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

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

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

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

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

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

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Introduction & Post-Meeting Overview

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

Mission Statement

The BHSC is committed to promoting activities/efforts that will help to understand and prevent beryllium-induced conditions and illnesses, including beryllium sensitization (BeS) and chronic beryllium disease (CBD), that may be caused or exacerbated by workplace exposure to beryllium. The BHSC mission is primarily educational in nature, and is accomplished through generation, collection, and dissemination of information to members and other interested parties.

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

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

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

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

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

Josef SOBIERAJ
Chair, BHSC Meetings & Symposia Sub-Committee
December 2023

BHSC 2023 Fall Meeting Agenda

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

AGENDA – Beryllium Health and Safety Committee Meeting
7-8 November 2023 – DOE Forrestal Building, Washington, D.C.
Also available virtually; links to be provided later

All times listed below are Eastern Standard Time (EST)

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

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

(Second day on next page)

Day 2 – Wednesday, 8 November 2023
Room 1E-245

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

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

BHSC Meetings & Symposia Sub-Committee

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

BHSC 2023 Fall Meeting Vendor Organizations

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

ALS Testing Services **Salt Lake City, Utah, U.S.A.**	**GVS-RPB: Respiratory Protection Solutions** **Royal Oak, Michigan, U.S.A.**

Day 1: Beryllium H&S: DOE, DOL & CBD Program Updates, Predicting BeS & CBD, NNSA Economic Assessment, Fusion & FLiBe Molten Salt

Three Borderline BeLPTs Predicting Beryllium Sensitization and Chronic Beryllium Disease

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

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

Margaret M. Mroz MSPH[1], Annyce Mayer MD MSPH[1], Lisa Barker MPH[1], and Lisa A. Maier MD, MSPH[1,2]

[1]*National Jewish Health, Denver, Colorado, U.S.A.*
[2]*University of Colorado, Denver, Colorado, U.S.A.*

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

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

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

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

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

National Jewish Health
Breathing Science is Life.

Three Borderline BeLPTs Predicting BeS and CBD

Peggy Mroz, MSPH
Annyce Mayer, MD MSPH
Lisa Barker, MPH
Lisa Maier, MD MSPH

BHSC Fall 2023
November 7, 2023

August 24, 2022

Senator Murray Meets with Hanford Workers, Announces Bill to Help Workers Access Care for Beryllium Exposure

ICYMI: Senator Patty Murray Secures Major Increase in President's Budget Request for Hanford Cleanup, Continues to Push on Federal Commitment – MORE HERE

Murray: "My new bill will expand access to benefits for sick workers who are not getting the care they need because of a technicality—this is a wrong I am determined to make right. Passing this legislation will save lives and I'll be working hard to get this done as soon as possible."

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Workers Speak Out

"For nearly thirteen years I've worked at Hanford and I'm very proud of the important work we do. One of the hazards workers face at Hanford is exposure to the toxic metal beryllium. Because of this risk my blood was drawn for a test – the beryllium lymphocyte proliferation test – and received three borderline results, which medical experts on beryllium consider beryllium sensitization," ***said , Hanford worker***. "Two years later, my doctor found a granuloma in my lungs and diagnosed me with Chronic Beryllium Disease. Despite a diagnosis by my doctors of beryllium sensitization and chronic beryllium disease, I have not received federal benefits for either condition under the Energy Employees Occupational Illness Compensation Act (EEOICPA). Senator Murray's legislation would change that and I strongly support the *Beryllium Testing Fairness Act*. I don't want any other worker to have to deal with the frustration I have had of dealing not only with a medical disease but also being denied the benefits we deserve."

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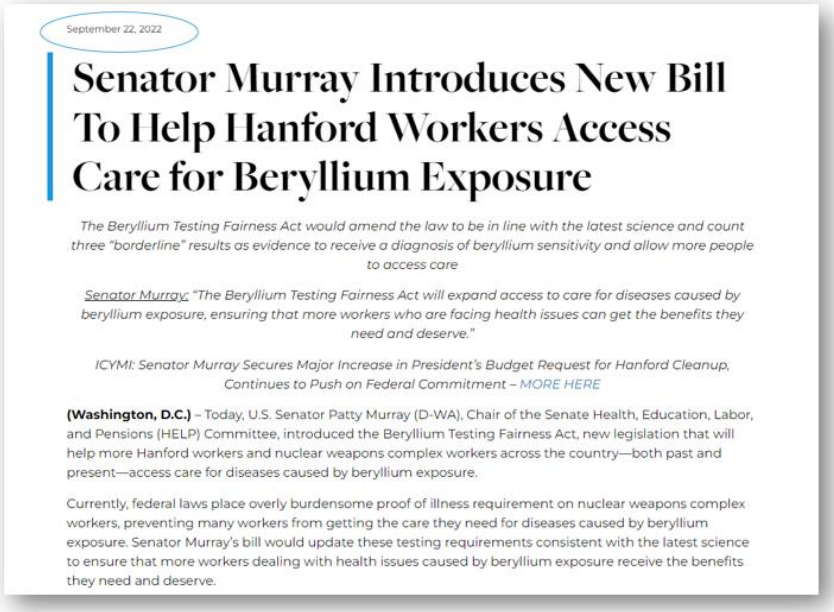

September 22, 2022

Senator Murray Introduces New Bill To Help Hanford Workers Access Care for Beryllium Exposure

The Beryllium Testing Fairness Act would amend the law to be in line with the latest science and count three "borderline" results as evidence to receive a diagnosis of beryllium sensitivity and allow more people to access care

Senator Murray: "The Beryllium Testing Fairness Act will expand access to care for diseases caused by beryllium exposure, ensuring that more workers who are facing health issues can get the benefits they need and deserve."

ICYMI: Senator Murray Secures Major Increase in President's Budget Request for Hanford Cleanup, Continues to Push on Federal Commitment – MORE HERE

(Washington, D.C.) – Today, U.S. Senator Patty Murray (D-WA), Chair of the Senate Health, Education, Labor, and Pensions (HELP) Committee, introduced the Beryllium Testing Fairness Act, new legislation that will help more Hanford workers and nuclear weapons complex workers across the country—both past and present—access care for diseases caused by beryllium exposure.

Currently, federal laws place overly burdensome proof of illness requirement on nuclear weapons complex workers, preventing many workers from getting the care they need for diseases caused by beryllium exposure. Senator Murray's bill would update these testing requirements consistent with the latest science to ensure that more workers dealing with health issues caused by beryllium exposure receive the benefits they need and deserve.

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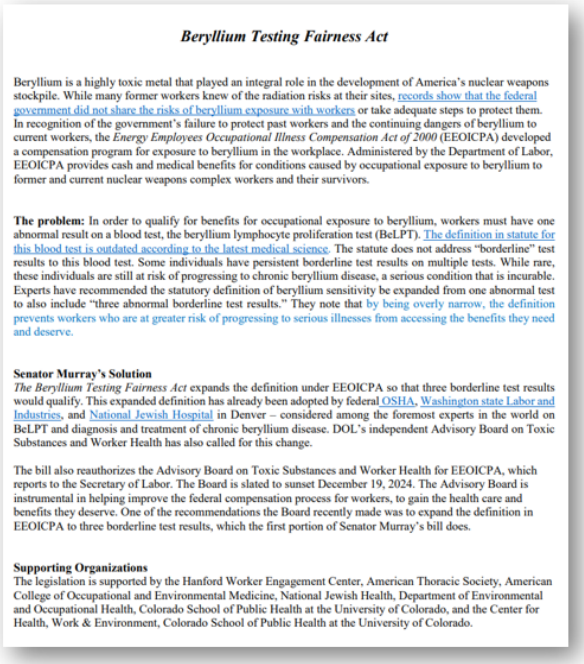

Beryllium Testing Fairness Act

Beryllium is a highly toxic metal that played an integral role in the development of America's nuclear weapons stockpile. While many former workers knew of the radiation risks at their sites, records show that the federal government did not share the risks of beryllium exposure with workers or take adequate steps to protect them. In recognition of the government's failure to protect past workers and the continuing dangers of beryllium to current workers, the *Energy Employees Occupational Illness Compensation Act of 2000* (EEOICPA) developed a compensation program for exposure to beryllium in the workplace. Administered by the Department of Labor, EEOICPA provides cash and medical benefits for conditions caused by occupational exposure to beryllium to former and current nuclear weapons complex workers and their survivors.

The problem: In order to qualify for benefits for occupational exposure to beryllium, workers must have one abnormal result on a blood test, the beryllium lymphocyte proliferation test (BeLPT). The definition in statute for this blood test is outdated according to the latest medical science. The statute does not address "borderline" test results to this blood test. Some individuals have persistent borderline test results on multiple tests. While rare, these individuals are still at risk of progressing to chronic beryllium disease, a serious condition that is incurable. Experts have recommended the statutory definition of beryllium sensitivity be expanded from one abnormal test to also include "three abnormal borderline test results." They note that by being overly narrow, the definition prevents workers who are at greater risk of progressing to serious illnesses from accessing the benefits they need and deserve.

Senator Murray's Solution
The Beryllium Testing Fairness Act expands the definition under EEOICPA so that three borderline test results would qualify. This expanded definition has already been adopted by federal OSHA, Washington state Labor and Industries, and National Jewish Hospital in Denver – considered among the foremost experts in the world on BeLPT and diagnosis and treatment of chronic beryllium disease. DOL's independent Advisory Board on Toxic Substances and Worker Health has also called for this change.

The bill also reauthorizes the Advisory Board on Toxic Substances and Worker Health for EEOICPA, which reports to the Secretary of Labor. The Board is slated to sunset December 19, 2024. The Advisory Board is instrumental in helping improve the federal compensation process for workers, to gain the health care and benefits they deserve. One of the recommendations the Board recently made was to expand the definition in EEOICPA to three borderline test results, which the first portion of Senator Murray's bill does.

Supporting Organizations
The legislation is supported by the Hanford Worker Engagement Center, American Thoracic Society, American College of Occupational and Environmental Medicine, National Jewish Health, Department of Environmental and Occupational Health, Colorado School of Public Health at the University of Colorado, and the Center for Health, Work & Environment, Colorado School of Public Health at the University of Colorado.

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July 27, 2023

Senator Murray Votes for National Defense Authorization Act, Senate-Passed Legislation Includes Murray's Bill to Help Hanford Workers Suffering from Toxic Beryllium Exposure

ICYMI: Murray's Bill to Help Hanford Workers Suffering from Toxic Beryllium Exposure Included in Must-Pass National Defense Authorization Act

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Does BeS/CBD Develop In Those With Repeated Borderline BeLPTs?

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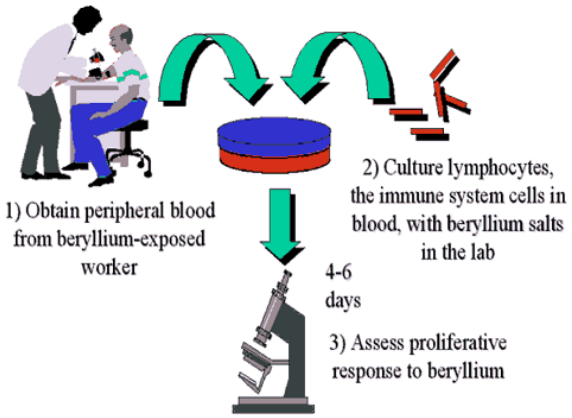
How is the BeLPT performed?



- Culture peripheral blood or BAL cells alone and w/ 3 concentration of Be on 2 days of culture
- Measure incorporation of ^{3}H-Td for proliferation
- Stimulation index or SI : ratio of Be-stimulated to unstimulated cpm
- Use positive controls to ensure cells are able to proliferate

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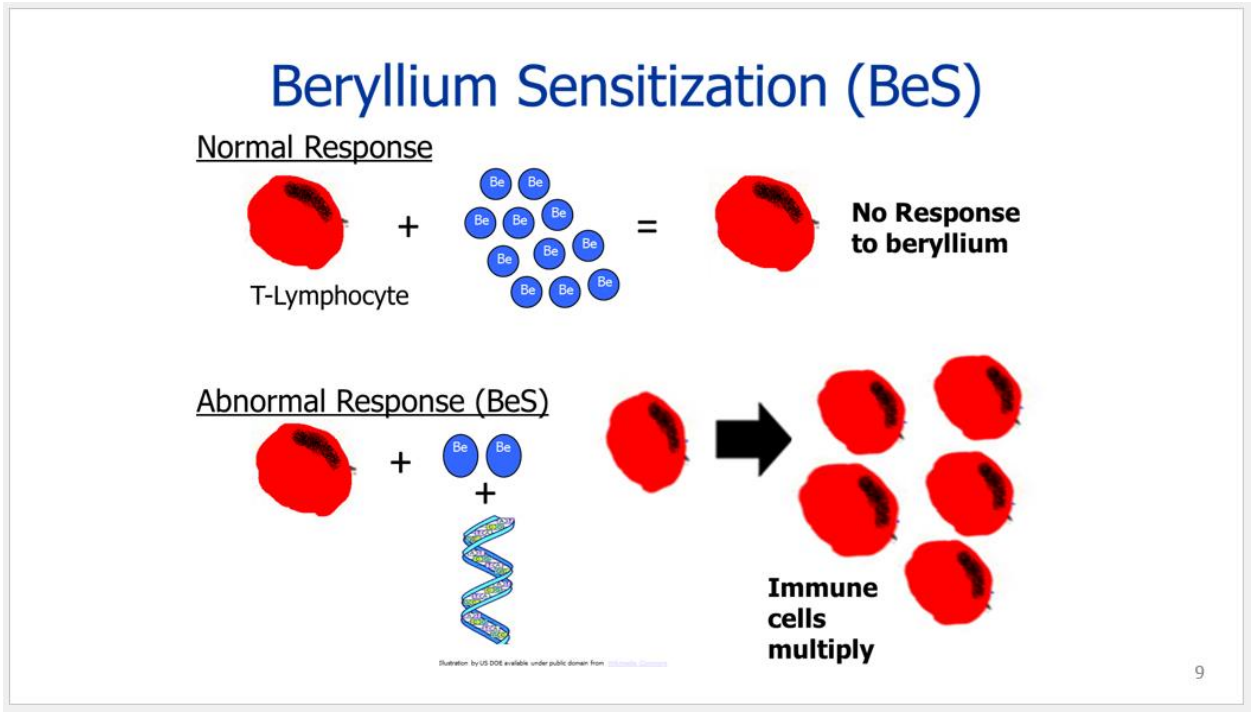
Beryllium Sensitization (BeS)
Normal Response
Be
T-Lymphocyte
No Response to beryllium
Abnormal Response (BeS)
Immune cells multiply
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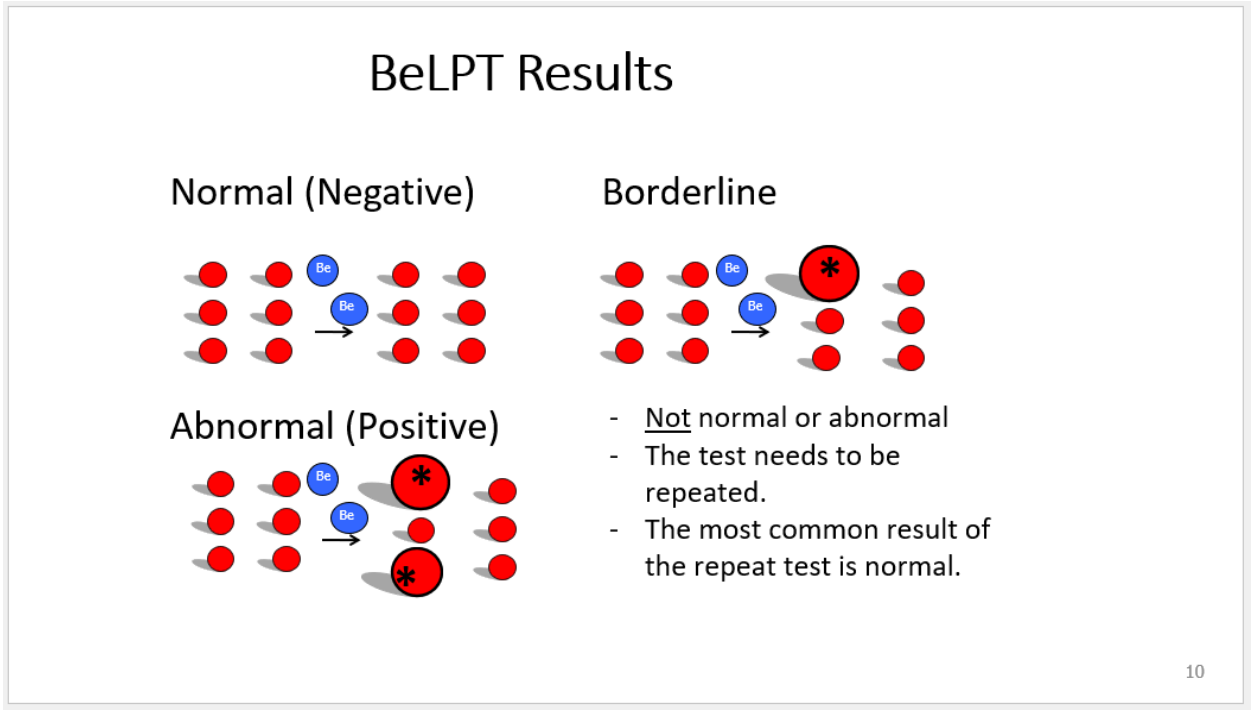
BeLPT Results
Normal (Negative)
Borderline
Abnormal (Positive)
- Not normal or abnormal
- The test needs to be repeated.
- The most common result of the repeat test is normal.
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What about repeated Borderline Tests?

