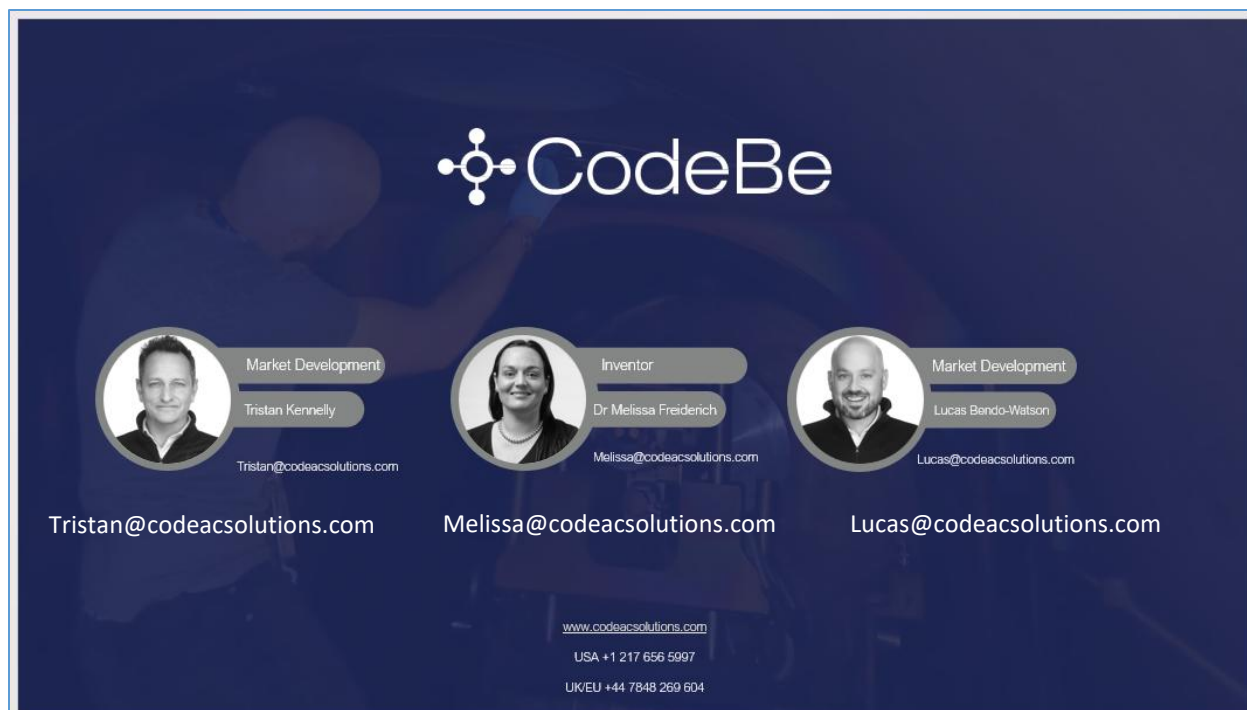
Cadence Medical

A repeat customer

USG Remediation Site

www.codeacsolutions.com

8



Link: [Codeac Solutions - Simple, Fast and Reliable Detection of Beryllium and Nuclear Materials](https://www.codeacsolutions.com)

Day 2: Technical Presentation

Beryllium-Bearing Salt Purification and Characterization

J. ZHANG et al. (Virginia Tech, Virginia, USA)

Beryllium-Bearing Salt Purification and Characterization

Jinsuo ZHANG, Amanda LEONG, Woohyuk LEE, and Logan McILWAIN

Virginia Tech, Blacksburg, Virginia, USA

Molten beryllium-bearing fluoride salts have broad applications in both fission and fusion nuclear reactors. Materials compatibilities between molten salt and structural materials are key concerns for safely operating these reactors. Available studies have shown that the molten salt corrosion is mainly due to the impurities (metal and non-metal impurities) in the salt. Therefore, purifying the salt is necessary to mitigate materials corrosion. This talk will discuss the following methods for salt purification:

- Physical purification to remove moisture and non-soluble impurities
- Chemical purification using HF/H₂, HF and/or H₂ to remove oxygen ions, oxides, corrosive metal fluorides, sulfides, carbonates, etc.
- Electrochemical purification to remove corrosive metal fluorides such as NiF₂ and FeF₂

After purification, the salt was characterized by combustion analysis for O, H, C, and S impurity concentrations and ICP-MS analysis for metal impurity concentration.

The purified salts with and without redox potential control were used for corrosion tests. The results showed that salt purification is an effective method for mitigating corrosion, and that corrosion can be reduced further through controlling redox potential during experiments.

Corresponding Author:

Dr. Jinsuo ZHANG, PhD

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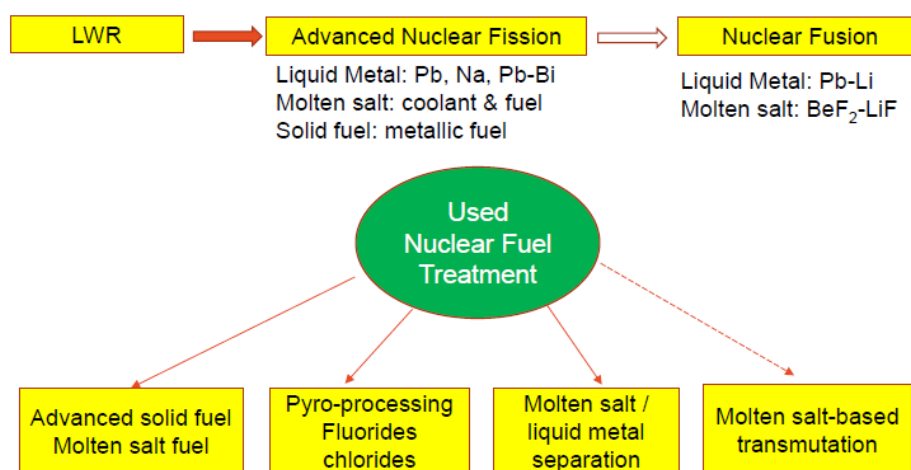
URL: www.nmfc.me.vt.edu

Be-Bearing Salt Purification and Characterization

Jinsuo Zhang¹, Amanda Leong¹, Woohyuk Lee¹, Logan McIlwain¹



Research Interests & Impact

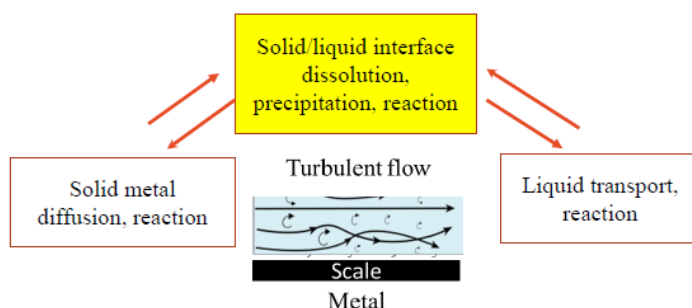


- ❑ **Impacts:** Nuclear Materials chemistry, safety, security and nuclear technologies
- ❑ **Sponsors:** DOE-NE, ARPA-E, NNSA, and Domestic and International Industries

Molten salt & Liquid lead

Corrosion Mechanisms

- ❑ **Liquid lead**
 - ❑ Physical dissolution
 - ❑ Solubility of metals in liquid lead
 - ❑ It is the lead itself who leads to corrosion
- ❑ **Molten salt**
 - ❑ Electrochemical process
 - ❑ Needs anodic and cathodic reactions
 - ❑ Mainly because of the oxidant impurities



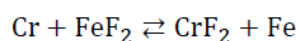
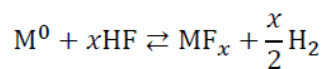
3 Nuclear Materials and Fuel Cycle Center



Molten salt corrosion is mainly impurity-driven

- ❑ **Non-Metal impurities**
Examples: H_2O , O_2 , HF , HCl , S^{2-} , O^{2-} , H^+
- ❑ **Metal impurities:**
Examples: Fe^{2+} , Ni^{2+} , Eu^{3+}

Examples of Corrosion Reactions:



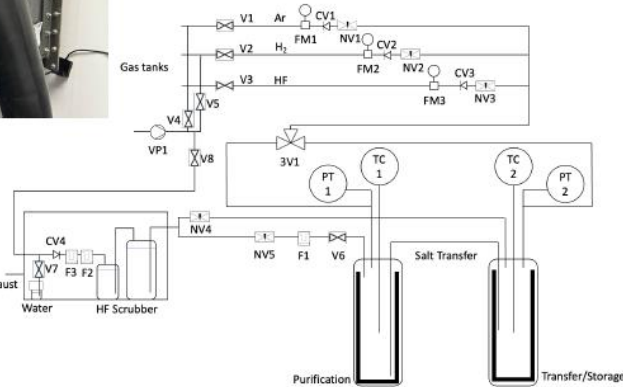
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Salt Purification System Setup