- **BeS:** 2 AB BeLPTs or AB bronchoalveolar lavage (BAL) BeLPT
- **Abnormal BeLPT (AB)**: ≥ 2 of 6 stimulation indices are elevated.
- **Borderline BeLPT (BL)**: 1 elevated stimulation index.

A study by ATSDR suggested that **3 BL BeLPTs** could predict BeS based on modeling (Middleton et. al. 2011)

Hypothesis: Repeated BL BeLPTs, in the absence of an AB test, can predict BeS and CBD.

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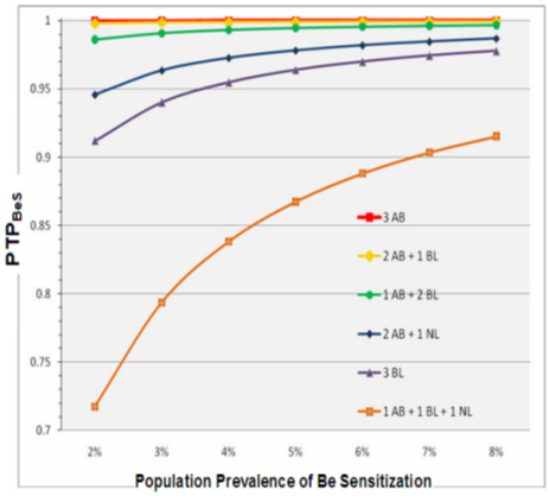
Predictive Value of Borderline BeLPT Results in Combination

- 1 AB + 1 BL
- 3 BLs
  - Predictive value approaches 2 AB
    - Prevalence ≥ 2-3%



Middleton DC Am J Ind Med 2008
Middleton DC Am J Ind Med 2011

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TABLE I. Post-Test Probability of BeS (PTP_{BeS}) at Various Prevalences, by Result Combination

	Post-test probability of BeS (PTP-BeS)[b]									
	Population prevalence									
Results (three-tests)[a]	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
3 AB	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2 AB, 1 BL	0.996	0.998	0.999	0.999	0.999	0.999	0.999	1.000	1.000	1.000
1 AB, 2 BL	0.972	0.986	0.991	0.993	0.995	0.996	0.996	0.997	0.997	0.997
2 AB, 1 NL	0.896	0.946	0.964	0.973	0.978	0.982	0.985	0.987	0.988	0.989
3 BL	0.837	0.912	0.940	0.955	0.964	0.970	0.974	0.978	0.980	0.983
1 AB, 1 BL, 1 NL	0.557	0.717	0.794	0.838	0.867	0.888	0.903	0.915	0.925	0.932

[a]Single test first round, split sample second round if AB or BL.
[b]If $PTP_{BeS} \geq 0.9995$, then $PTP_{BeS} \sim 1.000$.

Middleton et al 2011: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4347846/pdf/nihms663121.pdf

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Investigating 3 Borderline tests

- Medical record review: Workers evaluated in our clinic for possible CBD based on repeated BL BeLPT results without any AB results.
- The diagnosis of CBD was confirmed by BeS (AB BAL BeLPT) and granulomas on biopsy.
- The diagnosis of granulomatous lung disease (GLD) was established by granulomas on biopsy, no AB BeLPTs, and no evidence of other cause of GLD.
- An estimate of beryllium exposure (high, medium, low) was provided by an industrial hygienist.
- Demographics, PFTs, radiographic findings, BeLPT results, estimate of exposure, and final diagnosis were reviewed to characterize this population of beryllium-exposed workers.

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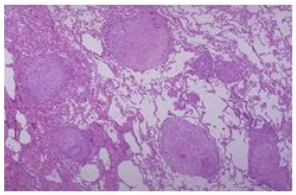
Results



We identified 10 workers with ≥ 2 BL BeLPTs who were evaluated for CBD at NJH

Results of Diagnostic Evaluation and Diagnosis

Number of BL BeLPTs	Respiratory Symptoms	Radiographic findings consistent with CBD	Abnormal BeLPT Results	Granulomas on Biopsy	Diagnosis
3	-	-	BAL	+	CBD
2	+	+	BAL	+	CBD
3	+	-	Blood	-	BeS
3	-	-	BAL	-	BeS
3	+	+	-	+	GLD
3	+	-	-	+	GLD
3	+	-	-	-	Be exposed
3	+	-	-	-	Be exposed
3	+	-	-	-	Be exposed
2	+	-	-	-	Be exposed

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Results

Demographics and Estimated Exposure by Diagnosis Group

Diagnosis	Age (median (range))	Gender	Smoking Status	Steroid use	Estimated amount of exposure
CBD (n=2)	60 years (56-63)	Male (n=2)	Never (n=1) Current (n=1)	None (n=2)	High (n=1) Low (n=1)
BeS (n=2)	66 years (48-83)	Male (n=1) Female (n=1)	Never (n=2)	Inhaled (n=1) None (n=1)	Medium (n=2)
GLD (n=2)	54 years (45-63)	Male (n=2)	Never (n=1) Former (n=1)	None (n=2)	High (n=1) Low (n=1)
Negative evaluation (n=4)	47 years (30-55)	Male (n=3) Female (n=1)	Never (n=2) Former (n=2)	Inhaled (n=1) None (n=3)	High (n=1) Low (n=3)

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Results

Radiographic Findings and Pulmonary Function Test Results at Diagnosis

Diagnosis	Radiographic findings	TLC (median (range), % pred)	FEV1 (median (range), % pred)	DLCO (median (range), % pred)
CBD (n=2)	Abnormal (n=1)* Normal (n=1)	113% (113)	94% (93-94)	88% (83-92)
BeS (n=2)	Normal (n=2)	119% (99-138)	84% (81-85)	83% (78-88)
Sarcoidosis (n=2)	Abnormal (n=1)* Normal (n=1)	105% (103-106)	95% (91-98)	88% (83-92)
Negative evaluation (n=4)	Evidence of other pathology # (n=3) Normal (n=1)	94% (64-117)	70% (42-86)	72% (38-93)

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Summary

- The results of this case series support the model-based prediction that 3 BL BeLPTs can predict BeS and our hypothesis that it can also predict CBD:
  - 2 of 10 workers had BeS
  - 2 had CBD.
  - 2 others had GLD without other identified cause.
  - 4 had no evidence of BeS, CBD, or GLD.
- No distinguishing differences were noted between CBD, BeS, and GLD groups in regard to demographics, exposure, radiographic abnormalities, or baseline PFTs.
- 3 BL BeLPTs (without any AB) is an uncommon result pattern (~ 0.05%).

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Conclusions

- 3 BL BeLPTs can predict BeS and CBD.
- Those with CBD showed a decline in DLCO after diagnosis (data not shown) suggesting that 3 BL BeLPTs can predict clinically significant disease.
- Beryllium-exposed workers with 3 BL BeLPTs warrant medical evaluation for CBD, like workers with one abnormal BeLPT.
- 3 BL BeLPTs is not a commonly observed pattern but data showed BeS/CBD in 4/10 workers.

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How common is 3 Borderlines??

Estimates of those exposed/tested with the BeLPT:

- Between 1998 and 2020: 21,854 Construction trades workers were screened with the BeLPT https://www.btmed.org/cms/media/i54isesu/ajim-doe-beryllium-2022.pdf
- Former Worker Medical Screening Program (1997-2020): Initial BeLPT test: 78,780 and rescreen BeLPT: 26,127 https://www.energy.gov/sites/default/files/2021-07/2020%20-%20FWP%20ANNUAL%20REPORT
- 37,805 employees are current beryllium associated workers. https://orise.orau.gov/BAWR/DashboardsReports/2018/index.html
- Total beryllium exposed and tested with the BeLPT:

  21854 + 78780 + 26127 + 37805 = 164,586

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More math…..

7,820 Rocky Flats participants tested between 1992 and 2001. of those, 37 (0.5%) had repeated borderline results.

Stange et al 2004: https://onlinelibrary.wiley.com/doi/epdf/10.1002/ajim.20082

- Using a rate of repeated borderline = 0.5%, approximately(164,586 x .005) 823 DOE current or former employees that have not had clinical evaluation for BeS/CBD
- Based on a PPV of 91% for 3 borderline tests (Middleton) and 40% in NJH case series, approximately 329 -750 cases of BeS/CBD are undetected and not receiving benefits.
- Approximately 5,000 BAW are tested with the BeLPT per year resulting in 10 -23 missed cases of BeS/CBD per year.
  https://oriseapps.orau.gov/BAWR/pdf/2017_Annual_BAWR_Report_Final.pdf

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Senator Murray's Solution

The Beryllium Testing Fairness Act expands the definition under EEOICPA so that three borderline test results would qualify. This expanded definition has already been adopted by federal OSHA, Washington state Labor and Industries, and National Jewish Hospital in Denver – considered among the foremost experts in the world on BeLPT and diagnosis and treatment of chronic beryllium disease. DOL's independent Advisory Board on Toxic Substances and Worker Health has also called for this change.

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Questions?

National Jewish Health®

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

Division of Energy Employees Occupational Illness Compensation: Beryllium Program Update

John VANCE

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

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

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

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

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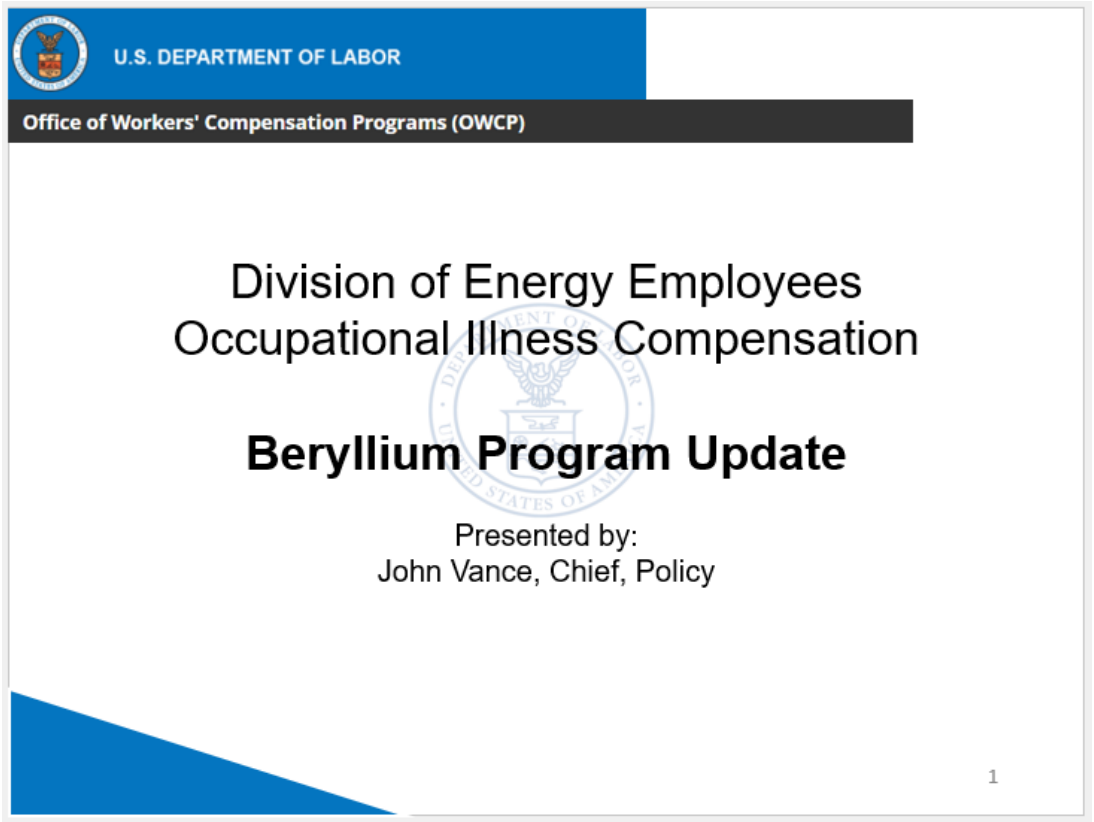
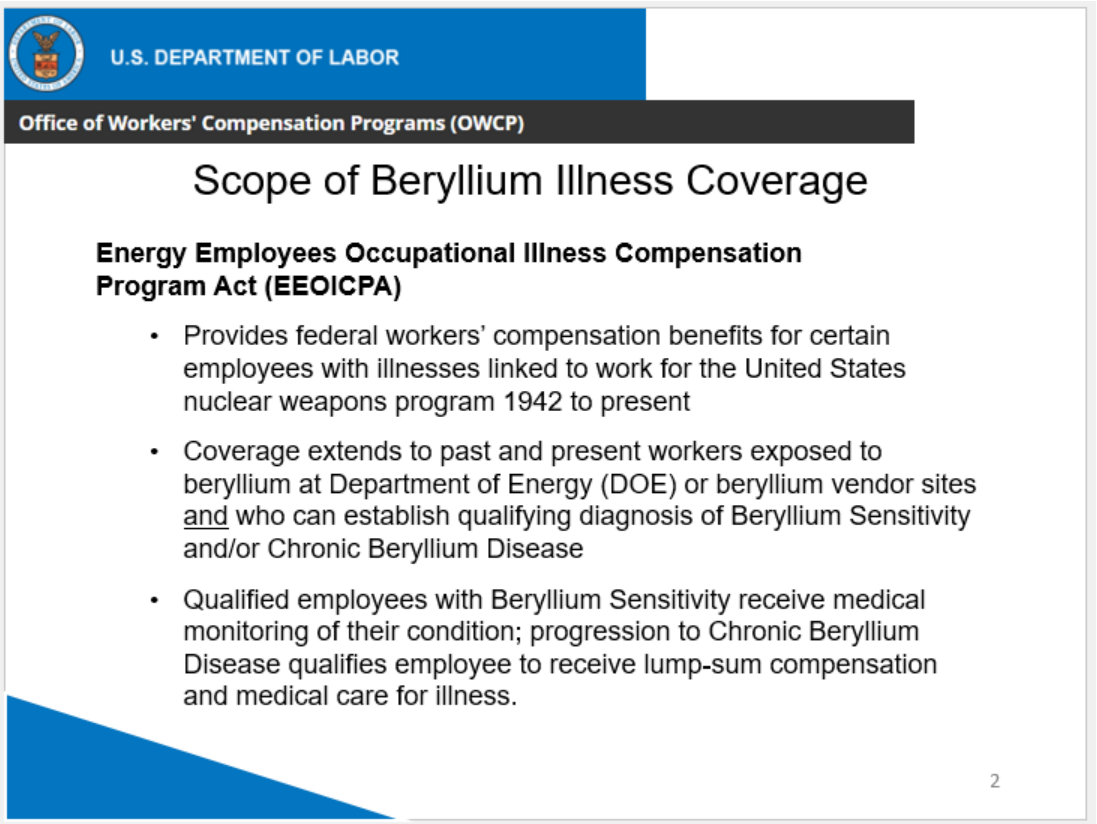

U.S. DEPARTMENT OF LABOR
Office of Workers' Compensation Programs (OWCP)
Division of Energy Employees Occupational Illness Compensation
Beryllium Program Update
Presented by:
John Vance, Chief, Policy
1


U.S. DEPARTMENT OF LABOR
Office of Workers' Compensation Programs (OWCP)
Scope of Beryllium Illness Coverage
Energy Employees Occupational Illness Compensation Program Act (EEOICPA)
• Provides federal workers' compensation benefits for certain employees with illnesses linked to work for the United States nuclear weapons program 1942 to present
• Coverage extends to past and present workers exposed to beryllium at Department of Energy (DOE) or beryllium vendor sites and who can establish qualifying diagnosis of Beryllium Sensitivity and/or Chronic Beryllium Disease
• Qualified employees with Beryllium Sensitivity receive medical monitoring of their condition; progression to Chronic Beryllium Disease qualifies employee to receive lump-sum compensation and medical care for illness.
2

U.S. DEPARTMENT OF LABOR

Office of Workers' Compensation Programs (OWCP)

Considerations for Compensation

- EEOICPA sets the clinical and diagnostic criteria for coverage
- Two Parts of EEOICPA with different rules for establishing compensable coverage:

Beryllium Employment Eligibility		
Employed By:	**Part B**	**Part E**
Beryllium Vendor	**YES**	**NO**
DOE Contractor and Subcontractors	**YES**	**YES**
Federal Government	**YES**	**NO**

3

U.S. DEPARTMENT OF LABOR

Office of Workers' Compensation Programs (OWCP)

Establishing Beryllium Illness– Part B

- Beryllium Sensitivity - (1) abnormal lymphocyte proliferation test (LPT) or lymphocyte transformation test (LTT)
- Diagnosis of Chronic Beryllium Disease on or after January 1, 1993