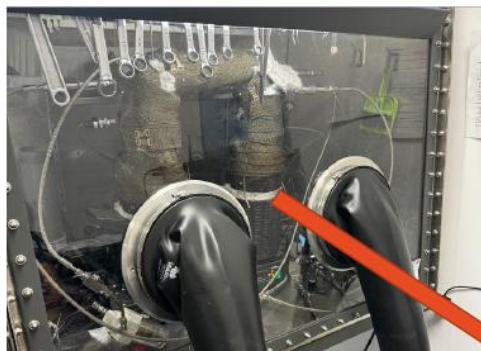
- Flow meter control for different gases
- Interchangeable containment material
- Incorporate HF gas system
- Filtration for particulate
- Neutralization system for toxic gas



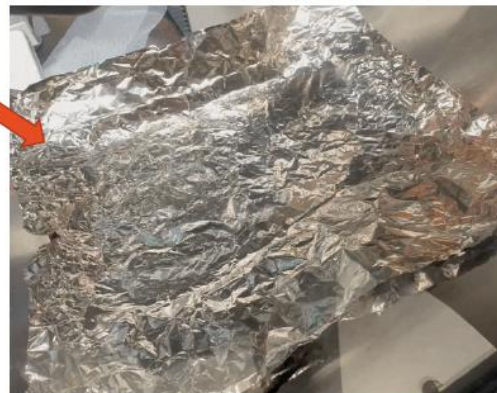
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Salt Purification Procedure



- Flow meter control for different gases
- Interchangeable containment material
- Incorporate HF gas system
- Filtration for particulate
- Neutralization system for toxic gas



Step	Typical Purification Procedure
1	Thermal Purification 300°C Argon (36hrs)
2	Melting + Purge 600°C Argon (24hrs)
3	10% HF in H ₂ (24hrs)
4	50% H ₂ in Ar (48hrs)
5	Argon purge (12hrs)
6	Coalesce (12hrs)
7	Salt Transfer

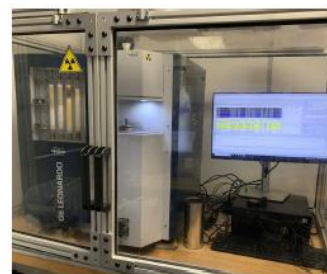
Purified NaF-BeF₂-UF₄-ZrF₄



6 Nuclear Materials and Fuel Cycle Center

Detection Methods

- Inert Gas Fusion (O & H)
 - High temperature inert fusion of sample material in graphite crucible by electric current
 - Oxygen measured in form of carbon monoxide by non-dispersive infrared detection (NDIR)
 - Hydrogen measured in form of H_2 by thermal conductivity detection (TCD)
- Combustion Gas Analysis (C & S)
 - High temperature combustion of sample material in alumina crucible at by inductive Joule-Thomson heating
 - Carbon measured in form carbon dioxide by nondispersive infrared detection (NDIR)
 - Sulfur Measured in form of sulfur dioxide by nondispersive ultraviolet detection (NDUV)

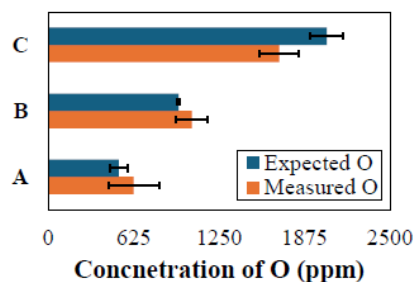
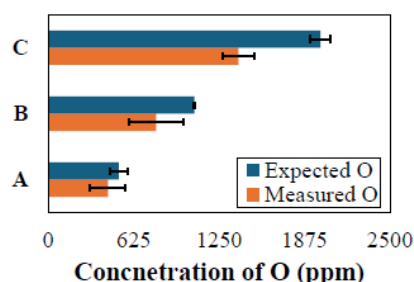


7 Nuclear Materials and Fuel Cycle Center



Oxygen Spiking

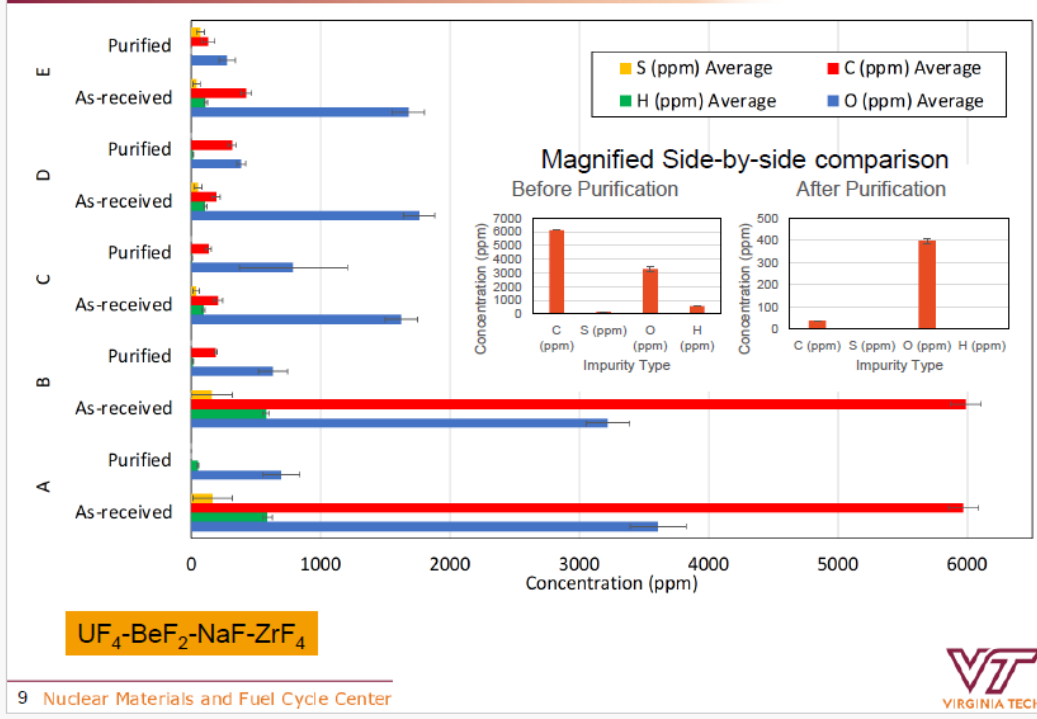
- $NaF + UO_2$
 - Materials used as received
 - NaF from Fisher Scientific (99.99%)
 - UO_2 ground by agate mortar and pestle
 - Target O concentrations of 500 (A), 1000 (B), and 2000 (C) ppm
 - Measured at 2,900 °C
 - Target sample weight 100.0 ± 1.0 mg
- 2 Trials
 - First trial (top) did not use carbon powder
 - Second trial (bottom) used 0.7 g carbon powder
 - Increased oxygen recovery with addition of graphite powder



8 Nuclear Materials and Fuel Cycle Center



Comparison of before and after purification



Hydrofluorination and chronoamperometry (CA)

- Concentrations of oxygen and hydrogen in salts were reduced after chemical purification of salt.
- The Ni concentration was reduced after chronoamperometry.

O/H analysis on as-received NaF, KF, and UF₄ and thermally and chemically purified FUNaK

ICP-MS analysis before and after CA

Salt	Concentration, µg/g	
	O	H
NaF	1608.26 ± 27.13	174.29 ± 8.15
KF	876.93 ± 94.10	48.92 ± 14.16
UF ₄	1757.56 ± 156.28	37.02 ± 6.91
Chemically purified FUNaK	312.03 ± 123.85	15.12 ± 8.15
Thermally purified FUNaK	1593.31 ± 425.18	13.98 ± 5.11

Sample	Concentration, mol%			
	Cr	Mn	Fe	Ni
Pre-test	0.004 ± 0.002	0.001 ± 0.000	0.034 ± 0.007	0.173 ± 0.010
Post-test	0.000 ± 0.000	0.000 ± 0.000	0.005 ± 0.001	0.016 ± 0.006
Change	-0.004	-0.001	-0.029	-0.157

Examining the effects of H_2 purge in salts

Test parameters: Purging of Be-bearing salt with 50% H_2 with balance Argon at 600°C.