After January 1, 1993

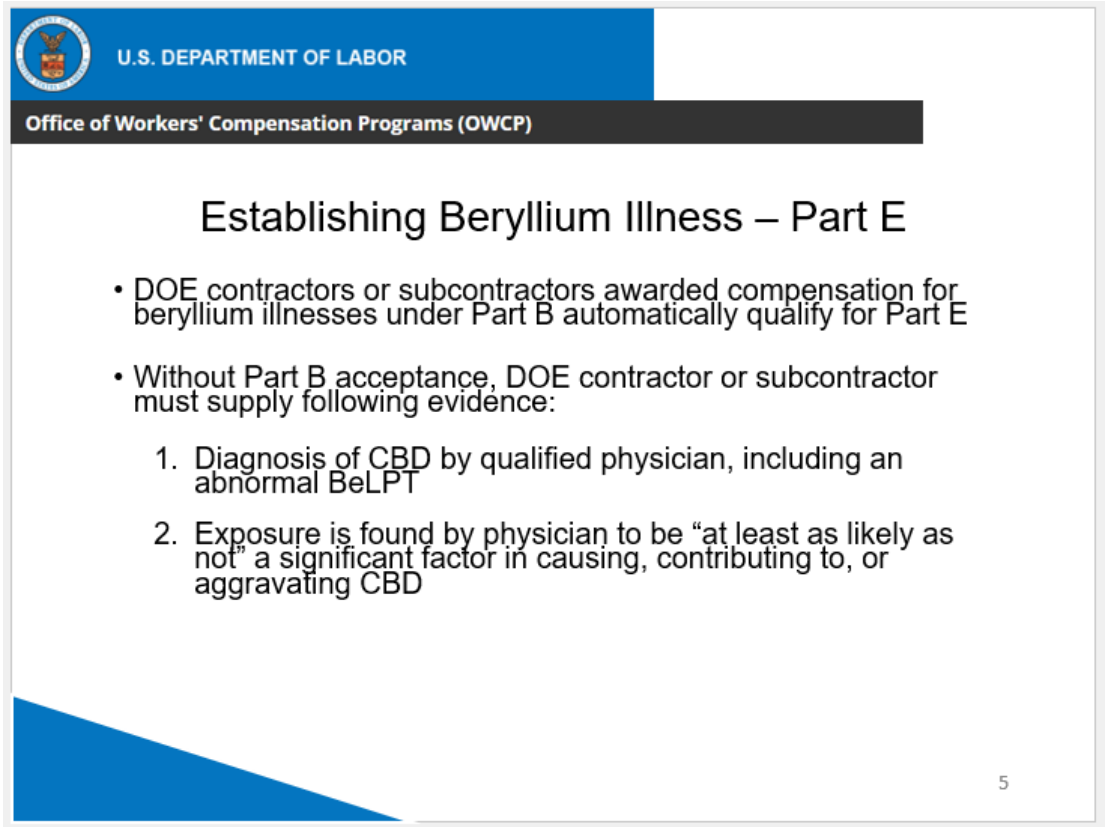
Abnormal BeLPT Or BeLTT and any of the following:

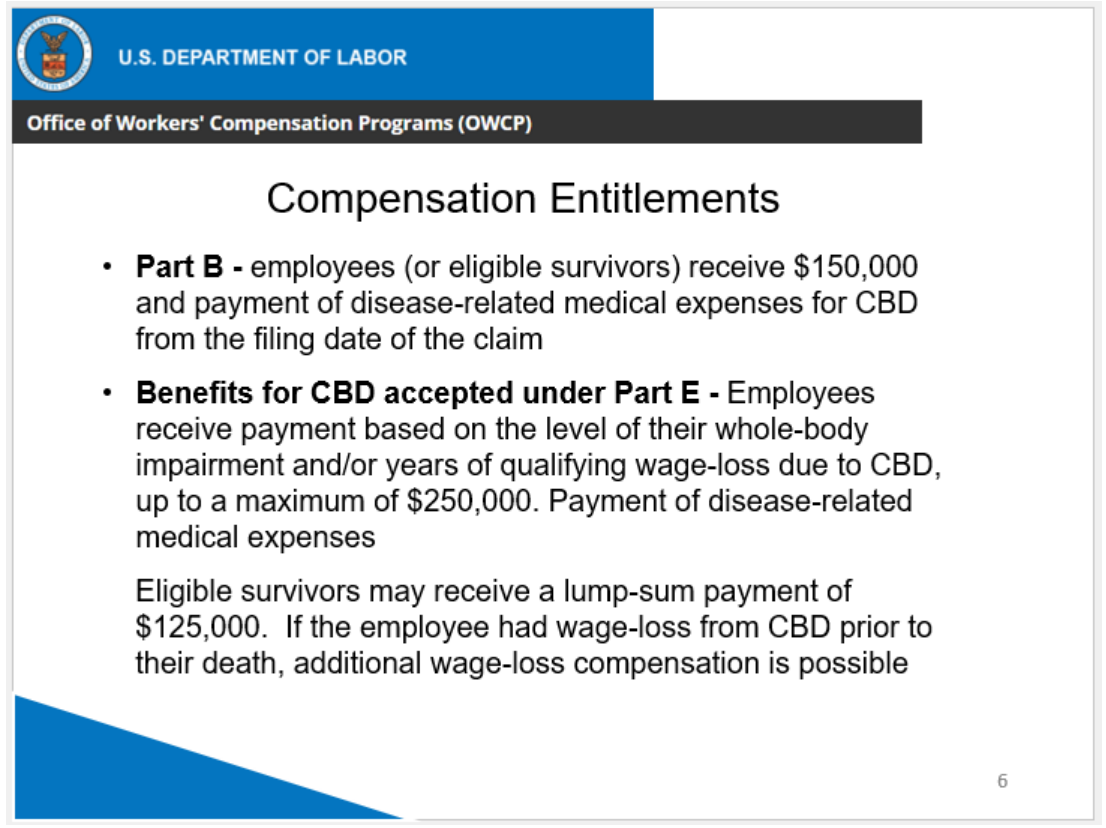
1. Lung biopsy with lung granulomas or lymphocytic process consistent with CBD
2. CAT scan showing changes consistent with CBD
3. Pulmonary function study or exercise tolerance test showing deficits consistent with CBD.

- Before 1993

Any three of the following:

1. Characteristic chest X-ray or computed tomography (CT) abnormalities
2. Restrictive or obstructive lung physiology testing or diffusing lung capacity defect
3. Lung pathology consistent with CBD
4. Clinical course consistent with a chronic respiratory disorder
5. Immunologic tests showing beryllium sensitivity (skin patch test or beryllium blood test)


U.S. DEPARTMENT OF LABOR
Office of Workers' Compensation Programs (OWCP)
Establishing Beryllium Illness – Part E
• DOE contractors or subcontractors awarded compensation for beryllium illnesses under Part B automatically qualify for Part E
• Without Part B acceptance, DOE contractor or subcontractor must supply following evidence:
1. Diagnosis of CBD by qualified physician, including an abnormal BeLPT
2. Exposure is found by physician to be "at least as likely as not" a significant factor in causing, contributing to, or aggravating CBD
5


U.S. DEPARTMENT OF LABOR
Office of Workers' Compensation Programs (OWCP)
Compensation Entitlements
• Part B - employees (or eligible survivors) receive $150,000 and payment of disease-related medical expenses for CBD from the filing date of the claim
• Benefits for CBD accepted under Part E - Employees receive payment based on the level of their whole-body impairment and/or years of qualifying wage-loss due to CBD, up to a maximum of $250,000. Payment of disease-related medical expenses
Eligible survivors may receive a lump-sum payment of $125,000. If the employee had wage-loss from CBD prior to their death, additional wage-loss compensation is possible
6

U.S. DEPARTMENT OF LABOR

Office of Workers' Compensation Programs (OWCP)

Beryllium Cases – Program Inception to March 2023

Beryllium Vendor Claims Accepted	
Categories	**Total Unique Cases**
Sensitivity Accept	522
CBD Accept	253

DOE Facility Claims Accepted	
Categories	**Total Unique Cases**
Sensitivity Accept	2927
CBD Accept	1126

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U.S. DEPARTMENT OF LABOR

Office of Workers' Compensation Programs (OWCP)

Recent Developments

- **Department of Energy's Federal Register Notice (Sept 14, 2023):**
  - Added Beryllium Mill in Delta Utah as a covered beryllium vendor facility, as well as the authority to identify other covered beryllium vendor facilities.
  - Defines successor names for certain statutory beryllium vendors for purposes of the compensation program. Includes all references to "Brush Wellman Incorporated" or "Brush Wellman, Inc." predecessor and successor entities:

    Brush Beryllium Company from 1969–1971,
    Brush Wellman, Inc. from 1971-January 23, 2001,
    Brush Resources, Inc. from January 23, 2001-March 8, 2011, and
    Materion Natural Resources, Inc. from March 8, 2011– Present
- **New covered Beryllium Vendor sites:**
  1. Beryllium Mill in Delta, UT
  2. Beryllium Mine at Topaz-Spor Mountain, UT
  3. Shoemakersville Plant, PA

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U.S. DEPARTMENT OF LABOR

Office of Workers' Compensation Programs (OWCP)

To learn more about our Program

DEEOIC Main Page

dol.gov/agencies/owcp/energy

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U.S. DEPARTMENT OF LABOR

Office of Workers' Compensation Programs (OWCP)

Questions?

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NNSA Site Responses to Beryllium Economic Assessment Questionnaire

Josef A. SOBIERAJ, Danny FIELD, and Julie FOWLER

National Nuclear Security Administration, USA

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

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

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

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

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

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

NNSA RESPONSES TO BERYLLIUM ECONOMIC ASSESSMENT

Josef A. Sobieraj[1], Danny Field[1], and Julie Fowler[1]
[1]National Nuclear Security Administration, NA-ESH-23 Worker Safety and Health Division, USA

Presented: 11/07/2023, BHSC Fall Meeting, Washington, D.C.

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U.S. DEPARTMENT OF ENERGY

Economic Assessment Memo

NNSA National Nuclear Security Administration

Department of Energy
Washington, DC 20585

December 5, 2022

MEMORANDUM FOR DISTRIBUTION

FROM: TODD N. LAPOINTE
DIRECTOR
OFFICE OF ENVIRONMENT, HEALTH, SAFETY AND SECURITY

SUBJECT: Request Assistance from Beryllium Sites in Completing the Economic Assessment Questionnaire for Amendments to Title 10, Code of Federal Regulations, Part 850, *Chronic Beryllium Disease Prevention Program*

The Office of Environment, Health, Safety and Security is requesting assistance in obtaining the information needed to update the costs, benefits, and paperwork burden information in support of an economic assessment for amendments to 10 CFR Part 850, *Chronic Beryllium Disease Prevention Program (10 CFR 850).* An economic assessment is an essential part of the rulemaking process because it ensures that decisions to amend regulations are informed by the best available information and provides the Department with the information needed to compare the action with reasonable alternatives.

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Economic Assessment Questionnaire

"The purpose of this questionnaire is to obtain information on the cost impacts of implementing proposed amendments to Title 10, Code of Federal Regulations, Part 850 (10 CFR Part 850), *Chronic Beryllium Disease Prevention Program, (CBDPP)*. The Office of Worker Safety and Health Policy within the Office of Environment, Health, Safety and Security will use this information to assess the impact and prepare the economic analysis for these proposed amendments."

"Below, we have provided tips on responding to the questionnaire. The actual questionnaire follows these tips. Please read the tips prior to completing the questionnaire. If you need further assistance, please contact April Brown at (301) 903-0370."

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Proposed Amendments

Thirteen Program Areas Assessed by Sites

1. Revising the Chronic Beryllium Disease Protection Program (CBDPP)
2. Action Level
3. Permissible Exposure Limits (STEL)
4. Regulated Areas
5. Exposure Monitoring
6. Medical Surveillance
7. Medical Restriction
8. Medical Removal
9. Medical Consent
10. Labeling and Release and Transfer
11. Signs
12. Reporting Standard
13. Performance Feedback

NNSA Site analyses yielded *expected and unexpected* cost impact results.

4

Documentation / Action Level

1. Revising the Chronic Beryllium Disease Protection Program (CBDPP)

1.1 How much do you think revising your CBDPP documentation would cost?

Range: $5,300 - $36,000 Average: $25,333

2.1 To properly sample for each of the alternative action levels provided in the table below, do you anticipate needing to implement new sampling and analysis methods to achieve a lower limit of detection?

New Method/Cost Component 0.05 µg/m3	Range: $0 - $375,000	Average: $58,610
New Method/Cost Component 0.10 µg/m3	Range: $0 - $34,600	Average: $5,039
New Method/Cost Component 0.15 µg/m3	Range: $0 - $34,600	Average: $5,039

2.2 What would be the annual cost of continuing to use these new sampling and analysis methods in subsequent years?

New Method/Cost Component 0.05 µg/m3	Range: $0 - $263,000	Average: $58,610
New Method/Cost Component 0.10 µg/m3	Range: $0 - $129,600	Average: $19,000
New Method/Cost Component 0.15 µg/m3	Range: $0 - $85,050	Average: $12,635

2.4 Would you anticipate any cost savings with regards to housekeeping if you only had to conduct routine surface sampling where beryllium is present in operational areas at or above each of the potential action levels provided in the table below?

New Method/Cost Component 0.05 µg/m3	Range: $0 - $193,763	Average: $34,345
New Method/Cost Component 0.10 µg/m3	Range: $0 - $193,763	Average: $34,345
New Method/Cost Component 0.15 µg/m3	Range: $0 - $193,763	Average: $34,345

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Permissible Exposure Limits (STEL)

3.1 Would you incur any additional costs for new materials or equipment required for measurement of a 15-minute STEL at the following alternative levels?

Item/Cost Component 1.5 µg/m3	Range: $0 - $46,792	Average: $6,099
Item/Cost Component 2.0 µg/m3	Range: $0 - $2,000	Average: $250
Item/Cost Component 2.5 µg/m3	Range: $0 - $2,000	Average: $250

3.2 How many areas in your site would you have to sample to ensure compliance with the STEL and, on average, how many samples you would have to process annually to monitor worker short-term exposures in these areas?

Number of areas to sample for STEL	Range: 0 – 80	Average: 13
Number of samples needed annually per area	Range: 0 - 100	Average: 23

3.3 What is an estimate of the cost of a short-term airborne sample at your site (including laboratory fees, time for an industrial hygienist, and materials)?

Total cost for a single short-term airborne sample	Range: $200 - $6,661	Average: $1,462

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Beryllium Regulated Areas

4.1 How many additional regulated areas would need to be established if the airborne action level (AL) is set at each of the action levels provided in the table below?

0.05 µg/m3	Range: 0 – 6	Average: 2
0.10 µg/m3	Range: 0 – 5	Average: <1
0.15 µg/m3	Range: 0 – 5	Average: <1

4.1.1 How many workers associated with each additional regulated area estimated in above question? Range: 0 – 70 Average: 16

4.2 Currently, what is an approximate range of costs for setting up a regulated area? (Cost ($) per area)

Low Cost Estimate Total Cost:	Range: $0 – $555,500	Average: $80,957
High Cost Estimate Total Cost:	Range: $0 - $913,500	Average: $199,706

7

Exposure Monitoring / Medical Surveillance

5.1 Should DOE propose changing the action level to any of the levels provided in the table below (which are measured in the worker's breathing zone by personal monitoring), what are number of samples needed annually per new area?

0.05 µg/m3	Range: 0 – 24	Average: 7
0.10 µg/m3	Range: 0 – 24	Average: 6
0.15 µg/m3	Range: 0 – 24	Average: 6

5.2 What is an estimate of the cost of a single airborne sample at your site (including laboratory fees, time for an industrial hygienist, and materials)?
Range: $200 - $5,511 Average: $1,381

6.1 The 2016 NOPR proposed that beryllium workers would no longer be allowed to opt out of medical surveillance. At your site, how many beryllium workers are currently opting out of medical surveillance program?

Range: 0 - 757 Average: 295

6.3 How much does a medical evaluation cost for a beryllium worker? Total cost for a medical evaluation.

Range: $450 - $3,400 Average: $966

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CONCLUSIONS

- The process for revising Federal Regulations (e.g., 10 CFR 850 CBDPP) has many steps and takes years to complete.
- Changes to Federal Regulations are impactful and require an Economic Impact Assessment.
- This presentation highlighted and summarized select Economic Assessment questionnaire responses from eight NNSA Sites
  (Note: All DOE sites were required to provide responses).
- There is a significant level of effort to assess impacts to proposed changes that essentially represents a comprehensive programmatic assessment.
- The proposed changes to 10 CFR 850 will result in overall additional costs but also results in cost savings in select areas (e.g., Housekeeping).
- DOE-EHSS has advanced in the regulatory process since completion of this Economic Assessment.
  (Note: This will be discussed in the next presentation).

9

QUESTIONS?

Contact Information:
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NA-ESH-23 Worker Safety and Health
Josef.sobieraj@nnsa.doe.gov
(806) 731-2506

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10 CFR Part 850 Chronic Beryllium Disease Prevention Program Rulemaking Update

A. BROWN (US Department of Energy, Maryland, USA)

10 CFR Part 850 Chronic Beryllium Disease Prevention Program Rulemaking Update

April BROWN, CIH

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

The Department of Energy (DOE) published a Notice of Proposed Rulemaking (NOPR) for public comment in the Federal Register (81 FR 36704) on June 7, 2016, proposing to amend its existing CBDPP regulations. The period for public comments ended on September 6, 2016. The proposed amendments in the NOPR were intended to strengthen the existing CBDPP and the worker protection programs established under 10 CFR part 851, Worker Safety and Health Program. The proposed amendments to the NOPR would have reduced the action level for worker exposure to ambient beryllium concentrations to 0.05mg/m^3, based on an 8-hour TWA exposure. DOE also proposed adopting OSHA's current and prospective PELs for worker exposure to beryllium and beryllium compounds in the NOPR. DOE did not propose adopting a short-term exposure limit (STEL) due to the fact that DOE's proposed action level of 0.05mg/m^3 would be exceeded in less than the 15-minute sampling period for the STEL if exposure levels were at OSHA's PEL of 2.0µg/m^3.