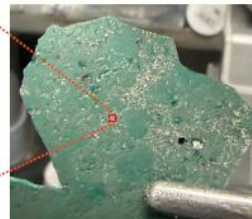
Pouring and Solidification



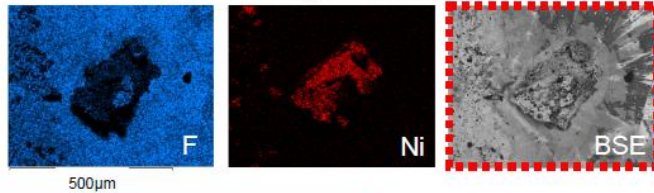
Solidified salt on Ni foil



Solidified Salt surface touching on wall of Ni200 crucible



SEM- EDS analysis on shiny particles

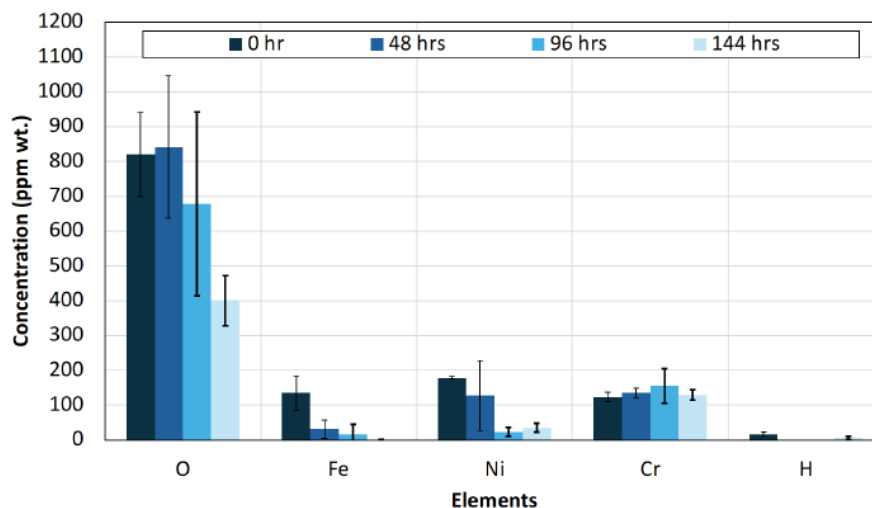


11 Nuclear Materials and Fuel Cycle Center



Evolution of impurities concentration with H_2 purge

- Oxygen decreases after 96hrs of purging
- Fe and Ni was reduced while Cr concentration remained the same
- Hydrogen decreased (samples not taken at 48 and 96hrs)



Note: Metallic fluorides were added into salt at the beginning of the tests
No sulfur was detected before and after tests (below detection limits >0.3ppm)

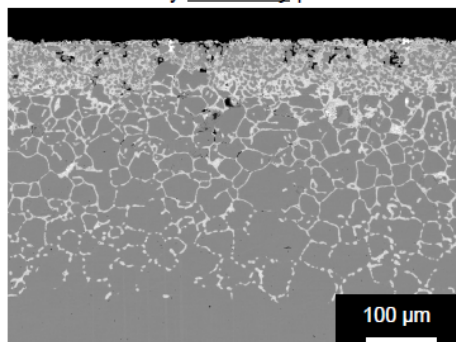
12 Nuclear Materials and Fuel Cycle Center



Chemical purification of FUNaK mitigated corrosion of SS316H

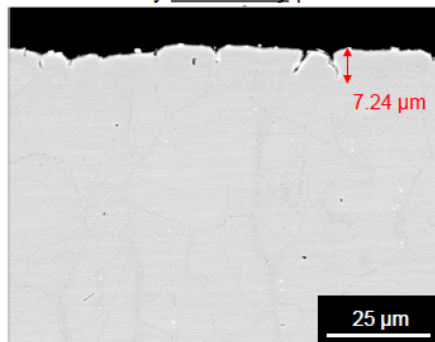
- ❑ Static Corrosion tests: 120 hours @800 C.
- ❑ Severe salt penetration through grain boundaries was observed from SS316H corroded by thermally purified salt.
- ❑ Compared to SS316H corroded by thermally purified FUNaK, those corroded by chemically purified salts showed much less corrosion with smaller salt-attack depth.

Corroded by thermally purified salt



Maximum Salt-attack Depth: 504.14 μm

Corroded by chemically purified salt



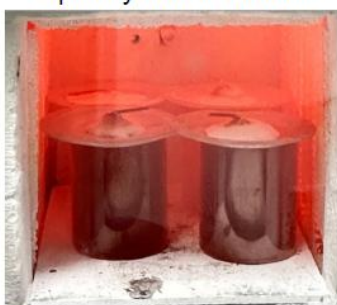
Maximum Salt-attack Depth: 7.24 μm

13 Nuclear Materials and Fuel Cycle Center



Oxygen Effects on corrosion (Be-bearing salt)

Open system in furnace



Sealed



SEM images of samples and concentration of oxygen (ppm)

Pre: 695±146 Post: 1427±195	Pre: 488±82 Post: 3727±230	Pre: 678±153 Post: 4923±873	Pre: 385±35 Post: 2455±534	Pre: 275±64 Post: 375±114	Pre: 269±114 Post: 361±35

Images of Post Test Salts



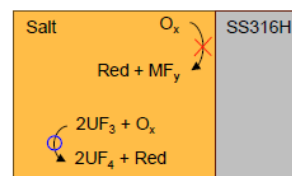
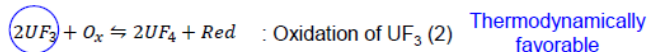
14 Nuclear Materials and Fuel Cycle Center



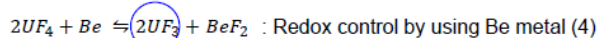
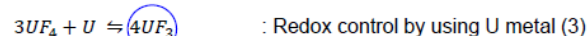
Corrosion Mitigation in the Molten salt under Metal Redox Control utilizing Beryllium and Uranium

Theoretical background

- To prevent the corrosion of structural material, the corrosion reaction (equ.1) should be suppressed.
- Corrosion mitigation strategy
: The introduction of UF_3 , the equation 1 will govern the equation 2 (corrosion of structural material)



- How to introduce UF_3 in the salt?
: To produce UF_3 in the salt, the U and Be metals will be introduced in the salt as shown below.



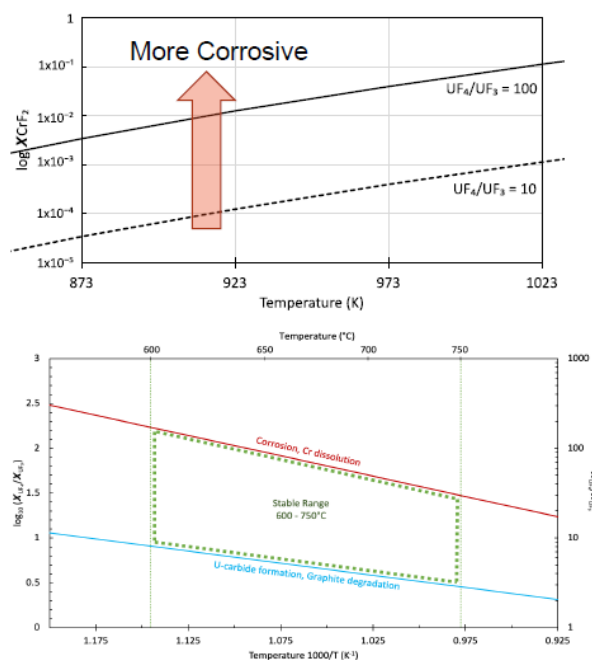
The UF_4/UF_3 ration will be controlled between 10-100 [1]. In this study, we use 45 as a target ratio.

[1] Zhang, Jinsuo, et al. "Redox potential control in molten salt systems for corrosion mitigation." Corrosion Science 144 (2018): 44-53.

15 Nuclear Materials and Fuel Cycle Center



Corrosion Mitigation-Redox Potential Control

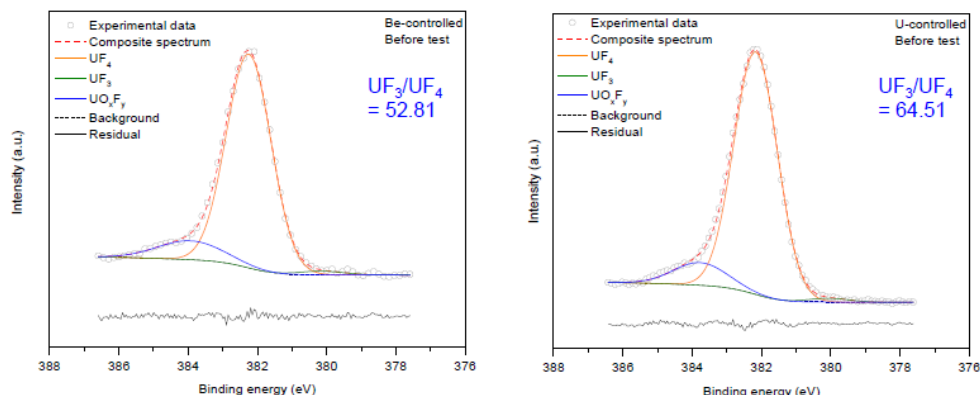


16 Nuclear Materials and Fuel Cycle Center



How to analyze the ratio

- XPS analysis after metal redox control.
- Slightly higher ratios of UF_3/UF_4 were obtained because metals reacted with the moisture in the salt.