OSHA issued new regulations in 29 CFR parts 1910, 1915, and 1926 on January 9, 2017 (82 FR 2470) to protect employees from exposure to beryllium and beryllium compounds in the workplace, following the publication of DOE's NOPR. OSHA's regulations included two new PELs for occupational exposure to beryllium and beryllium compounds: (1) an 8-hour TWA PEL of 0.2µg/m^3 and (2) a 15-minute STEL of 2.0µg/m^3. In its final rule, OSHA stated that it was establishing an 8-hour TWA PEL of 0.2µg/m^3 because it determined that occupational exposure to beryllium at the previous PEL of 2.0µg/m^3 posed a substantial risk of material impairment to the health of exposed workers and that the lower TWA PEL of 0.2µg/m^3 would substantially reduce this risk. To reduce the risk of beryllium sensitization and chronic beryllium disease among beryllium-exposed employees, OSHA established a STEL of 2.0µg/m^3, as measured over a 15-minute sampling period. OSHA also adopted an action level for ambient beryllium of 0.1µg/m^3, based on an 8-hour time-weighted average.

Instead of adopting OSHA's current or prospective TWA PELs, DOE is issuing this SNOPR to propose that the Department set its own 8-hour TWA PEL of 0.2µg/m^3 for dispersed beryllium, which is consistent with OSHA's current TWA PEL. As an alternative to the previously proposed airborne action level of 0.05mg/m^3, the Department proposes an airborne action level of 0.1µg/m^3, computed as an 8-hour TWA exposure, as measured in the worker's respiratory zone by personal monitoring. The Department proposes a STEL of 2.0µg/m^3, measured over a fifteen-minute period. The Department's proposed TWA PEL, STEL, and action level would be consistent with OSHA's current TWA PEL, STEL, and action level. The presentation will discuss both the NOPR and SNOPR for 10 CFR 850.

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Office of Environment, Health, Safety, and Security (EHSS-11)
EMAIL: april.brown@hq.doe.gov

10 CFR Part 850 Chronic Beryllium Disease Prevention Program

Department of Energy

Beryllium Health and Safety Committee
November 7, 2023

Presented by:
April Brown, CIH, EHSS-11

Office of Environment, Health, Safety and Security
U.S. Department Of Energy

EHSS
Office of Environment, Health, Safety and Security

Agenda

- **Updates**
  - 10 CFR Part 850
    - 2016 Notice of Proposed Rulemaking
    - 2023 Supplemental Notice of Proposed Rulemaking
  - Implementation Guide for use with 10 CFR Part 850, Chronic Beryllium Disease Prevention Program (DOE G 440.1-7A)

Office of Environment, Health, Safety and Security 2

10 CFR Part 850

Promulgated: December 8, 1999

- Effective date: January 7, 2000
- Compliance date: January 7, 2002
- Established – chronic beryllium disease prevention program
- Adopted OSHA's 8-hour time weighted average – 0.2 µg/m^3

Expanded standard

- action level, exposure monitoring, hazard assessment, respiratory protection, regulated area, hygiene facilities and practices, housekeeping, medical surveillance, medical removal, medical consent, and more

Office of Environment, Health, Safety and Security 3

10 CFR Part 850 Amendment Process

Notice of Proposed Rulemaking (NOPR)

- Published June 7, 2016
- 90-day Comment period - September 6, 2016
- Four public hearings: Richland, WA; Oak Ridge, TN; Las Vegas, NV; and Washington, DC

50 sets of comments

- DOE contractors, private industry, trade associations, worker advocates, public health and medical professionals, safety and health professionals, state government and other interested individuals.

Office of Environment, Health, Safety and Security 4

2016 Notice Of Proposed Rulemaking

Principled Proposed Amendments

- Revise the definitions of beryllium, beryllium worker, and beryllium associated worker, and add new definitions for beryllium sensitization and chronic beryllium disease.
- Lower the action level to 0.05 mg/m^3.
- Allow the use portable laboratories.
- Modify the release criteria of formerly beryllium-contaminated equipment or areas without labeling if they contain beryllium in inaccessible locations or embedded in hard-to remove substances, provided certain levels are not exceeded.
- Allow releasing beryllium contaminated equipment, items or areas with removable beryllium above 0.2 mg/100 cm^2 or that have beryllium in material on the surface at levels above the natural level in soil at the point of release.

Office of Environment, Health, Safety and Security 5

2016 Notice Of Proposed Rulemaking

Principled Proposed Amendments

- Ensure beryllium-associated workers are notified yearly of their right to participate in the medical surveillance program.
- Require mandatory medical and periodic evaluations for beryllium workers.
- Require medical evaluations for beryllium and beryllium-associated workers showing signs and symptoms of beryllium sensitization or chronic beryllium disease when the SOMD determines an evaluation is warranted.
- Require exit medical evaluations for beryllium workers and beryllium associated workers who voluntarily participated in the medical surveillance program.
- Require medical restriction requirements for workers.

Office of Environment, Health, Safety and Security 6

2016 Notice Of Proposed Rulemaking

Principled Proposed Amendments

- Require mandatory medical removal for workers based on the site occupational medicine director's written opinion.
- Ensure beryllium workers are informed and understand that medical testing is mandatory.
- Revise the training requirements for beryllium-associated workers.
- Revised the wording on beryllium warning signs.
- Require labels for equipment or items containing beryllium in inaccessible locations or embedded in hard-to-remove substances.
- Revised the consent forms for beryllium and beryllium-associated workers.

Office of Environment, Health, Safety and Security 7

10 CFR Part 850 Amendment Process

Supplemental Notice of Proposed Rulemaking (SNOPR)

- Published on August 23, 2023.
  - 30-day public comment period
  - Response due September 22, 2023.
- Alternative action level
- Short-term exposure limit

Update Final Economic Assessment

- Economic Assessment Questionnaire to Beryllium-affected Program Offices: EM, NA, NE, and SC
- Responses completed on April 30, 2023.

Office of Environment, Health, Safety and Security 8

2023 Supplemental Notice Of Proposed Rulemaking

Principled Proposed Amendments

- Proposed § 850.22—Permissible Exposure Limits
  - The Department is proposing to promulgate its own PELs:
    - TWA PEL (an airborne concentration of beryllium of 0.2 µg/m³, calculated as an 8-hour TWA exposure).
    - STEL 2.0 µg/m³
- Proposed § 850.23—Action Level
  - 0.1 µg/m³, calculated as an 8-hour TWA exposure

Office of Environment, Health, Safety and Security 9

10 CFR Part 850 Amendment Process

Update Final Economic Assessment

- EHSS received responses:
  - EM, NA, NE, and SC

- **EHSS and Economists**
  - Reviewing responses
    - Potential questions
  - Drafting final document

Office of Environment, Health, Safety and Security 10

10 CFR Part 850 Amendment Process

Develop draft Final Rule

- Based on comments from the NOPR and SNOPR's public comments

Based on comments from the NOPR and SNOPR's public comments

- Review and concur
  - Comments
  - Comment resolution – EHSS and Program Offices

Office of the General Counsel

- Review and concur
  - GC Comments
  - Comment resolution – EHSS and GC

Office of Environment, Health, Safety and Security 11

10 CFR Part 850 Amendment Process

Secretary of Energy

- Review and concur

Office of Management and Budget Review

- Other Federal Agencies review and comment
- Approves draft final rule and economic assessment
  - Final rule Publication in the Federal Register

Secretary of Energy

- Approves and signs the final rule

Congressional Notification

- GC and EHSS

Federal Register

- Review and comment
- EHSS and GC resolve comments
- Publish in the Federal Register

Office of Environment, Health, Safety and Security 12

Proposed 10 CFR Part 850 Final Rule

Effective Date: 30 days after publication date

- Compliance Date: One year after the effective date
- Engineering controls – 2 years after the effective date

Strengthen existing provisions

- Incorporates lessons learned
- Clear distinction between Beryllium worker and Beryllium-associated workers

Office of Environment, Health, Safety and Security

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Proposed 10 CFR Part 850 Final Rule

Action level

Permissible exposure limit

Clarifies:

- Medical surveillance program
- Medical removal and removal benefits
- Role of the Site Occupational Medical Director
- Medical restriction
- Conditionally-hired individuals
- Release of beryllium equipment and real property
- Use of direct reading/portable testing equipment

Office of Environment, Health, Safety and Security

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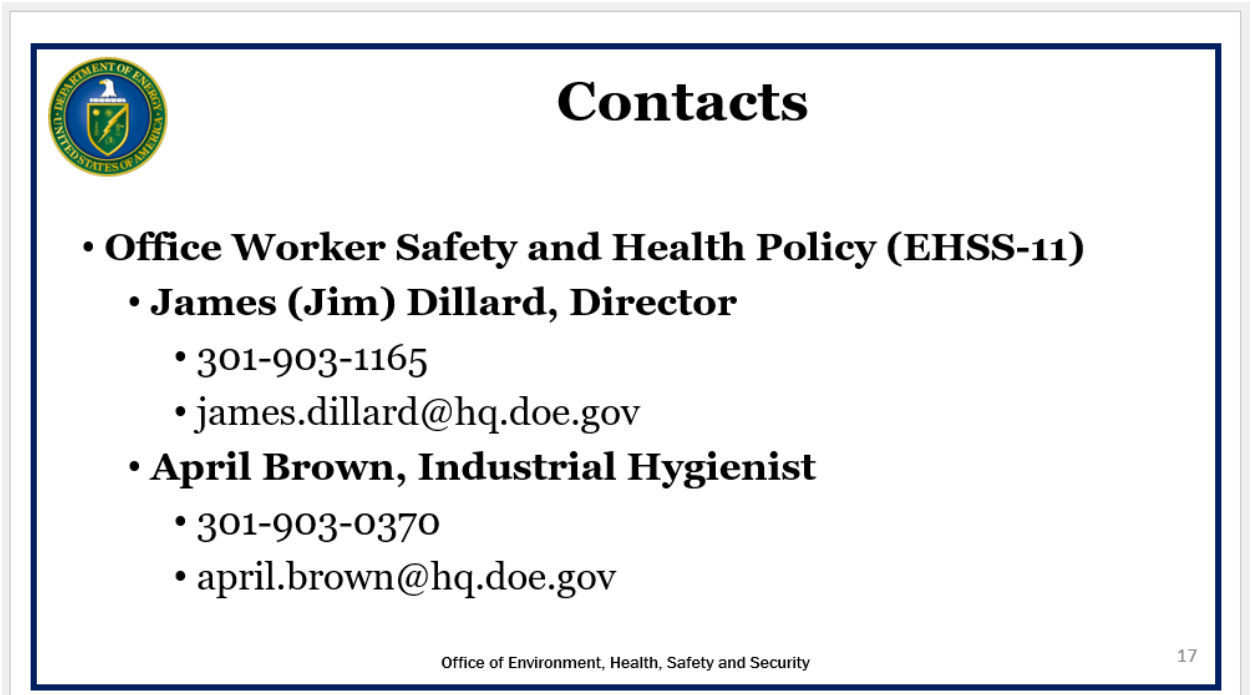
Implementation Guide DOE G 440.1-7A

- EHSS-11 is seeking examples to add to Implementation Guide based on the updates to the rule.
  - Areas includes inventory, hazard assessment, exposure limits, monitoring, exposure reduction, regulated areas, hygiene practices, etc.
- EHSS-11 wants to create a working group to help revise the guide.

Office of Environment, Health, Safety and Security 15

Questions

Office of Environment, Health, Safety and Security 16


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

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

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

Eric W. BOYLE

US Department of Energy, Washington, DC, USA

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

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

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

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

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

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

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

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

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

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

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

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U.S. DEPARTMENT OF ENERGY | Legacy Management

U.S. DEPARTMENT OF ENERGY | History

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Overview

I. Institutional Origins of DOE
II. Brief Overview of Manhattan Project
III. From AEC to DOE
IV. DOE Organizing Statutes
V. Major Themes in DOE History

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The Global Fusion Industry in 2023

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

The Global Fusion Industry in 2023

Andrew HOLLAND

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

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

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

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

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

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

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

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

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FUSION INDUSTRY ASSOCIATION

The Global Fusion Industry in 2023

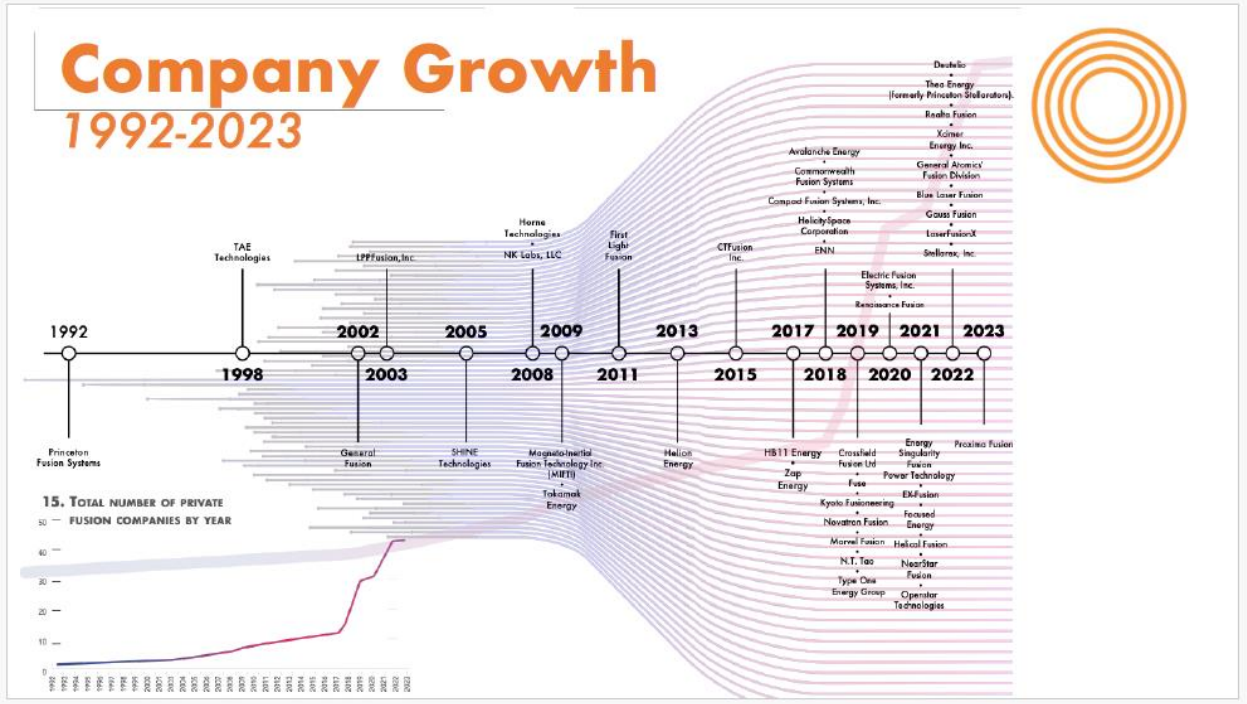
Berylium Health and Safety Committee
November 7, 2023

Andrew Holland
Chief Executive Officer

Overview: The Private Fusion Industry Today

- 43 verified private fusion companies
- **$6.2 billion in investment**
- 13 new fusion companies
- Increasing optimism on timescales
- Growing interest from governments in Public Private Partnerships
- Growing geographical diversity
- But – many challenges remain


FIA Membership
Commonwealth Fusion Systems
HELION
tae
ZAP ENERGY
generalfusion
TYPE ONE ENERGY
GAUSS FUSION
HB11 ENERGY
LASER BORON FUSION
AVALANCHE
Tokamak Energy
FOCUSED ENERGY
KYOTO FUSIONEERING
XCIMER ENERGY CORPORATION
first light
THEA ENERGY
EX-Fusion
MIFTI
RENAISSANCE FUSION
Proxima Fusion
fuse
HelicitySpace
ELECTRIC FUSION SYSTEMS
REALTA FUSION
Helical Fusion
LONGVIEW FUSION
BLUE LASER FUSION
SHINE
MarvelFusion
STELLAREX
OPENSTAR TECHNOLOGIES LTD
NOVATRON
nT-tao
LaserFusionX
HORNE TECHNOLOGIES
PrincetonSATELLITE SYSTEMS
nearstar FUSION
NK
LPP FUSION