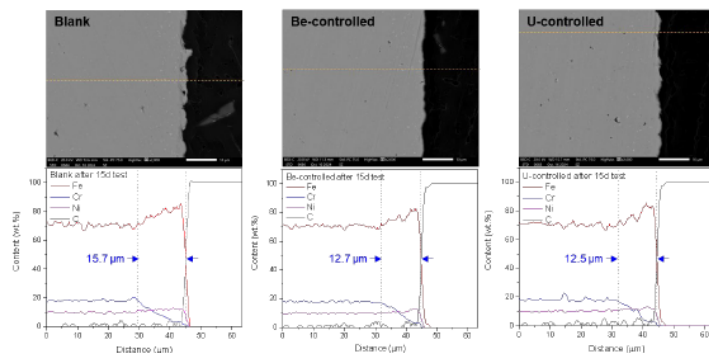
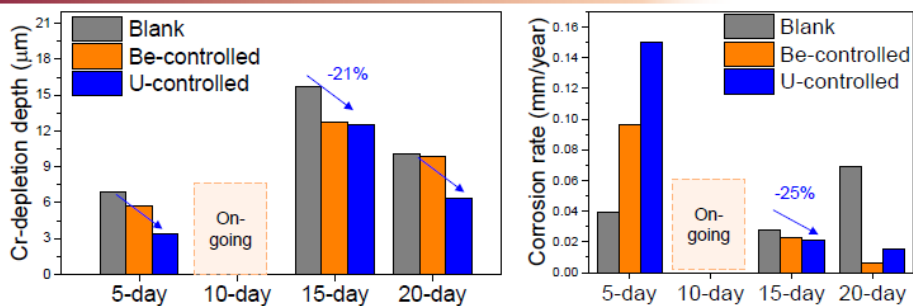


Target UF_4/UF_3 ratio	Be		U	
	Avg.	St. Dev	Avg.	St. Dev
45	52.81	2.62	64.51	11.06

17 Nuclear Materials and Fuel Cycle Center



Corrosion test-An example



15-day tests

18 Nuclear Materials and Fuel Cycle Center



Conclusion

- ☐ Before doing any tests, salt must be purified
- ☐ Combined physical, chemical and electrochemical methods can effectively remove metal, non-metal, and their chemical compounds
- ☐ Be-metal can be applied for redox potential control
- ☐ In the redox potential control salt, the corrosion is less than non-redox control salt
- ☐ Inert Gas fusion (O&H) and combustion gas analysis (C&S) are effective tools to characterize the non-metal content in fluoride salts

Day 2: BHSC Business Meeting

Led by Roland CHRETIEN, Chair and Josef SOBIERAJ & Chris DORN, Vice Chairs

Business Meeting Minutes compiled by Jack BENNETT, BHSC Recording Secretary

Minutes – BHSC 2025 Spring Business Meeting

Wednesday, 26 March 2025

10:04 EDT – 11:10 EDT

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 1-4 are in the voting session; remainder are in non-voting session)

1. Approval of this agenda
 - a. There is a quorum between those present and online.
 - b. The agenda was reviewed, and minor typographical errors were corrected. A motion for approval was made by Greg Heldt, seconded by Chris Dorn and approved by affirmation.
2. Election of Officers and other Board vacancies
 - a. Report of Nominating Committee (D. Field)
 - i. Danny Field reported that this will be his last official act as BHSC Board Member. Roland is assuming the position after doing two three-year terms. At Dan's request, Jack described the nomination\ voting process for Chris becoming chair of the BHSC. Chris received 43 affirmative and 0 negative votes. Danny offered Chris his congratulations and mentioned that although the term is 3 years that it tends to be 6 since the last three Chairs (Roland, Danny, and Mike Brisson) each did two terms.
 - ii. There is now an opening for Vice Chair. Chris nominated Beth Walker. Jack will send out an email asking for other nominations.
 - b. There are current vacancies in:
 - i. Research Subcommittee Chair and Co-Chair
 - ii. Membership Secretary
 - iii. Several member-at-large positions
 - c. Roland will become Immediate Past Chair, which carries with it the duty to nominate members for open positions on the Board
 - i. Roland thanked Danny for all his service to the Board
 - d. Lisa proposed that Victoria Robichaud replace Peggy Mroz as Co-Chair of the Med-Epi subcommittee in the Board Meeting. Although it was not required, Roland asked the Board if they agreed and received unanimous consent.
3. New business requiring a vote today
 - a. None
4. Chairman's Brief Report (R. Chretien)
 - a. Roland reviewed the activities since Spring 2024, including the Symposium in the Fall of 2024. The BHSC received money from the Symposium, which now allows BHSC to consider ways to improve the organization. Other important activities included a significant amount of work on the Practitioner's Guide and planning activities for this meeting.

5. Status of Funds (D. Jensen)
 - a. Funds available
 - i. PayPal - \$2,922.81
 - ii. Wells Fargo- \$22,829.36
 - b. Projects/debits
 - i. “Go Daddy” renewal, sponsorship
 - ii. Minor expenses for this meeting,
 - iii. Sponsorship of International Beryllium Workshop (see #7 below for more information)
6. Membership Report (J. Fowler)
 - a. No report from Julie, but Roland estimates there are more than 100 members, because a one-year membership was included in the registration fee for the Symposium. He hopes they stay involved, because it gives them access to the members only section and the ability to vote.
7. New Business (not requiring a vote)
 - a. Roland announced that BHSC is sponsoring the International Beryllium Workshop taking place in Japan. Since the cost is <\$2500, it does not require a vote. However, he asked the Board, and they agreed it was a good thing to do. The Board decided on a Gold level sponsorship.
 - b. Roland reviewed Article 1, Section 5 of the Bylaws, which discusses ethical conduct and read the section aloud. He said that good science requires robust debate, but it is important to be aware of conflicts of interest. He said that if a member violates this section that the offending member can\will be removed.

Break for Subcommittee Meetings

8. Subcommittee Reports
 - a. **Risk Communication:** Greg Nichols reported that the “band is getting back together” and he needs a co-chair. Greg talked about the need to develop tools to support the community both domestically and internationally.
 - b. **Research Needs:** No report
 - c. **Technical Standards/Practices/Measures:** Wes Adams and Eric Allred serve as Chair\Co-Chair and said that the Spring Meeting “Practitioner’s Guide” presentation will cover updates and status.
 - d. **Medical/Epidemiological:** Lisa said that during the breakout the group discussed FWP, testing new hires after 6 months, dove into some components of chest x-rays and spirometry. They said that deeper discussion on guidance that practitioners could give to workers after Be sensitization would be a good thing.
 - e. **Meetings and Symposia:** See below.
 - f. **Sampling and Analysis:** Kul reported that there were 17 attendees in the breakout. The discussions were around the Be Finder, field accreditation, how many samples to collect to assure statistical significance, etc. He said that the group meets every other month, and if anyone is interested in joining, they should contact him.

- g. **FLiBe:** The group discussed that it would be good to make meetings more accessible to US, European, and Japanese stakeholders. The meeting times will need to be periodically adjusted to make that possible. At the moment, the meeting times are not convenient for members in Asia or Australia.

9. Chair's Remarks (Chretien\Dorn)

- a. Josef introduced Roland and provided a recap of Roland's highlights since 2017. He said that Roland provided strong leadership through COVID tough years and during the good years since. He led the publishing of the 1st edition of the Practitioner's Guide and the efforts to publish the 2nd edition. He led the development of two symposia (2017 and 2024), in spite of a busy day job.
- b. Roland said his accomplishments were a team effort for the Board and others, and thanked everyone for their support, in this role and his other roles. Had the honor to be Chair and build on the efforts of others. The first challenge was putting the 2017 Symposium together, and a lot of people worked to make it happen. COVID was a down period for the BHSC. We were planning a 2020 Symposium and had to cancel, as well as the 2021 version that was going to take its place. He said the Chair needs to have his finger on the pulse of the organization and make decisions based on resources available. During the bad times, he challenged the group to decide whether to maintain the status quo until we got the energy back or dissolve the BHSC. The group decided to maintain the status quo, and as we were coming out of COVID, the energy started to come back, and the BHSC became re-energized, e.g. improved the website, the Practitioner's Guide revamp, and expanding internationally. He finished up by saying that succession planning is important. He routinely does it in his day job and always included it in the Board meeting agenda. He asked the membership to support Chris, and thanked everyone.
- c. Josef introduced Chris. He said they became Vice Chairs three years ago, and never got around to figure out who was 1st or 2nd Vice Chair. He said that Chris used his network to get leaders in industry and academia to support BHSC. He said that Chris promoted BHSC visibility by publishing minutes on Research Gate, and that he and Chris often discussed strategic vision for the BHSC.
- d. Chris said that the number one thing he wants to do is to say "thank you" for your support in his nomination and election. Roland has been a fantastic example in leadership and has even furthered Chris's understanding of leadership. Chris joined the BHSC during COVID (2020). It was a challenging time, and he remembered when Roland asked the tough questions. He hopes he will be able to ask the tough questions if necessary. He said he never planned to be Chair, and never pursued it, but he just wanted to contribute. He realized this was an amazing organization and wondered how it took him so long to find it. He also realized we need to spread the word and tell people about the good things we are doing, and publishing on Research Gate accomplishes that. Continuing our good work, especially the Practitioner's Guide, will be the top priority and he wants to get done by summer. He will go to the International Be Workshop (BeWS-17) in Japan to let them know about the Guide and how valuable it is. Another goal is expanding our global presence but not forgetting DOE and how important it is to the BHSC. We will never forget DOE. We also need to become a 501c3 or 501c6 to allow us to get on a better financial footing to allow us to help Board members travel and do other things as well.