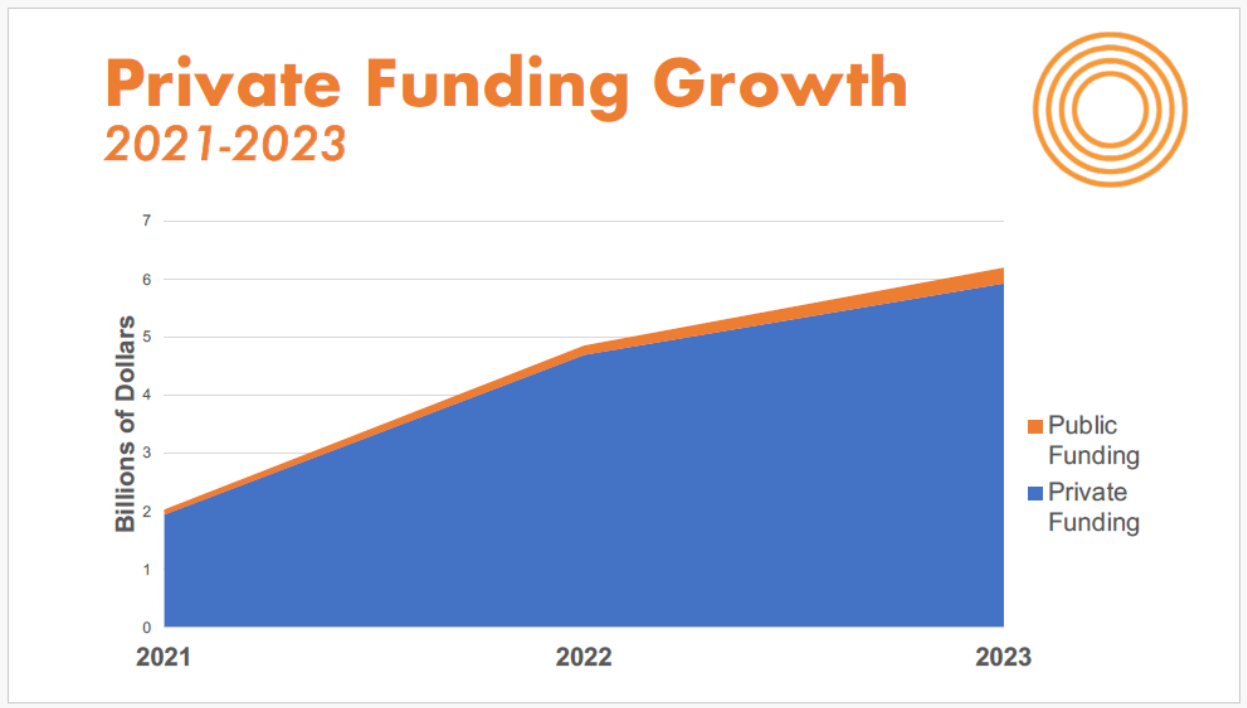

Company Growth
1992-2023
1992
1998
2002
2003
2005
2008
2009
2011
2013
2015
2017
2018
2019
2020
2021
2022
2023
TAE Technologies
LPPFusion,Inc
Horne Technologies
NK Labs, LLC
First Light Fusion
CTFusion Inc.
Avalanche Energy
Commonwealth Fusion Systems
Compact Fusion Systems, Inc.
HelicitySpace Corporation
ENN
Electric Fusion Systems, Inc.
Renaissance Fusion
Realta Fusion
Xcimer Energy Inc.
General Atomics' Fusion Division
Blue Laser Fusion
Gauss Fusion
LaserFusionX
Stellarex, Inc.
Princeton Fusion Systems
General Fusion
SHINE Technologies
Magneto-Inertial Fusion Technology Inc (MIFTI)
Tokamak Energy
Helion Energy
HB11 Energy
Zap Energy
Crossfield Fusion Ltd
Fuse
Kyoto Fusioneering
Novatron Fusion
Marvel Fusion
N.T. Tao
Type One Energy Group
Energy Singularity
Fusion Power Technology
EX-Fusion
Focused Energy
Helical Fusion
NearStar Fusion
Openstar Technologies
Proxima Fusion
15. TOTAL NUMBER OF PRIVATE FUSION COMPANIES BY YEAR

A Global Industry
Led by American Companies

- 25 American Fusion Companies
  - With > 80% of the investment
- Growing global diversity
  - 12 countries with at least one fusion company
- A global supply chain
- A global workforce
- Global scientific leadership

Variety of Approaches

- 1 Dense Plasma Focus
- 1 Direct laser-driven p811
- 1 Epicyclotron: a hybrid beam background approach
- 1 Electro-centripetal confinement with magnetic plasmas not in thermodynamic equilibrium
- 3 Field Reversed Configuration
- 1 Hypervelocity Gradient Field Fusion
- 1 Laser-driven inertial confinement
- 1 Laser-driven Direct Drive Inertial Confinement Fusion
- 1 Levitated Dipole
- 1 Magnetic mirror
- 1 Mirror machine
- 1 Magnetized target fusion
- 1 Modified Stellarator
- 1 Muon-catalyzed fusion with high density fuel
- 2 Magnetic-electrostatic confinement
- 1 Magnetized Liner Inertial Fusion (MagLIF)
- 1 Plectonemic reconnection
- 1 Poloidal magnetic confinement, e.g. Levitron, LDX, Intrap
- 1 Pulsed magneto-plasma pressurized confinement
- 1 Shock-driven inertial confinement
- 1 Spindle cusp, superconducting shielded-grid Inertial Electric Confinement
- 6 Stellarator
- 6 Tokamak/Spherical Tokamak/Advanced Tokamak
- 2 Z-pinch
- 1 N/A


Private Funding Growth
2021-2023
Billions of Dollars
0
1
2
3
4
5
6
7
2021
2022
2023
Public Funding
Private Funding


Notable investments since last survey
$23m THEA Energy
$250m TAE
$79m Kyoto Fusioneering
$55m Energy Singularity Fusion Power Technology
$200m ENN
$50m SHINE Technologies
$41m Avalanche
$22m n-Tao
$20m General Atomics
$67m Focused Energy

Trends: Broad-Based Investment

- 27 announced capital raises
- Median raise: $9,000,000

But…a difficult investment environment for large raises?

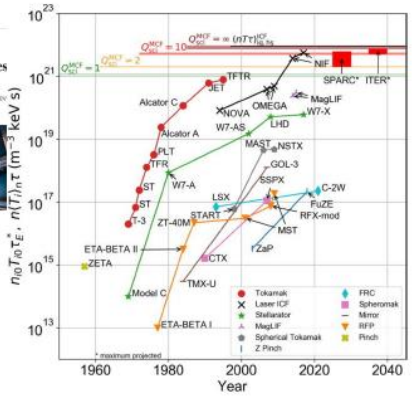
Why Now?

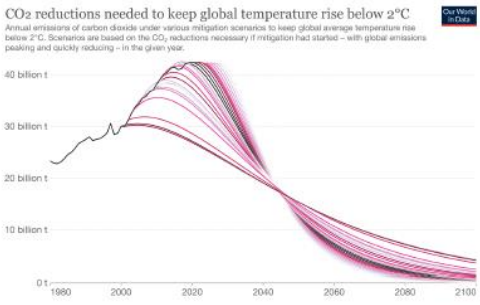
Fusion is READY + The world NEEDS fusion


WSJ

Nuclear-Fusion Breakthrough Accelerates Quest to Unlock Limitless Energy Source

Experiment yields net-positive energy, a milestone in effort to develop nuclear fusion as a source of clean power





Why Now?

Fusion is READY

Today's Scientific and Technological Advances Enable Breakthroughs

New Materials
New materials, including High Temperature Superconductors, advanced lasers, new alloys, power management chips, and more enable smaller, cheaper machines.

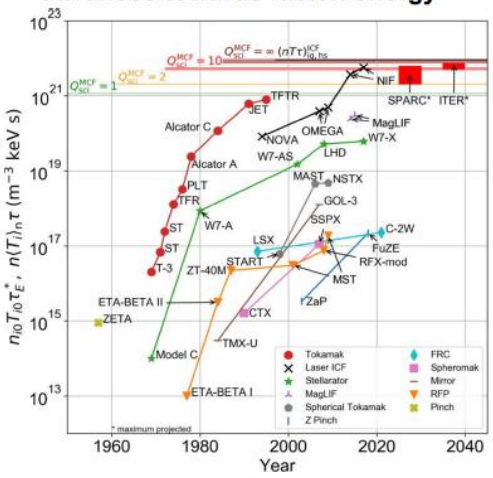
High Speed Computing
Advances in computing power allow advanced modeling and the application of artificial intelligence to experiments.

Greater Scientific Understand of Plasmas
Breakthrough fusion experiments at NIF and elsewhere will bring greater fidelity to models and enable faster experimentation.

Advanced Manufacturing
Will allow quick and cheap production of components in complex shapes and with new materials.

Business Model Improvement
The application of the Silicon Valley-style venture capital has injected funding, urgency, and greater tolerance of risk.

Historical progress shows continuous advances towards fusion energy

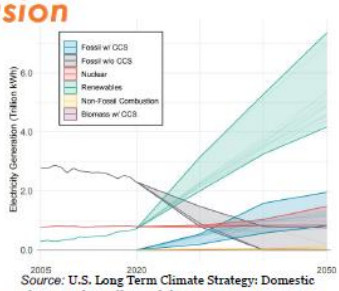


Why Now?

The world NEEDS fusion

Fusion is a Climate Solution

Meeting the world's climate goals are **almost impossible** without massive deployment of zero-emissions dispatchable power.



Source: U.S. Long Term Climate Strategy: Domestic Climate Policy Office and the State Department, 2021

Fusion provides Energy Security

Fusion energy will **break the geopolitics of energy**, so that no dictator can control the price of energy. Fusion energy will be manufactured, not mined.

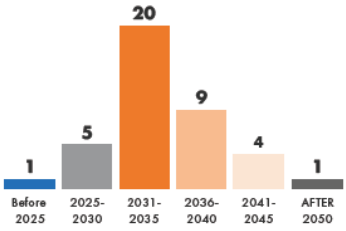
Fusion is a Business Opportunity

Bloomberg: fusion energy industry could be valued at ***$40 trillion***

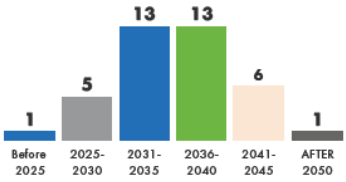
McKinsey: fusion could be "***dominant***" source of energy in Europe by 2050

Fusion companies already are spending over $500m per year

When will the first fusion plant deliver electricity to the grid? (40 responses)



When will the first fusion plant demonstrate a low enough cost/high enough efficiency (Q) to be considered commercially viable? (40 responses)



Growing Confidence

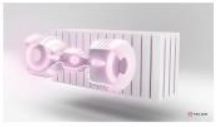
- 88% expect fusion power on the grid in the 2030s or before
- 84% expect commercial cost competitiveness on same schedule

Industry's Timeline

60 years of research	Mid 2020s	Late 2020s	Early 2030s	Mid 2030s
• Scientific basis for fusion energy	• Scientific Proof of Concept	• Design and build Pilot Plants	• Operate Pilot Plants, first sales	• Commercial Fusion, rapid scale-up to global deployment

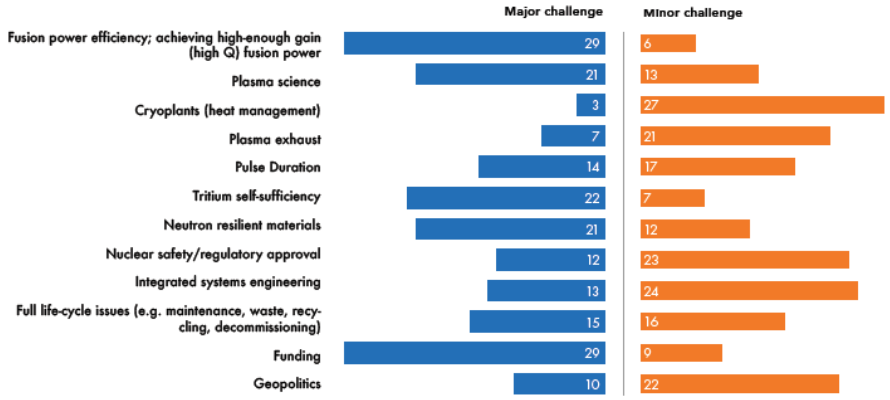






Expecting Challenges

What do you see are the main challenges for fusion energy up to 2030?
(38 Reponses, non-reported answers indicate not seen as a problem/don't know)



FIA Supply Chain Report: *Key Findings*

- Fusion developers spent **over $500m** on their supply chain in 2022, and that will grow to over $7bn per year by the time they build their "First of a Kind" power plant, and potentially trillions in a mature fusion industry (timescales for this range from 2035-2050).
- *Technological diversity in fusion*: there is not a fusion "supply chain" – there are fusion "supply chains"
- High value supply chain needs are primarily **specialized precision manufactured components**
  - Steady-state Magnetic = high-powered magnets + resilient materials
  - Pulsed power = power electronics and semiconductors
  - Laser IFE = specialized laser & optics components
  - Fusion Fuel Cycle = Lithium blanket
- Biggest challenge = balancing suppliers' scale with business risk.
  - Fusion companies need suppliers to invest in scale ahead of demand, but suppliers are reluctant to do so without confirmed commitments or clear timelines.
  - Chicken vs Egg?

FUSION INDUSTRY ASSOCIATION

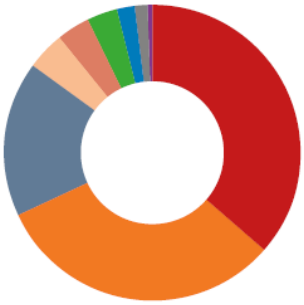
The Fusion Industry Supply Chain:

Opportunities and challenges

Industry Growth

- $500 million per year industry today -> $7 billion in a decade

Declared annual spending on supply chain by fusion companies



- Specialized components - non-fusion specific (e.g. vacuum pumps) **$176,490,000**
- Raw materials **$154,345,000**
- Contract engineering **$82,650,000**
- Specialized components - fusion specific (e.g. magnets, lasers) **$19,665,000**
- Commodity 'off-the-shelf' components **$18,085,000**
- Software **$16,085,000**
- Professional services **$9,475,000**
- Contract construction **$6,255,000**
- Fuel **$1,870,000**

Supply Chain Needs Now

- Vacuum technology is (almost) the only shared technological need across the fusion technologies
- In a fusion energy facility, the walls exposed to the plasma will be bombarded by highly energetic neutrons.
- A solution is a composite wall consisting of a suitable coating on a substrate chosen for its strength and ease of fabrication. The techniques employed to deposit several of these candidate materials onto stainless steel substrates as thick coatings are described.

Current demands from the fusion supply chain (26 responses. Answered 'critical' or 'important').

See Appendix 1 for expanded table.

	Critical/important
Vacuum pumps	24
Precision engineering and manufacturing services	24
Control Software	21
Power semiconductors	20
Deuterium, tritium, or other gaseous fusion fuels	19
Recruitment	19
Specialized metals, e.g. high-grade steel	17
Common metals, e.g. nickel, copper	16
Engineering, Procurement and Construction Firms	16
Heat management technologies	14
Natural Lithium	14
First wall materials	14
Legal services	14
Cryogenic devices	13
Magnets	12
RF heating	10
Lithium (enriched)	10
High Temperature Superconducting (HTS) Tape	9
Lasers (assembled)	6
Rare earth metals	6
Laser components, eg. diodes, laser glass	5

Supply Chain Needs Will Grow

Demand increase for fusion components over next ten years (26 responses. Answered 'critical' or 'important').

See Appendix 1 for expanded table.

	Order of magnitude/ significant increase
Vacuum pumps	14
Precision engineering and manufacturing services	14
Heat management technologies	13
Deuterium, tritium, or other gaseous fusion fuels	13
Engineering, Procurement and Construction Firms	13
Recruitment	13
Power semiconductors	12
Specialized metals, e.g. high-grade steel	12
Control Software	12
First wall materials	11
HTS Wire	10
Magnets	10
Cryogenic devices	10
Natural Lithium	10
Lithium (enriched)	8
Legal services	8
RF heating	7
Rare earth metals	7
Common metals, e.g. nickel, copper	6
Lasers (assembled)	5
Laser components, eg. diodes, laser glass	5

Number of companies expressing concerns about current and future supply constraints (only categories with 3+ responses included below).

See Appendix 1 for expanded data.

Affiliate Members

BAY FUSION
SIMIC
Mitsubishi Corporation
THALES
Google
TWI
BUTTING
AMPLEON
CleanTech Alliance
Roland Berger
KIND
Sumitomo Corporation of Americas
Enriching lives and the world
COHERENT
EXO FUSION
Southern Company
framatome
BILFINGER
BILFINGER NOELL GMBH
FLUOR
equinor
eni
METOX
ALSYMEX
radiasoft
TVA
SVC
SOCIETY of VACUUM COATERS
IF JAPAN
FARADAY FACTORY
CDE
ENERGIZING IDEAS
CORNELL DUBILIER
BRUKER
Sapienta
ALCEN
digiLab
SCHOTT
STELLAR
ENERGY for the COMMON GOOD
Soon enough to make a difference
LEONARDO
ONTARIO POWER GENERATION
Cryoelectra
RF Technology for Particle Accelerators
ENERGY FOUNDATION
CLEARPATH ACTION
HTS
HIGH TEMPERATURE SUPERCONDUCTORS
OAK RIDGE
CURTISS-WRIGHT
DIVERSIFIED TECHNOLOGIES, INC.
KTC
Keller Technology Corporation
Morgan Lewis
KINECTRICS
COSYLAB
TERRA PRAXIS
WOODRUFF • SCIENTIFIC
ARNOLD MAGNETIC TECHNOLOGIES
American Conservation Coalition
research instruments
ASG SUPERCONDUCTORS
AEROSPACE
AMPEGON
pillsbury
AIR LIQUIDE
INTERLOCK ENERGY
STRONG ATOMICS
NEW LIGHT FUSION CONSULTANTS
TRUMPF
EPRI
FRAZER-NASH CONSULTANCY
IDOM
FUSION ENERGY INSIGHTS
K&L GATES
ENERCON
ETEC
EAST TENNESSEE ECONOMIC COUNCIL
tecnatom
TELEDYNE BROWN ENGINEERING
ATDG
TRIANGLE DESIGN GROUP LLC
OXFORD SIGMA
OCEM POWER ELECTRONICS

How FIA Accelerates Fusion

Public Private Partnerships

The private sector should have access to the scientific research that governments have pursued for decades. Public-Private Partnerships that include government support to private fusion companies can rapidly accelerate fusion development by driving new private financial support.