Chris said that he is a collector, not only of things but quotations. There is an old African proverb that says, “If you want to go fast go alone, but if you want to go far go together.”

10. Plans for 2025 Fall Meeting

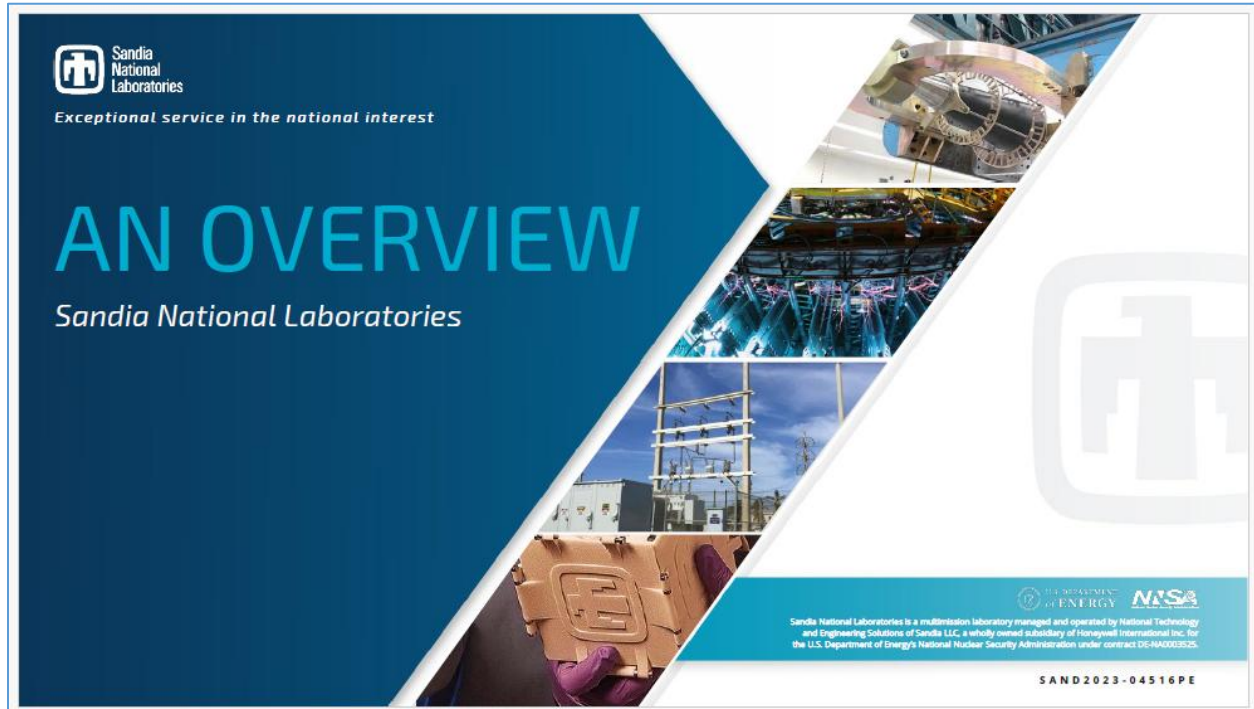
- a. Josef reported that we are well along with the planning. The meeting will be hosted by Sandia National Laboratory in Albuquerque, New Mexico, and we have developed a nice logo. Chris Quinn-Vawter from Sandia shared a presentation about Sandia’s history, and that Sandia has 11 sites nationwide, with about 16K employees. He described their portfolios and hopes to see us in November. He will try to get us into some of the interesting facilities for tours. Josef then shared the meeting announcement which had the logo. The BHSC Fall Meeting dates are Nov 18th and 19th 2025

11. Adjournment

- a. In his closing remarks, Roland talked some more about the vacancies. He said that Research used to be very active, and that we hope to bring it back. In the past, it brought new method ideas forward. We also need to look at young professionals and develop a pathway for them. We have need for a new Membership Secretary, so please tell Chris if you interested. Roland reiterated that we need help and asked for volunteers.
- b. Chris made a motion to adjourn that was seconded by Lisa and passed by affirmation.

BHSC 2025 Fall Meeting Announcement

Chris QUINN-VAWTER (Sandia National Laboratories, New Mexico, USA)



OUR HISTORY IS TRACED TO THE MANHATTAN PROJECT

The slide includes a historical document from the White House dated May 13, 1949, addressed to Mr. Wilson. The document discusses the Atomic Energy Commission's intent to use Sandia Laboratories for the development of the atomic weapon program. A yellow highlight on the document reads: 'In my opinion you have here an opportunity to render an exceptional service to the national interest.' Below the document is a portrait of Dr. Lewis A. Wilson, President of American Telephone and Telegraph Company. To the right, a photo shows a man and a woman looking at a control panel. At the bottom, there is a photo of a blimp and a logo for the 'BELL SYSTEM'.

- July 1945: Los Alamos creates Z Division
- Nonnuclear component engineering & systems integration
- Federally Funded Research and Development Center
- November 1, 1949: Sandia Laboratory established
- March 8, 1956: Sandia California officially opened
- AT&T: 1949-1993
- Martin Marietta: 1993-1995
- Lockheed Martin: 1995-2017
- Honeywell: 2017-present

2

SANDIA IS A FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTER MANAGED AND OPERATED BY

National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc.

Government-owned, contractor-operated

FFRDCs are long-term strategic partners to the federal government, operating in the public interest with objectivity and independence and maintaining core competencies in missions of national significance

3

WE HAVE FACILITIES ACROSS THE NATION

Main Sites
Albuquerque, New Mexico
Livermore, California

ARM Research Facility
Barrow, AK

Tonopah Test Site
Tonopah, NV

Minneapolis -St. Paul
Office

Kauai Test Facility
Kauai, HI

Sandia
Livermore, California

Sandia
Albuquerque, New Mexico

Waste Isolation Pilot Plant
Carlsbad, NM

Pantex Plant
Amarillo, TX

Scaled Wind Farm Technology Facility
Lubbock, TX

Weapons Evaluation Test Laboratory/
Amarillo, TX

Sandia Field Office
Washington D.C.

4

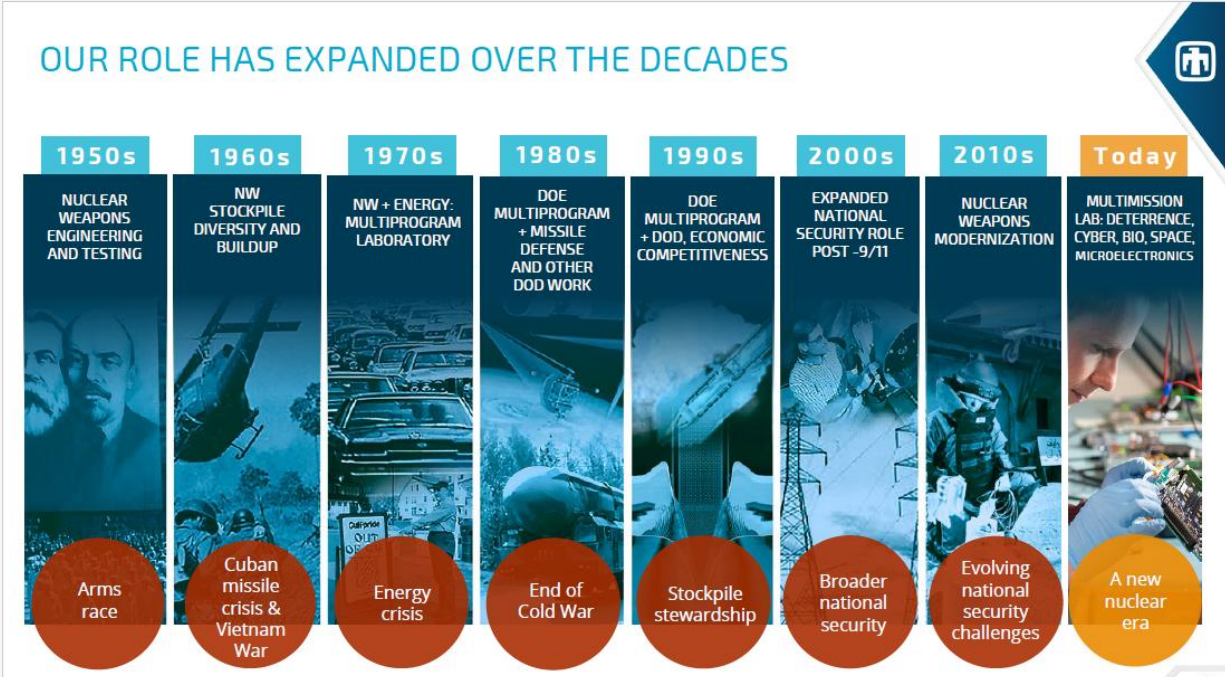


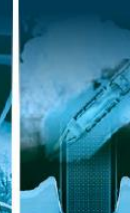
SANDIA'S CORE VALUES

- Serve the nation
- Respect each other
- Act with integrity
- Deliver with excellence
- Team for great results

5

OUR ROLE HAS EXPANDED OVER THE DECADES



1950s	1960s	1970s	1980s	1990s	2000s	2010s	Today
NUCLEAR WEAPONS ENGINEERING AND TESTING	NW STOCKPILE DIVERSITY AND BUILDUP	NW + ENERGY: MULTIPROGRAM LABORATORY	DOE MULTIPROGRAM + MISSILE DEFENSE AND OTHER DOD WORK	DOE MULTIPROGRAM + DOD, ECONOMIC COMPETITIVENESS	EXPANDED NATIONAL SECURITY ROLE POST -9/11	NUCLEAR WEAPONS MODERNIZATION	MULTIMISSION LAB: DETERRENCE, CYBER, BIO, SPACE, MICROELECTRONICS
							
Arms race	Cuban missile crisis & Vietnam War	Energy crisis	End of Cold War	Stockpile stewardship	Broader national security	Evolving national security challenges	A new nuclear era

6

NATIONAL SECURITY IS OUR MISSION

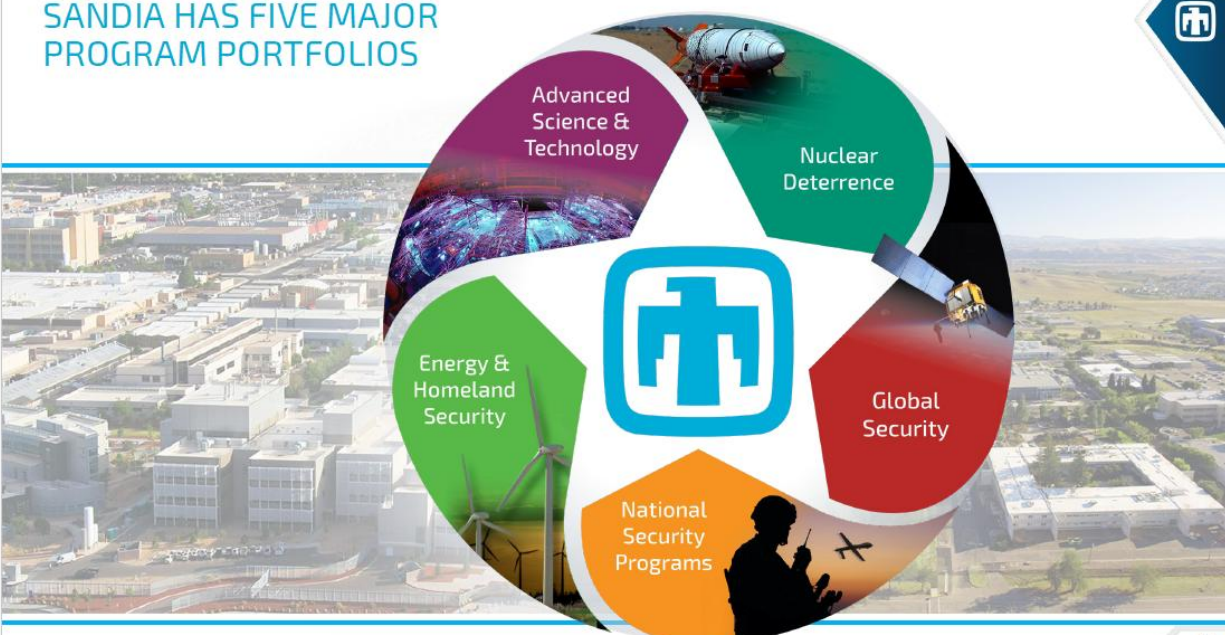
Sandia delivers essential science and technology to address the nation's most challenging security issues



PURPOSE	We render exceptional service in the national interest
VISION	We make Sandia a leader in keeping the world safe and secure
MISSION	We use innovative science and engineering to anticipate and solve the most challenging national security problems
OBJECTIVE	In 10 years, we will have unleashed high-velocity engineering to counter global threats

7

SANDIA HAS FIVE MAJOR PROGRAM PORTFOLIOS



Advanced Science & Technology

Nuclear Deterrence

Global Security

National Security Programs

Energy & Homeland Security

8



NUCLEAR DETERRENCE

Responsibilities form a critical mandate



Warhead systems engineering & integration

Specialized component production

- Neutron generators
- Sandia external production
- Microelectronics
- Thermal batteries

Multidisciplinary capabilities

Required for design, qualification, production, surveillance, computation/ experimentation

- Major environmental test facilities & diagnostics
- Materials sciences
- Light-initiated high explosives
- Computational analytics

Design agency for nonnuclear components

- Gas transfer systems
- Radar
- Safety systems
- Arming, fuzing and firing systems
- Neutron generators





Sandia's Weapon Quality organization proactively drives component and system reliability to ensure weapon quality

9



NUCLEAR DETERRENCE MODERNIZATION PROGRAMS

Nine major programs
Over **15 additional** sustainment and warhead design/production activities





W80-4 Life Extension Program (LEP)



W88 Alteration (ALT) 370*



B61-12 LEP *
B61-13 LEP

* Transitioning to stockpile



Sea Launched Cruise Missile - Nuclear (SLCM-N)



Mk21 Arming & Fuzing Assembly



Mobile Guardian Transporter

W93 Program



W87-1 Modification Program

10



 **ANNUAL STOCKPILE ASSESSMENT**

 Sandia is responsible for nuclear weapon systems and components over their entire lifecycle

Each year we assess the **safety and reliability** of every stockpile weapon type and document the findings in a letter from the Laboratories director to the Secretaries of Energy and Defense and the Chairman of the Nuclear Weapons Council

This assessment becomes a part of the annual formal report to the President of the United States on the overall condition of the stockpile

11



 **GLOBAL SECURITY** 

We deliver technical innovation that advances security and peace around the world

- Develop space- and ground-based sensor systems to monitor emerging threats
- Supply technology and training to respond to weapons of mass destruction crises
- Provide capabilities to protect U.S. nuclear weapons and materials at fixed sites and in transit
- Produce systems that deter proliferation and verify compliance with international agreements using space-borne and ground-based sensing technology
- Lead global technical engagement to prevent the misuse of nuclear, chemical, biological and radiological materials

12



NATIONAL SECURITY PROGRAMS

Provide trusted, threat-informed pathfinder technology for national security

Cyber Threat Program



Proliferation Assessments



Science & Technology Products



Surveillance & Reconnaissance



Information Sciences for National Security



Integrated Military Systems





13



ENERGY & HOMELAND SECURITY

Secures the nation's critical infrastructures and environment against attacks, threats and climate change by performing world-class research and development

- Enable the full potential of renewable energy and subsurface resources
- Ensure the safety, security and resilience of nuclear power and the electric grid, and the safe management and disposal of radioactive wastes
- Advance efficient and sustainable energy use for a changing world
- Reduce the nation's vulnerability to chemical, biological, radiological and nuclear threats
- Increase our nation's digital and physical critical infrastructure security and resilience to natural and human-made threats





14



ADVANCED SCIENCE & TECHNOLOGY

Integrates use-inspired, multidisciplinary efforts to propel the science of the possible for Sandia's missions

OFFICE OF SCIENCE (SC) PROGRAM

- Advanced and unique scientific and engineering capabilities support SC's priorities for DOE's missions
- SC-funded Sandians perform innovative, world-class research that cannot be pursued elsewhere and achieve national and international impact while countering science and technology surprise
- Provides an important talent pipeline, helping to attract and retain the best and brightest fundamental science researchers who contribute broadly across Sandia's missions over their careers



15

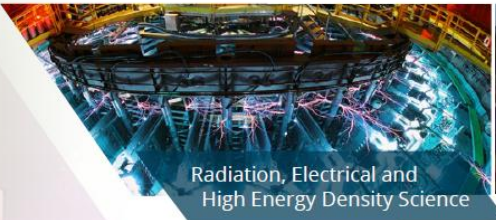


ADVANCED SCIENCE & TECHNOLOGY

Research Foundations play an integral role in mission delivery



Nanodevices & Microsystems



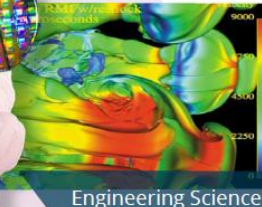
Radiation, Electrical and High Energy Density Science



Materials Science



Computing Information Science



Engineering Science



Earth Science



Bioscience

16

WHEN THE WORLD CALLS, SANDIA ANSWERS





USS Iowa
Sandia helped determine the cause of the explosion that killed 47 crew members on the U.S. Navy battleship. We used expertise in explosives and materials science to analyze the incident, including the gun turret and the potential for human error or mechanical failure.