Ensuring Regulatory Certainty

The regulatory regime for fusion should be predictable, proportional to the risk, and supportive of innovation, while also giving confidence about ensuring public safety and security. Fusion energy regulation must be permanently separated from fission regulation and should not require lengthy permitting process for every facility.

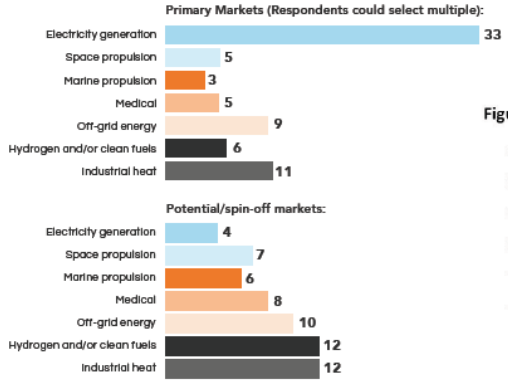
Incentives to Build a Global Fusion Energy Industry

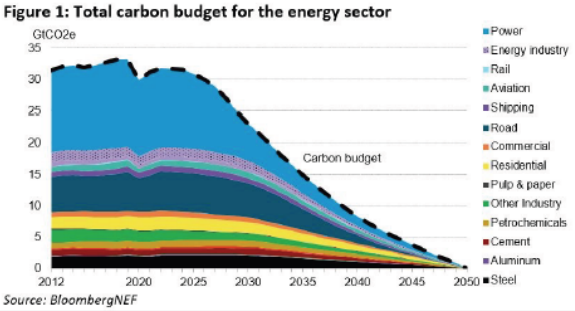
Fusion does not need special status or excessive subsidies but should have a level playing field as it grows into a new industry.

Progress

Why? Fusion will Change the Outlook for 2050 Net Zero

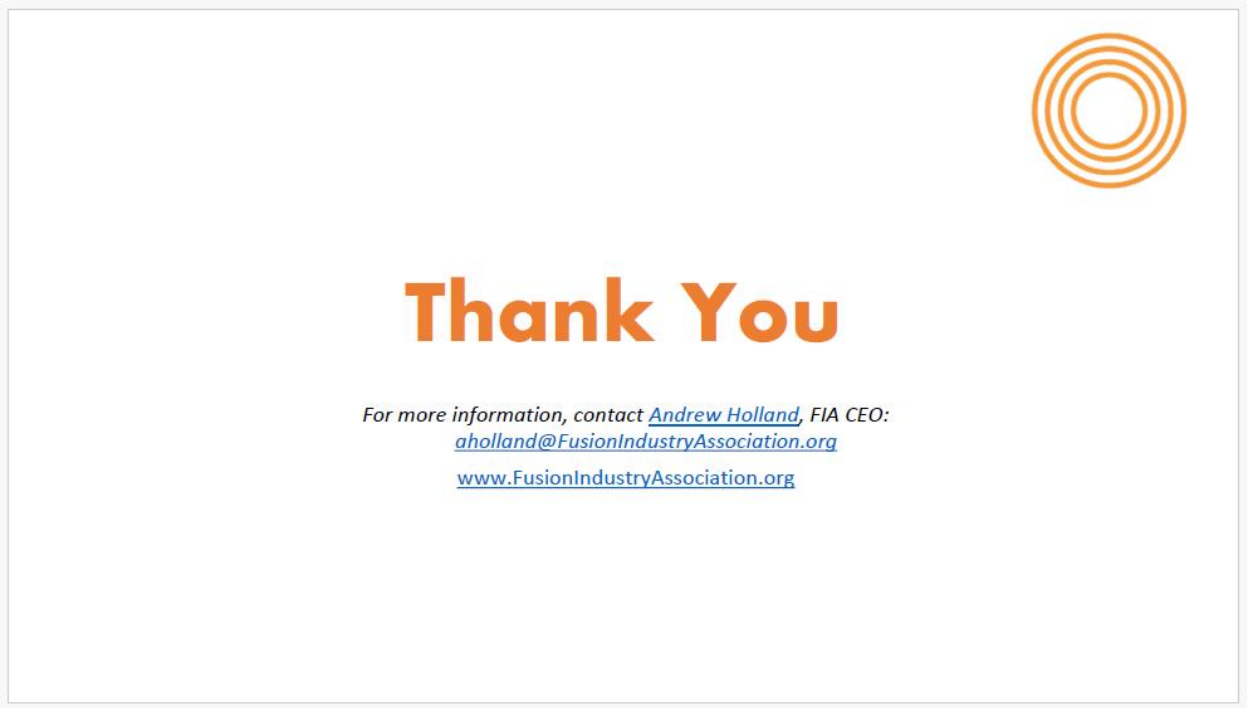
*Fusion is a source of nearly unlimited **clean, firm power***





Results: FIA's Vision for the 2030's

- **Industry** builds multiple fusion pilot plants of different sizes, technologies, and fuel cycles, preparing to scale-up into a globally-leading export industry.
- **Fusion Supply Chain** grows to over $7 billion per year industry (already over $500 million today)
- **Governments** support fusion commercialization push with world-leading science, computing power, and test facilities - the **infrastructure** that enables a fusion industry.
- **Research Universities** form the backbone of the **fusion workforce** and train the next generation.


Thank You
For more information, contact Andrew Holland, FIA CEO:
aholland@FusionIndustryAssociation.org
www.FusionIndustryAssociation.org

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

C.K. DORN (Kyoto Fusioneering America Ltd., Washington, USA)

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

Christopher DORN

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

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

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

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

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

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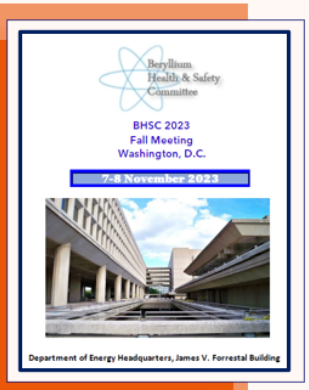
KYOTO FUSIONEERING

Be4FUSION
Specialty Materials & Business Consulting

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



Chris DORN

Beryllium Health & Safety Committee
BHSC 2023 Fall Meeting, DOE Forrestal Bldg.
Washington, D.C., U.S.A.

7th November 2023

FUSION for the FUTURE.

Be4FUSION

Contents

- **Overview & History**
  - Beryllium Workshop (BeWS) Series
  - BeYOND Industrial Forum Series
- **BeWS-16 Program**
  - Overall Technical Content
  - BHSC-Relevant Highlights
- **Announcement about next BeYOND**
  - Founding Concept
  - Technical Program to date
  - Proposed Scope moving forward
- **Summary & Conclusion**

Overview: The Beryllium Workshop Series

Be4FUSION

- **Workshop Genesis**
  - Japan Fusion Mission
  - September 1989 at Idaho National Lab
- **Beryllium Technology Workshop**
  - 1991 Satellite of ICFRM
  - Idea for Series Event
- **Founding the Series**
  - FZK (Germany), INL (USA), JAERI (Japan), and Kazakhstan University
  - Application for IEA Sponsorship
- **IEA Series Established**
  - Odd-Numbered Years
  - Satellite of ICFRM or ISFNT

Organized under the auspices of
The IEA Technology Collaboration Program on Fusion Materials (FM TCP)

History: The Beryllium Workshop Series

Be4FUSION

Meeting	Year	Attendees	Papers	Organizations	Location
BeWS-0	1991	42	12	12	Clearwater Beach, Florida, USA
BeWS-1	1993	52	20	23	Karlsruhe, Germany
BeWS-2	1995	45	37	26	Jackson Lake Lodge, Wyoming, 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, California, 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, Catalonia, 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	20	Karlsruhe, Germany
BeWS-16	2023	~40	22	~20	Santander, Cantabria, Spain

Overview: The BeYOND Industrial Forum

Be4FUSION

- **Workshop Concept**
  - Link Research Centers with Industry
  - Greater Emphasis on Industrial Issues
    - Technology Transfer
    - Scale-Up from Laboratory to Production
    - Environmental, Health & Safety (EH&S)
- **Starting the Series**
  - Partnership: KBHF & Brush Wellman
  - Funding from KIT & Industry Partners
- **Event Parameters**
  - Even-Numbered Years
  - Timing Coordinated with SOFT
  - Always in Europe
  - Mostly in Karlsruhe, Germany (KIT)

BeYOND
Beryllium Opportunities for New Developments

- 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

BeWS-16: Overall Technical Content

Be4FUSION

- **Held over 2 Days**
- **Workshop Sessions**
  - Plenary (Introductory)
  - Fabrication & Recycling
  - Molten Salt Breeders
  - Mechanical Properties of Beryllium & Beryllide Intermetallic Compounds
  - Irradiation Damage & Helium Implantation
  - Modeling
  - Health & Safety
  - BeYOND Industrial Forum

BeWS-16:	19-10-23				
Start	**End**	**Time**	**Item**	**Presenter**	**Session**
9:00 AM	9:30 AM	0:30	Welcome address	President of Cantabria	
9:30 AM	10:00 AM	0:30	Present Status of Advanced Neutron Multipliers for JA DEMO activities	Jae-Hwan Kim	1.1 Introductory
10:00 AM	10:30 AM	0:30	Overview of analysis methods for beryllium from controlled fusion devices	Marek Rubel	1.2 Introductory
10:30 AM	10:50 AM	0:20	Break		
10:50 AM	11:15 AM	0:25	Reaction kinetics in the leaching process of beryllium from beryl	Suguru Nakano	2.1 Fabrication & Recycling
11:15 AM	11:40 AM	0:25	Recycling of neutron-irradiated beryllium and titanium beryllide	Vladimir Chakin	2.2 Fabrication & Recycling
11:40 AM	12:05 PM	0:25	Recycling of Beryllides: Novel Approach for Cost-Effective and Efficient Fabrication	Ramil Gaisin	2.3 Fabrication & Recycling
12:05 PM	12:30 PM	0:25	Attempts for uranium removing in beryllium using arc plasma	Norihiro Ikemoto	2.4 Fabrication & Recycling
12:30 PM	2:00 PM	1:30	Lunch		
2:00 PM	2:25 PM	0:25	FLiBe Molten Salt as a Tritium Breeder/Coolant for Fusion: Fostering Collaboration for Breakthrough Progress	Chris DORN	3.1 Molten salt breeders
2:25 PM	2:50 PM	0:25	Prototype verification of tritium breeding with liquid immersion blanket technology using flibe	Kevin B. Woller	3.2 Molten salt breeders
2:50 PM	3:15 PM	0:25	Beryllium Worker Protection Model for the Production and Handling of FLiBe	Theodore Knudson	3.3 Molten salt breeders
3:15 PM	3:35 PM	0:20	Break		
3:35 PM	4:00 PM	0:25	Screening tests to qualify thermo-mechanical properties of beryllium pebble beds with non-spherical pebbles	Jörg Reimann	4.1 Mechanical properties of Be & Beryllides
4:00 PM	4:25 PM	0:25	Study of Mechanical Properties of Beryllium Intermetallic Compounds Fabricated by Plasma Sintering	Taehyun HWANG	4.2 Mechanical properties of Be & Beryllides
4:25 PM			ADJOURN		

BeWS-16 Highlight: MiRESSO Introduction

Be4FUSION

- **Novel Refining Process for Primary Beryllium**
  - Fewer process steps expected to result in lower costs
  - Demonstrated in laboratory quantities only to date
  - Beryl Ore source in Brazil
- **Spin-Off from QST Research Center in Japan**
  - Founded in May-2023
  - Commercial Production & Availability planned for 2027
  - Primary Target: fusion DEMO Reactor, which will need 350t of beryllium-contained

MiRESSO

BeWS-16 Highlight: MIT-KF FLiBe Research

Be4FUSION

- **Introduction**
  - U.S. Bold Decadal Vision
  - Public-Private Partnerships
- **FLiBe Fusion R&D: Current & Planned**
- **Fusion Blankets & FLiBe: Challenges**
- **Outcomes: Fusion Blanket Workshop**
- **Pathways Forward through Collaboration**
  - Fission & Fusion, e.g., MIT
  - Private Fusion Companies, Universities & Government Labs & Research Centers

BeWS-16 Highlight: Be Facility Design

Be4FUSION

- **Lead Author: BHSC Member Beth Walker**
  - Former Novanta Staff
  - MD, Safer Environment Ltd.
- **Challenges Addressed**
  - Old 1950s Legacy Facility
  - New Site, Sensitive Area
  - Air-Flow & Layout Plan
  - Humidity, Temperature & Pressure Control
  - Safe Air: HEPA & A/C
  - Water Treatment
- **New Facility a Success**
  - UK Excellence in Health & Safety Award, 2023

Announcement: Future of the BeYOND Forum

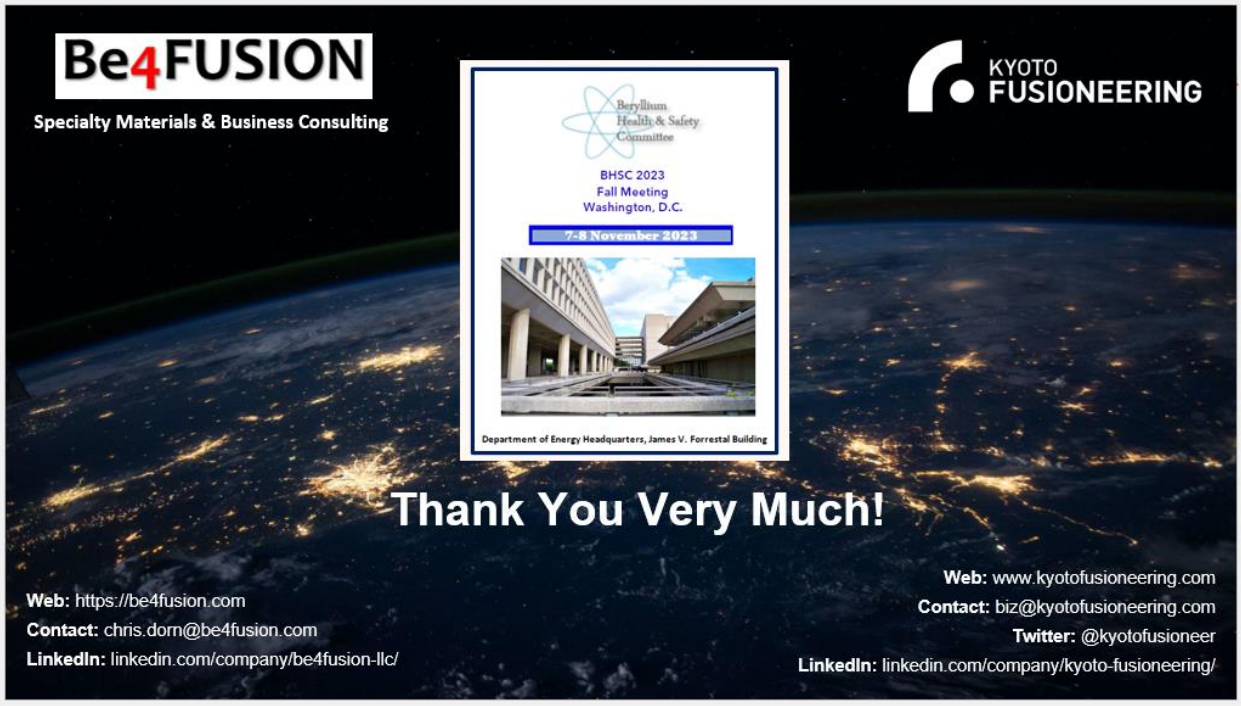
Be4FUSION

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

Summary & Conclusion

Be4FUSION

- **2009-2022 Two Regular Periodic Workshops on Beryllium**
  - Occurring in Alternating Years as Satellites of Larger Conferences
  - BeWS Series under IEA Auspices since 1990s
  - BeYOND Series since 2009 with Emphasis on Connections to Industry & EH&S
- **BeWS-16 Technical Program**
  - Focused mainly on Fusion-Related Research in Traditional Institutions
  - With changing Fusion Industry, Interest in FLiBe Molten Salt from Private Companies, but Government-Sponsored Research Centers are still working on Solid Breeder Materials
  - MIT-Plasma Science & Fusion Center (PSFC) & Kyoto Fusioneering trying to work together and collaborate with Fission Industry to advance FLiBe Research for Fusion
- **What Happens Next?**
  - BeWS-17: Should take place in Fall 2025, possibly in conjunction with ICFRM in Japan or with ISFNT in the USA; decision should be made in the next couple of months
  - BeYOND: Proposed to expand scope to include Global Fusion Partnerships (GFPs); next event should take place 19/20-Sep-2024, possibly in conjunction with SOFT (Dublin, Ireland)



Overview of LiF-BeF_2 Research & Management at Savannah River National Laboratory
L. OLSON et al. (Savannah River National Laboratory, South Carolina, USA)

Overview of LiF-BeF_2 Research and Management at Savannah River National Laboratory

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

Savannah River National Laboratory, Aiken, South Carolina, USA

Savannah River National Laboratory (SRNL) is conducting research on LiF-BeF_2 salt, more commonly known as FLiBe, for fusion applications. Molten FLiBe is being investigated as a blanket material for fusion reactors, where it captures neutrons produced by fusion reactions in the plasma, carries away thermal energy for power production, and breeds tritium to fuel the deuterium-tritium fusion reaction. Recent work has focused on the development of viable FLiBe reference electrodes and demonstration of corrosion mitigation using metallic beryllium in contact with the salt.