Unabomber
Our expertise in forensic analysis, materials science and explosives was used to study the devices used by Theodore Kaczynski in a series of bombings over nearly two decades. We helped law enforcement understand the bombs' construction and functioning, which was crucial in linking the attacks.



Space Shuttle Columbia
Sandia's engineering teams helped NASA understand the shuttle's destruction, analyzing the foam strike on the wing and its effects.



TWA Flight 800
After the plane exploded within minutes of takeoff from New York, killing all 230 people on board, Sandia analyzed the wreckage and did simulations to understand the dynamics including fuel tank ignition and the role of electrical systems, clarifying circumstances surrounding the tragedy.



Deepwater Horizon Oil Spill
Our experts helped develop the cap that sealed the well, stopping oil from leaking into the Gulf of Mexico. They also worked on solutions for monitoring and preventing similar incidents in the future.



Shoe Bomber
When Richard Reid tried to detonate explosives hidden in his shoe on American Airlines Flight 63 in 2001, Sandia provided expertise in materials analysis to understand the nature of the explosives and how they could be detected. The research led to improved airport security and detection technologies to prevent similar attacks in the future.



Fukushima Daiichi Nuclear Disaster
Sandia played a key role in assessing the nuclear reactor damage and providing safety and mitigation recommendations after the earthquake and tsunami caused severe nuclear meltdowns.

We also helped with:

- Sensors for Vietnam
- Nuclear waste storage (WIPP, Yucca Mountain)
- Strategic Petroleum Reserve
- Chernobyl Exclusion Zone
- Oil-warfare effects in Kuwait
- Post-9/11 counterterrorism
- Anthrax attacks
- Hurricane Katrina
- Sago Mine
- Ebola outbreak
- COVID-19 pandemic

17

SANDIA IS BUILDING CLIMATE SECURITY THROUGH SCIENCE, TECHNOLOGY AND ACTION



- Advance the state of the art within three climate focal areas: measurement and modeling, clean energy and processes, and resilient infrastructure
- Apply climate expertise to strategic cross-cutting issues including risk assessment and decision support, intervention, arctic science and security, mitigation and adaptation, and treaty monitoring and verification
- Develop cutting-edge R&D facilities like a next generation concentrating solar power plant and climate security analysis center
- Model the way forward in site sustainability with the goal of net-zero emissions at Sandia/California by 2040 and Sandia/New Mexico by 2045



18

OUR MULTIPLE SCIENCE AND ENGINEERING DISCIPLINES UNITE TO PRODUCE TECHNOLOGIES THAT CHANGE THE WORLD



Sandia pioneered clean room technology to protect the circuitry that controls nuclear weapons. It went on to be used in hospitals, computers and smartphones.



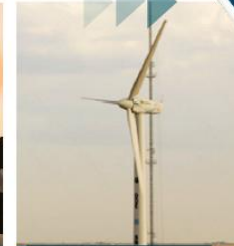
Sandia's mobile SpinDX diagnostic device can test for viruses, bacteria and active toxins in less than an hour while the microneedles technique extracts interstitial fluid to quickly diagnose major illnesses or measure exposure to chemical or biological agents



Sandia found it was possible to build and operate a high-speed passenger ferry and research vessel powered solely by zero-emission hydrogen fuel cells. **The research led to the first fuel cell vessel built in the U.S. and the world's first commercial fuel cell**



Sandia is a leader in research for Unmanned Aerial Vehicles and associated countermeasures building off our robotics legacy. **Our robotics have been used to reach trapped miners, demilitarize submunitions and disable IEDs.**



An innovative, 27.5-meter wind turbine blade developed by Sandia and industry **produces up to 10 percent more energy** than traditional linear blade designs without increasing wear and tear on the machine

19





Sandia National Laboratories



BHSC 2025 Fall Meeting

Beryllium Health & Safety Committee
Albuquerque, New Mexico
18-19 November 2025

The Sandia National Laboratories in Albuquerque, New Mexico will be the host facility for the BHSC 2025 Fall Meeting on 18-19 November 2025. It should be a great event, and it will hopefully include a tour of some of the Sandia facilities (still to be confirmed). Please check the BHSC website for details and updates as available.

Appendices

BHSC 2025 Spring Meeting Participants List

Family Name	First Name	Organization	Country	Status
Adams	Wesley	NNSA Los Alamos Field Office	US	Virtual
Allred	Eric	NNSA Nevada Field Office	US	Virtual
Ashley	Kevin	Ashley Analytical Associates	US	Virtual
Baker	Derrick	DOE Office of Management	US	Virtual
Banta	Gregory	Force Health Protection, CFHS HQ	CA	In Person
Barker	Lisa	National Jewish Health	US	In Person
Barksdale	Jermaine	NNSA Savannah River Field Office	US	Virtual
Beaulieu	Tim	Massachusetts Institute of Technology	US	Virtual
Bejar Alonso	Isabel	CERN (European Centre for Nuclear Research)	CH	Virtual
Bendo-Watson	Lucas	Codeac Solutions, Inc.	UK	Virtual
Bennett	Jack	Lawrence Livermore National Lab	US	In Person
Bernholc	Nicole	Brookhaven National Laboratory	US	Virtual
Bradley	Adam	Portsmouth Paducah Project Office	US	Virtual
Brisson	Mike	Savannah River National Laboratory	US	Virtual
Brown	April	DOE HQ Worker Safety and Health Policy	US	Virtual
Brown	Michael	NNSA Y-12 Field Office	US	Virtual
Bryson	Drew	UT-Battelle/ORNL	US	Virtual
Bye	Amanda	Xcimer Energy	US	In Person
Cannon	Amory	ORAU/ORISE/DOE Ctr	US	Virtual
Carroll	Stephanie	Atomic Worker Advocacy Inc	US	Virtual
Casalina	Cindy	NNSA HQ Worker Safety and Health	US	Virtual
Chandler	Sybil	NNSA Kansas City Field Office	US	Virtual
Chauhan	Ankur	Homi Bhabha National Institute	IN	Virtual
Chiusano	Stephen	DOE Office of Fossil Energy and Carbon Management	US	Virtual
Chretien	Roland	Edgewater Technical Associates	US	In Person
Combs	William	Catawba Corporation	US	Virtual
Coppersmith	Pamela	DOE Richland Office	US	Virtual
Cousins	Joanne	Atomic Weapons Establishment	UK	Virtual
Crosby	Kali	DOE HQ Health Studies and Activities	US	Virtual
Davis	Lindsay	CNS - Y-12 National Security Complex	US	Virtual
Devine	Meghan	Commonwealth Fusion Systems	US	In Person
Dobbins	Joseph	DOE Office of Management	US	Virtual
Dooris	Matthew	DOE HQ Worker Safety and Health Policy	US	Virtual

*Minutes of the Beryllium Health & Safety Committee (BHSC) 2025 Spring Meeting
25-26 March 2025 – Cobourg, Ontario, Canada*

Family Name	First Name	Organization	Country	Status
Dorn	Chris	Be4FUSION LLC Rockland Resources Ltd.	US	In Person
Dumas	Constantine	Materion Brush Inc.	US	In Person
Fadel	Gus	U.S. Department of Energy, Office of Safety and Security, Safety Division	US	Virtual
Field	Danny	NNSA HQ Worker Safety and Health	US	Virtual
Foster	James	NNSA HQ Worker Safety and Health	US	Virtual
Freiderich	Melissa	Codeac Solutions/ Color Tech Holdings Inc.	US	Virtual
Garg	Kul	Livermore Field Office	US	Virtual
Glover	Joanna	Cameco Fuel Manufacturing	CA	In Person
Goraieb	Aniceto	Karlsruhe Beryllium Handling Facility GVT GmbH & Co. KG	DE	Virtual
Gordon	William	Los Alamos National Laboratory	US	Virtual
Greenough	Megan	Katmai Diversified Services	US	Virtual
Hall	William	HMIS	US	Virtual
Hanebuth	Julie	Argonne National Laboratory	US	Virtual
Hand	Donna	Help By hand LLC	US	Virtual
Hanna	Cliff	General Atomics	US	Virtual
Heck	Lindsay	U.S. Army Corps of Engineers	US	Virtual
Heldt	Gregory	Materion Brush Inc.	US	In Person
Helland	Jessica	ALS Environmental, Salt Lake	US	Virtual
Holden	Vern	UCOR LLC	US	Virtual
Holey	Brandy	Kansas City National Security Campus	US	Virtual
Howe	Teresa	General Dynamics Mission Systems	US	In Person
Imai	Tomoaki	MiRESSO Co. Ltd.	JP	In Person
James	Dustin	Savannah River Field Office	US	Virtual
Jensen	Annalyn	Utah State University	US	Virtual
Jensen	Dan	NNSA Nevada Field Office	US	Virtual
Jensen	Doug	Cameco Corporation	CA	In Person
Jolley	Jaden	BWXT Nuclear Energy Canada, Inc.	CA	In Person
Joniec	James	Savannah River Field Office	US	Virtual
Kennelly	Tristan	Codeac Solutions, Inc.	UK	Virtual
Kivuyo	Janet	United States Coast Guard Academy	US	Virtual
Knox	Chris	Cameco Fuel Manufacturing	CA	In Person
Knudson	Ted	Materion Corporation	US	Virtual
Kopp	Jody	Cameco Corporation	CA	In Person
Kreager	Chuck	DOE Office of Science (HQ)	US	Virtual
Kubiak	Karen	Department of Energy - Idaho Field Office	US	Virtual
Lamere	Edward	Massachusetts Institute of Technology	US	Virtual

*Minutes of the Beryllium Health & Safety Committee (BHSC) 2025 Spring Meeting
25-26 March 2025 – Cobourg, Ontario, Canada*

Family Name	First Name	Organization	Country	Status
Maestas	Lynn	NNSA HQ Worker Safety and Health	US	Virtual
Mariella Jr.	Raymond	University of San Francisco	US	Virtual
Meade	Bevan	ALS Environmental	US	Virtual
Meyer	Ken	Pantex Plant	US	In Person
McCandless	Tom	MCC Geoscience Inc. (Exploration & Mining)	CA	Virtual
Nakamichi	Masaru	MiRESSO Co. Ltd.	JP	In Person
Neville	Robert	Cameco Fuel Manufacturing	CA	In Person
Neyens	Mallory	DOE HQ Worker Safety and Health Policy	US	Virtual
Nichols	Gregory	Oak Ridge Institute for Science and Education (ORISE)	US	In Person
Oh	Thomas	Lawrence Livermore National Laboratory	US	Virtual
Peek	Matthew	NNSA Pantex Field Office	US	Virtual
Polek	Michael	U.S. Army Corps of Engineers	US	Virtual
Price	Regina	DOE HQ Worker Safety and Health Policy	US	Virtual
Quinn-Vawter	Christopher	Sandia National Laboratories	US	Virtual
Reed	William	Los Alamos National Laboratory - N3B BWXT	US	Virtual
Rhambarose	Harri	DOE- Enterprise Assessments	US	Virtual
Robichaud	Andre	Infrastructure Health & Safety Association	CA	In Person
Robichaud	Eric	General Interest	CA	In Person
Robichaud	Victoria	Cameco Fuel Manufacturing	CA	In Person
Roddy	Crystal	Cameco Fuel Manufacturing	CA	In Person
Saban	Cindy	NNSA - Savannah River Field Office	US	Virtual
Isaiah	Idriss	Hematology Lab (ImmuniT)	CA	Virtual
Serra	Joanna	DOE Office of Science (HQ)	US	Virtual
Shirey	Pamela	BWXT Nuclear Operations Group, Inc.	US	Virtual
Shore	Jordan	Massachusetts Institute of Technology	US	Virtual
Slade	Don	Cameco Fuel Manufacturing	CA	In Person
Slightham	George	GS Consulting Rockland Resources Ltd.	CA	In Person
Smith	Lindsay	Y-12 National Security Complex	US	Virtual
Sobieraj	Josef	NNSA HQ Worker Safety and Health	US	Virtual
Somers	Scott	Battelle - Pacific NW National Lab	US	Virtual
Stein	Elliot	DOE - Office of Science	US	Virtual
Taruru	Seuri	Nevada National Security Site - Mission Support and Test Services	US	Virtual
Thayn	Paterick	Pacific Northwest National Laboratory	US	Virtual
Volza	Joseph	NNSA Sandia Field Office	US	Virtual
Walker	Beth	Safer Environment Ltd.	UK	In Person

Family Name	First Name	Organization	Country	Status
Wentz	Romona	DOE - Hanford Site	US	Virtual
Wilmot	Zeke	Los Alamos National Laboratory	US	Virtual
Wirgau	Thomas	DOE- Enterprise Assessments	US	Virtual
Woller	Kevin	Massachusetts Institute of Technology	US	Virtual
Yada	Shian	NNSA Pantex Field Office	US	Virtual
Yakushiji	Koki	Mitsui & Co., Ltd.	JP	In Person
Zaleski	Christopher	General Atomics	US	Virtual
Zhang	Jinsuo	Virginia Tech University	US	Virtual

Country Name Key

CA = Canada

CH = Switzerland

DE = Germany

IN = India

JP = Japan

UK = United Kingdom

US = United States of America

Meeting & Venue Photos



Opening remarks kicked off the BHSC 2025 Spring Meeting. Left: Cameco General Manager Doug JENSEN delivers his welcome to 28 in-person attendees at the Venture 13 Centre in Cobourg and another 80-90 participants online. Photo credits: Chris KNOX, Cameco Fuel Mfg.



Following the remarks from Cameco leadership, participants were welcomed by BHSC Chair Roland CHRETIEN (left) and Vice Chairs Chris DORN (middle) and Josef SOBIERAJ (right). Due to travel constraints, Josef joined the meeting online. The photo at left also shows Roland, by Day 2 the outgoing Chair, congratulating Chris as incoming Chair.



Most of the in-person participants at the BHSC 2025 Spring Meeting assembled in the Venture 13 Centre, where the Meeting was held on Tuesday, 25 March 2025. Photo credit: Chris KNOX, Cameco Fuel Mfg.



Left: The Spring Meeting participants look on as Beth WALKER of Safer Environment Ltd. in the UK talked about the challenges involved in the safe decontamination and decommissioning of former beryllium facilities. Right: Close-up of the speaker. Photo credits: Chris KNOX of Cameco Fuel Mfg.



Representatives from Materion Brush Inc. gave an in-depth presentation about genetic testing as it relates to beryllium health effects. Left: Dr. Constantine “Gus” DUMAS, Medical Director at Materion, was the presenter and corresponding author. Right: Greg HELDT, who is in charge of Beryllium Product Stewardship at Materion and a presentation co-author, was also in attendance at this year’s Spring Meeting.



In-person attendees look on at the Venture 13 Centre (left) as Victoria ROBICHAUD of Cameco (right) explains some of the logistics for the Spring Meeting, including the opportunity to sign up for tours of the local Cameco facilities (see next page). Photo credits: Chris KNOX of Cameco Fuel Mfg.



BHSC 2025 Spring Meeting participants in action. Left: Lisa BARKER of National Jewish Health shown here during her presentation on sarcoidosis. Middle left: Jack BENNETT of Lawrence Livermore National Lab and BHSC Recording Secretary, shown here taking minutes during the business meeting. Middle right: Greg NICHOLS of ORISE giving a report from the Risk Communications Sub-Committee. Far right: Tomoaki "Tom" IMAI of MiRESSO Co. in Japan, who introduced the BHSC attendees to his company and their new process for refining beryl ore into beryllium. Photo credits: Chris KNOX of Cameco Fuel Mfg.



Day 2 of the 2025 Spring Meeting included tours of the Cameco Fuel Manufacturing facilities in Cobourg and Port Hope. Left: A Cameco worker assembling a zirconium alloy fuel bundle, which is brazed together using beryllium. Right: An exterior photo of Cameco's Port Hope facility. Both photos courtesy of Cameco Fuel Manufacturing.



The success of the 2025 Spring Meeting would not have been possible without the generous sponsorship of Cameco Fuel Manufacturing and the two active BHSC members who made it all happen: Victoria ROBICHAUD (left) and Crystal RODDY (right). Photo credit: Chris KNOX of Cameco Fuel Mfg.