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

As-received FLiBe salt is maintained in an anhydrous environment. BeF_2 is hygroscopic and deliquescent at room temperature, whereby upon heating any adsorbed water will react to form HF, which can in turn attack containment materials. For this reason, all FLiBe work at SRNL is undertaken in a glovebox designated for beryllium use, with additional protocols in place for both minimizing contamination within the glovebox and eventual decontamination. Once experimental cells are loaded with FLiBe in the glovebox, they are sealed, removed from the glovebox, and transported into a fume hood where electrochemical measurements are acquired under inert gas flow; any potential off-gassing is captured in a bubbler apparatus. All beryllium waste generated, including solid waste from testing and liquid waste streams from rinsing, cleaning, and off-gas bubbling, is designated and separated. The SRNL beryllium management plan encompassing safe conduct of operations and ensuring worker safety will be discussed in detail.

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

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Overview of $LiF\text{-}BeF_2$ (FLiBe) Research and Management at Savannah River National Laboratory

Luke Olson (Presenter), Christopher S. Dandeneau, Gavin Mattingly, Justin Eppenbrock, Sherolyn Bishop, Robert Sindelar, Brenda L. Garcia-Diaz

BHSC Fall Meeting, November 7-8, 2023, Washington, D.C.

SRNL-STI-2023-00569

U.S. DEPARTMENT OF ENERGY

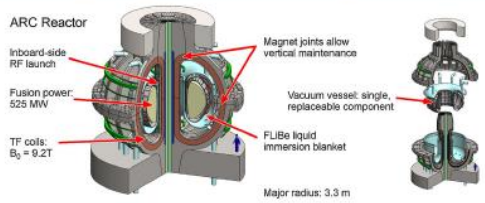
Managed and operated by Battelle Savannah River Alliance, LLC for the U. S. Department of Energy.

BSRA

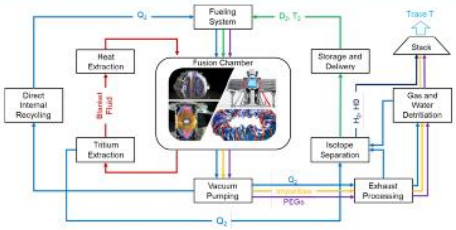
Outline

- Beryllium (Be) R&D at SRNL related to FLiBe
- Be management plan being followed
- Decommissioning, clean-up, and rehabilitation

FLiBe is proposed for fusion applications due to good neutronic and physical properties, but handling requirements and potential toxicity presents complications

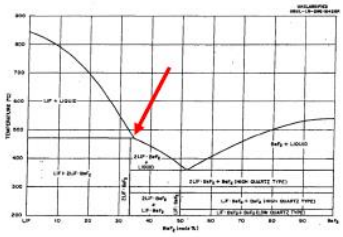


B.N. Sorbom et al., Fus. Eng. Design, 100, p. 378 (2015)



https://commons.wikimedia.org/wiki/File:FLiBeSolidandMelted.gif

https://commons.wikimedia.org/wiki/File:LithiumTriflateHygroscopy.jpg

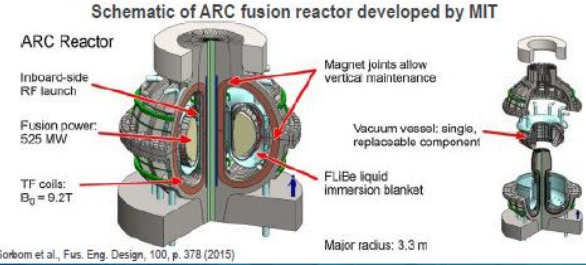


Examples of phenomenon, not all are directly applicable

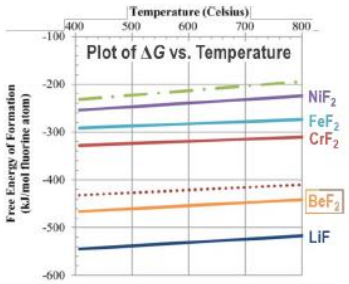
Active redox control of molten salts is beneficial for FLiBe fusion blankets

- **Structural material degradation via impurity-driven corrosion is one of the primary drawbacks of FLiBe**
  - Impurities in the salt → Unstable fluoride formation (e.g., HF, TF) → Corrosion via reactions with structural alloy elements (Cr, Fe)
- **<u>Redox control strategy</u>: Mitigate corrosion of alloys in FLiBe by introducing an active metal to lower redox potential of salt to value below reduction potential of constituent alloy elements**
- **Project Goals: Electrochemically detect impurities/corrosion products in FLiBe and achieve active, real-time redox control through the addition of Be metal**

Schematic of ARC fusion reactor developed by MIT



B.N. Sorbom et al., Fus. Eng. Design, 100, p. 378 (2015)

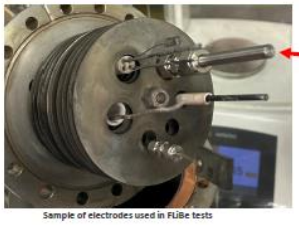


High thermodynamic stability of BeF_2: Introduction of Be will mitigate corrosion of alloying elements

C.W. Forsberg et al., Nucl. Tech., 194, p. 295 (2016)

SRNL is currently performing electrochemistry and immersion testing using FLiBe and Be metal with promising results to date

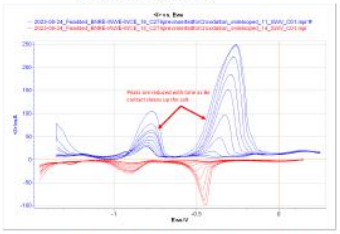
Simplified EChem cell schematic



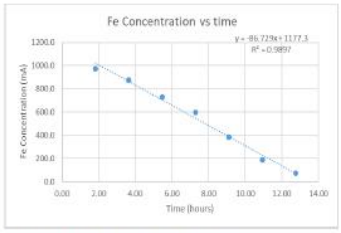
Sample of electrodes used in FLiBe tests

Be metal electrode (Article)

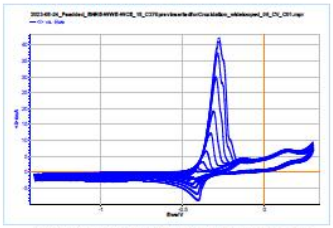
FLiBe post test



Square Wave Voltammetry showing impurity reduction after Be contact



Reduction in Fe impurity with time after Be contact



Cyclic Voltammetry showing impurity reduction after Be contact

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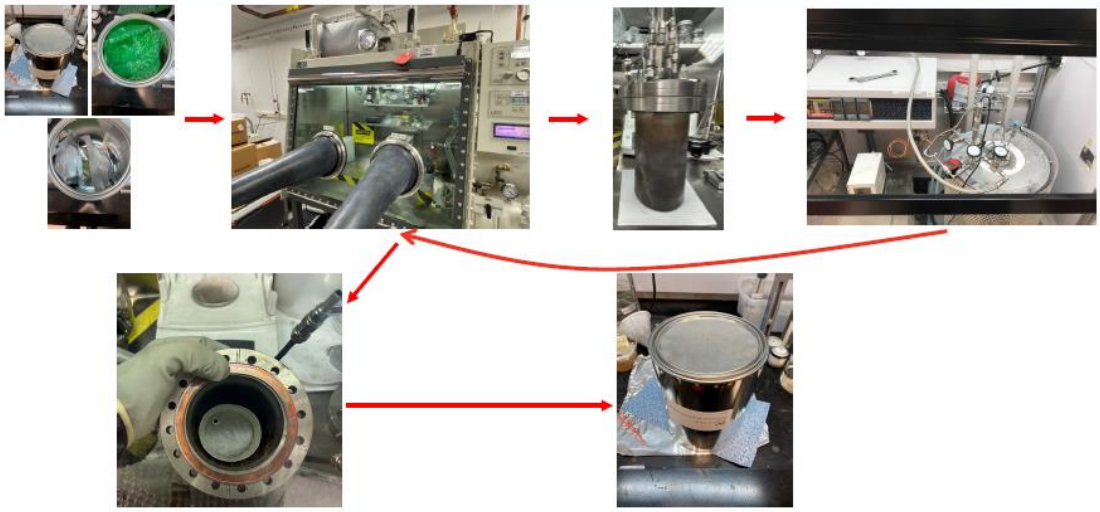
FLiBe storage and primary handling occurs in an argon atmosphere glovebox, with a short transport through a hallway to a fume hood in a sealed vessel, so the potential for exposure is low



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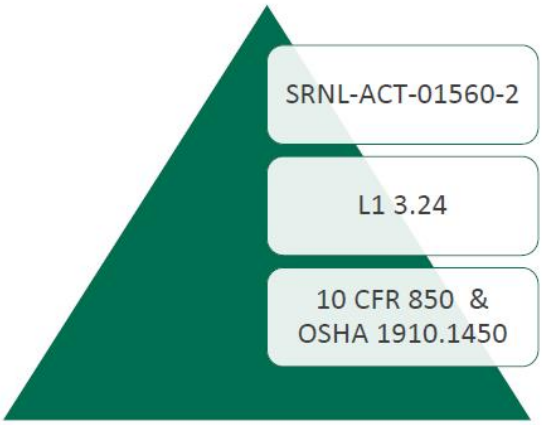
A Be management plan was formulated, but we actively seek input from this community



- Flow down from federal regulations
- Site: SRS Beryllium Program
- Lab:
  - SME feedback on procedures for handling and clean-up
  - Hazard Analysis System
    - Activity SRNL-ACT-01560-2

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Worker training and monitoring

- SRS Beryllium Program
  - Define site and lab training and monitoring requirements
- Any potential Be material and Be handling is isolated that reduces exposure potential for Be. Be metal is solid rod and not machined.
  - Be salt is handled only in glovebox
  - Be vapors would be captured by bubbler in fume hood
  - Potential Be containing wastes and rinses are kept separate
  - Swipes will be taken to ensure clean surfaces and minimize cross contamination
  - Glovebox vented out stack
- **Voluntary** enrollment in medical surveillance program due to no actual contact risk

SRS beryllium program site

https://en.wikipedia.org/wiki/Beryllium

https://en.wikipedia.org/wiki/Training#/media/File:IBMComputerTrainingWorkshop.JPG

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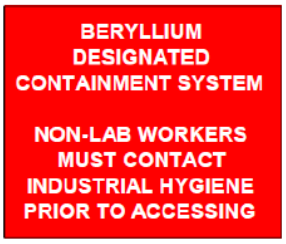
Be physical space considerations: Be and its waste are kept separate and in designated locations

- Small scale R&D work means exempt from the DOE 850 Beryllium Rule → working under the OSHA lab standard
- In glovebox
  - Separated experimental items/storage, and sealed/closed while not in use
  - Separated waste storage
- Outside of glovebox:
  - Water rinses of equipment kept in separate labeled containers



Postings per L1 1.49 Rev. 2

Warning Signs and Labels

Compliant with:
- 29 CFR 1910.1450
- Lab Standard
- Manual 4Q, Procedure 209

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Decommissioning activities

- Goal: be able to decontaminate glovebox for reuse in other projects after FLiBe missions
- Required activities
  - Bag up all wastes in the glovebox and wipe down glovebox to remove any potential surface contamination
  - Coordinate with IH to take Be surface wipes for analysis
  - Based on results: release glovebox or further mitigation
    - Options: 1) two wipes before work or clean-up and 4 wipes after work begins, 2) decon work and 3 more wipes, then 3) the cost of a new glovebox. We can note we think option 1 is what is expected, but option 3 is the ultimate max.
- Decommissioning activities and waste disposal all documented in HAS

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Summary Slide

- Research has begun with Be containing molten salts that may be used in fusion energy applications and using Be metal to mitigate corrosion in them
- Engineered barriers and protocols have been put in place to minimize potential Be contact and mitigate the hazards
- A high-level decommissioning plan has been developed
- Feedback and comments requested from this BHSC group

Savannah River National Laboratory

11

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

Conducting Safe Research on Beryllium-Containing Solid Materials

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

Conducting Safe Research on Beryllium-Containing Solid Materials

Anne CAMPBELL[1], Blake HENRY[2], Susan FISCOR[2], Erica PAXTON[2], and April CASE[2]

[1]*Materials Science & Technology Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA*
[2]*Safety & Operations Services Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA*

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

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

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

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

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OAK RIDGE National Laboratory

Conducting Safe Research on Beryllium-Containing Solid Materials

Anne Campbell
Materials Science & Technology Division

Blake Henry, Susan Fiscor, Erica Paxton, April Case
Safety & Operations Services Division

Oak Ridge National Laboratory, Oak Ridge, TN, USA

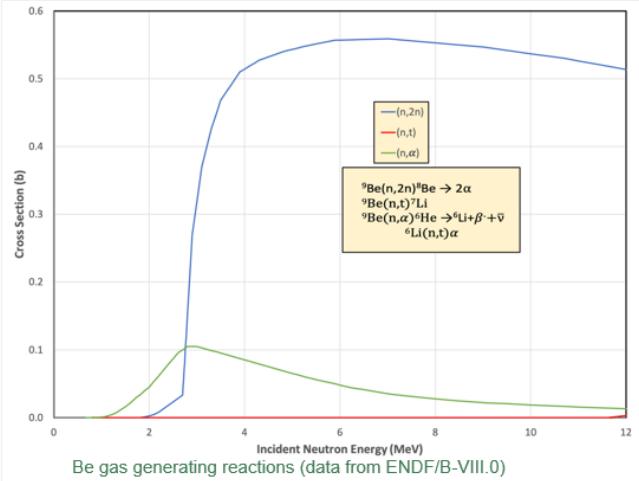
ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

BHSC Fall Meeting 2023
7-8 November 2023 ▪ Washington, D.C., U.S.A.

Why beryllium in nuclear energy?

- Neutron moderator – collisions between neutrons and Be atoms remove kinetic energy from neutrons allowing them to continue chain reaction
- Neutron multiplier – high energy neutron (>2.7 MeV) collide with ^{9}Be and cause to split into 2 ^{4}He and 2 neutrons
  - $^{9}Be(n,2n)^{8}Be \rightarrow 2\alpha$
- Neutron reflector – surrounds fuel so neutrons that escape fuel region are scattered (i.e. reflected) back into the fuel
- Tritium breeding for fusion reactor fuel



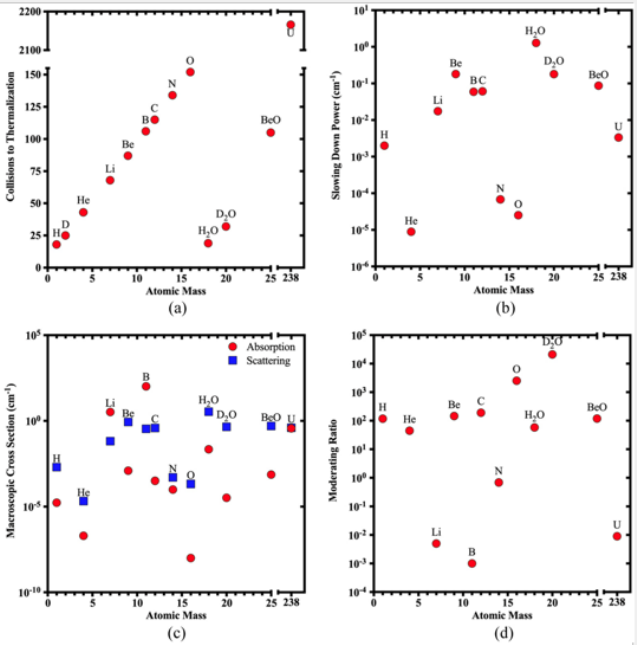
Be gas generating reactions (data from ENDF/B-VIII.0)

OAK RIDGE National Laboratory

2

Motivation
Advanced Fission Reactors

- Beryllium has multiple desired uses within advanced nuclear fission reactors
  - Mainly for "thermal" neutron reactors concepts
- Molten salt reactors utilizing FLiBe salt as primary coolant
  - Some use TRISO solid fuel, others use dissolved fuel in the form of UF



Campbell & Burchell Timothy D. (2020). Radiation Effects in Graphite. Comprehensive Nuclear Materials 2nd edition, vol. 3, pp. 398–436

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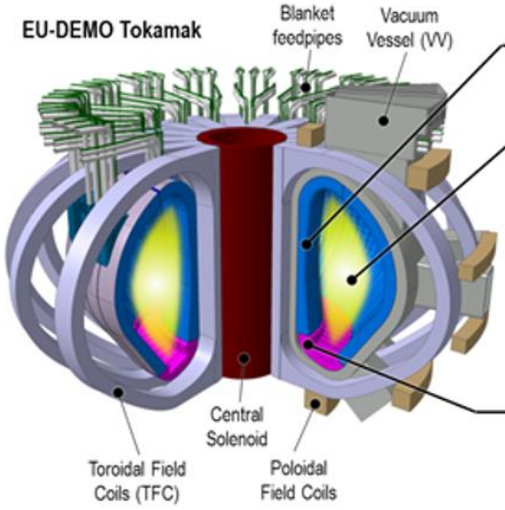
Example Fusion Reactor



- **Breeding Blanket (BB)**
  - Functions: T breeding, heat extraction, (shielding)
  - Fusion: $D + T \rightarrow He + n$ (~30% n lost due to {streaming, leaking, absorption})

$Li + n \rightarrow {}^4He + T + (n')$

Li compound (ceramics) as T (ceramic) breeder (CB)

${}^9Be + n \rightarrow 2\,{}^4He + 2n$

Be/Be compound as neutron multiplier material (NMM)

- **Divertor (DIV)**
  - Functions: exhaust He, plasma impurities and thermal power, (shielding)

https://www.inr.kit.edu/english/226.php

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Technical Challenges with Beryllium

- Toxicity and concomitant difficulty in production & manufacturing
- High swelling under irradiation, especially at high temperature (> 600 °C)
- High tritium retention (40% at 600 °C) (good for fission, bad for fusion)
  - A small but significant (<1%) amount of tritium is bred in beryllium
    - $^{9}Be(n,T) \rightarrow {}^{7}Li$
    - $^{9}Be(n,\alpha)^{6}\mathrm{He} \xrightarrow{\beta^-} {}^{6}Li(n,T)\alpha$
  - Diffusivity of tritium in beryllium metal is low (it would be a decent permeation barrier)
- Highly exothermic reaction with air and water (hydrogen generation)
- Helium production bad for structural materials (helium embrittlement)
- Use of beryllium alloys can alleviate some of these technical challenges

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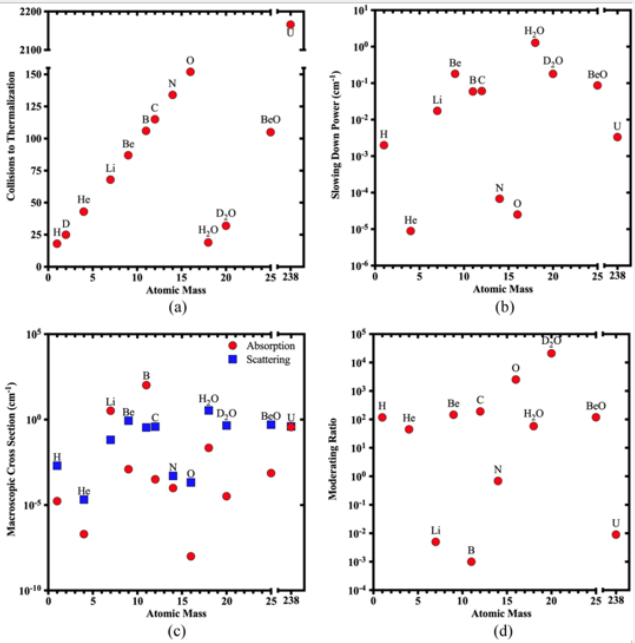
Slide adapted from P. Humrickhouse
30th Symposium on Fusion Engineering

Why Beryllium Carbide?

- High moderating efficiency and low absorption cross section
- Be slowing down power ~2.5x > than carbon (typical moderator for thermal fission reactors)
- Chemically compatible with coolant salts
- Antifluorite crystal structure – the same crystalline configuration (with anions and cations reversed) as exceptionally radiation damage resistant fluorite type crystals (e.g., UO_2
  - The anti-fluorite crystal (Li_2O) has also been shown to have high radiation damage tolerance [1,2]



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[1] Moriyama et al., *Journal of Nuclear Materials*, **258-263**, (1998) 587-594.
[2] Noda, et al., *Journal of Nuclear Materials*, **123**, (1984) 908-912

Campbell & Burchell Timothy D. (2020). Radiation Effects in Graphite. Comprehensive Nuclear Materials 2nd edition, vol. 3, pp. 398–436

Technical Challenges with Beryllium Carbide

- Long history of graphite as neutron moderators (CP-1, X-10 >80 years) research and knowledge – only limited low dose studies in Be_2C [1-3]
- Be_2C is brittle, vulnerable to thermal stress cracking
  - Can we mitigate brittle nature via fiber reinforcement?
- Be_2C it toxic, moisture sensitive, chemically reacts with U
  - Would need a protective layer (NbC)
- Be_2C is a methanide (when exposed to H it decomposes into methane)
  - Can this be utilized for tritium management strategy?
  - Methane is easily trapped and doesn't diffuse through metal alloys
- Be does have gas generating reactions with neutrons (He and ^3H)
  - May be beneficial for fusion systems for ^3H production

[1] Maya et al., GA-A-17842; (1985)
[2] Marion & Muenzer, SAND--78-0227C, CONF-780622, (1978)
[3] Feldman & Silverman, NAA-SR-114, (1951)

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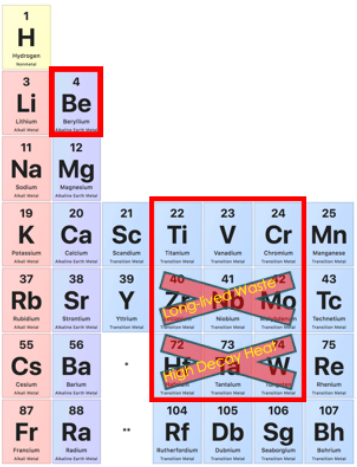
Beryllides for Fusion Reactors

- Need materials with high beryllium content but better oxidation resistance
- Focus on group 4-6 transition metal beryllide intermetallic compounds
  - Be_XM, where X=12 or 13; >92% beryllium
  - Hard, brittle, high melt temperature (1500-1900 °C)
- Beryllides with a high beryllium density makes them potentially attractive multipliers for tritium breeding blankets; low-activation metals Ti, V, Cr are attractive alloying elements



- Titanium beryllide, $Be_{12}Ti$, is the most extensively studied beryllide for fusion
  - Significantly lower oxidation rate compared to pure Be
  - Irradiation to 19.5 dpa, 2740 appm He in HIDOBE-01 revealed much lower swelling and tritium retention compared to pure Be

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[1] A.V. Fedorov, *Fusion Engineering and Design* **102** (2016) 74-80.
[2] F. Druyts, https://www.osti.gov/etdeweb/servlets/purl/20658771

Slide adapted from P. Humrickhouse
30th Symposium on Fusion Engineering

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Testing of Beryllium Containing Solids for Advanced Nuclear Applications

- Susceptibility of Be in Be_2C, $Be_{12}Ti$, $Be_{12}V$, $Be_{12}Cr$ to oxidation still a concern
  - Reduced in these alloys but not eliminated
  - Be0 primary reductant
  - Requires environmental controls to prevent oxidation, but also to protect researchers (glove boxes)
- Need to be able to quantify the oxidation/reduction behavior in various environments
- Need to be able to quantify changes to materials properties due to neutron irradiation damage

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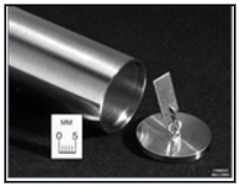
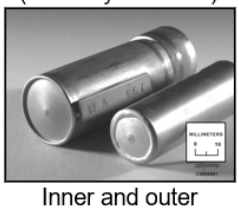
High Temperature Stability

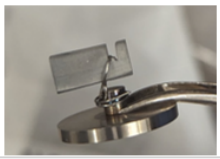
- Thermal stability can be potential no-go concern
- Measure X-ray diffraction (XRD) pattern of samples pre-exposure
- Weld samples in double Molybdenum capsules
  - Can use inert gas or salts as environment
  - Perform high temperature exposures in a box furnace
- Open capsules and remeasure XRD spectra
  - Determine if any significant change in phases present and their concentration



Sample mounted on Mo capsule lid (courtesy J. Keiser)



Inner and outer capsules (courtesy J. Keiser)



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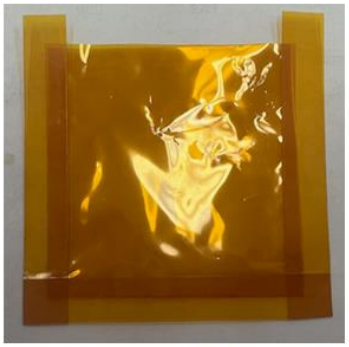
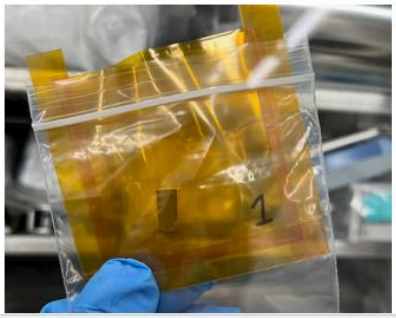
Containment for Measurements Outside Gloveboxes



- ORNL has long history of working with radioactive materials – leverage this institutional knowledge to develop containment methods and procedures for Be-alloys
- X-ray Diffraction requires measurement outside a glovebox
  - Kapton film and tape are used for encapsulation as it does not interfere with x-ray penetration
  - Sandwich Be_2C between two pieces of Kapton film with edges sealed shut with overlapping pieces of Kapton tape



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Be Containment During XRD Measurements

- XRD stage wrapped in Glad Press'n Seal wrap
  - In the event the Kapton packet had any undetected removable Be
  - Any transfer would be to wrap rather than stage
  - Same methodology used with radioactive samples

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Degradation/oxidation in controlled environment

- Be_2C degrades to methane in the presence of hydrogen
  - Can this be used for ^3H mitigation?
- Small pieces of Be_2C will be exposed to inert gas in a skimmer with fixed concentrations of hydrogen gas or moisture
  - Quantify the rate of decomposition of Be_2C into methane
- Engineering controls required since sample handling after measurement will expose sample to air

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Irradiation Damage

- Neutron irradiation in materials test reactors (ORNL HFIR, INL ATR) are time and cost intensive to fully qualify a material for reactor use
  - Cannot be bypassed
- Ion irradiation can provide preliminary information about behavior
  - Preliminary radiation damage
  - Can be used to implant transmutation gases (H, He) in crystal and study gas behavior in Be-alloys
    - Mobility and gas distribution at various temperatures (single atoms in crystal, aggregation to grain boundaries, diffusion to sinks, escape from material)
  - Limited interaction volume, cannot replace neutron irradiation

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Work Controls for Ion Irradiation (University of Michigan)

- Gold sputter coat done in glovebox acts as containment of during ion irradiation
- New 3-piece sample holder (right)
- 5-layer containment when moving samples from glovebox to ion irradiation lab
  - Gold sputter coat sample loaded into molybdenum box in glove box
  - Airtight bag, plastic box with 4 latches, stainless steel cylinder with 3 latches

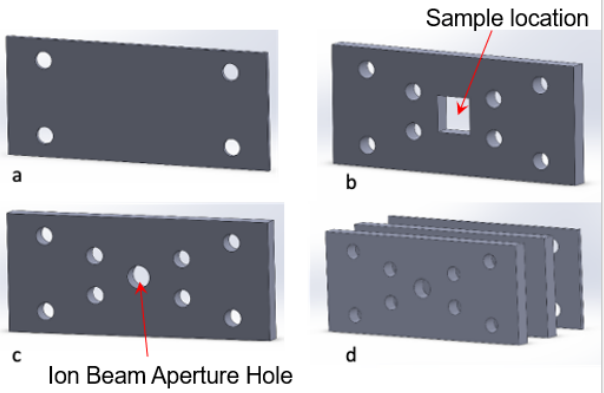

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Figure curtesy D. Muzquiz (UM)

Preliminary Ion Irradiation Safety Testing

- SiC surrogates used to test gold coating integrity – irradiated at similar conditions as Be_2C
  - 250 nm gold coating sufficient for conditions of interest
- First ion irradiation of Be_2C performed August 2023 (sample loaded on stage to right)
  - Swabs of stage, cold trap, work bench, and vacuum chamber show no detectible Be after ion irradiation

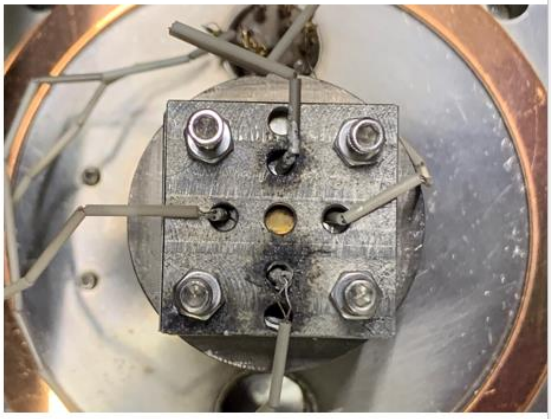

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Figure curtesy D. Muzquiz (UM)

Neutron Irradiation Effects on Properties (NQA-1 Quality Rigor)

- Measure materials properties pre- and post-irradiation in inert environment (glove box)
  - Mass/volume/density – requires cleaning & drying
  - Mechanical properties (strength, elastic properties)
  - Thermal properties (coefficient of thermal expansion, thermal diffusivity/conductivity)
  - Electrical properties (electrical resistivity)
- Much of the equipment needed for these measurements would not easily fit within small (2-3 glove) gloveboxes. May require specially designed gloveboxes
- Include shielding in walls or lead bricks to protect users during post-irradiation measurements of activated samples
- Does not consider technical challenges related to microstructure characterization and microscopy

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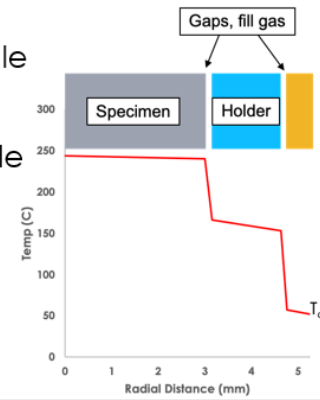
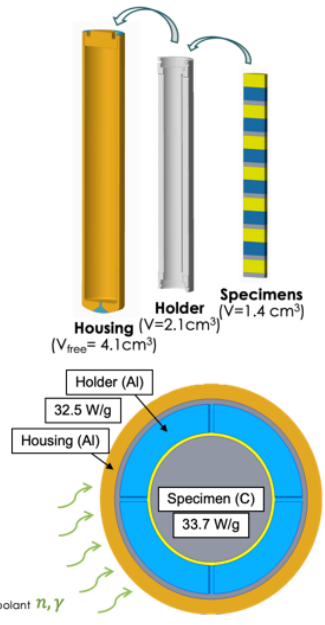
Preparation for Irradiation in MTRs

- Capsule assembly – in inert environment (glove box)
  - Clean all pieces – remove oils or other residue
  - Assemble specimens in capsules
  - Dry in vacuum furnace
  - Separate glove box for capsule backfill with inert gas for temperature control and e-beam welder to seal capsule
  - Hydrostatic & gas leak check of welded capsule





Figures curtesy A. Schrell

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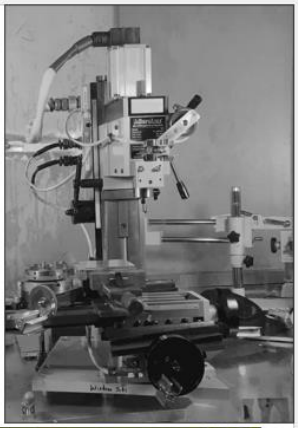
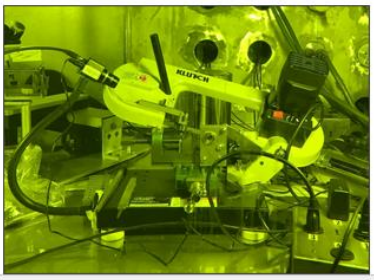
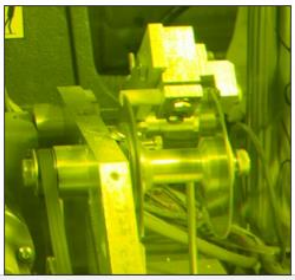
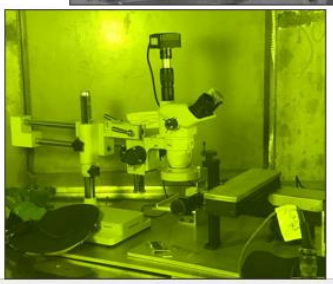
Post-Irradiation Sample Retrieval

- Must be hot cell to due to activity of capsule after irradiation in MTR
- Must be filled with inert atmosphere
  - Most active hot cells operate in air
  - Could be achieved with a modular hot cell (couple $M)
- Must include slow speed saw, possibly table-top mill to cut open capsules
- Equipment/tools for specimen handling, inventory, and packaging









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Final Thoughts Experience

- Testing and development of beryllium-alloys for advanced nuclear applications will not be an easy task
  - More technically challenging than development of a new metal, refractory, or composite
  - Higher up-front cost
    - Materials development and manufacture for testing
    - Infrastructure for material property testing
- Knowledge of how to prevent contamination of equipment and personnel from radioactive samples provide a solid foundation for Be containment
- These same types of technical challenges are also being experienced for fuel and coolant qualification for FLiBe-cooled fission reactors

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

Colorimetric Beryllium Detection

Melissa FREIDERICH, Courtney HUNTLEY, and Laurie LINDSAY

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

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

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

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

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

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

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

Douglas BROWN, P.E.[1], Aaron DICKERSON, P.E.[2], and Todd HAVENS[3]

[1]Merrick & Company, Los Alamos, New Mexico
[2]Merrick & Company, Greenwood Village, Colorado
[3]Merrick & Company, Albuquerque, New Mexico

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

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

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

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

- Limited Capacity of Existing System: Utilizing an existing exhaust system can be complex, especially if it was not initially designed to handle the specific needs of hazardous materials like beryllium.

- Limitations of Fixed Manual Dampers: LANL's preference for manual fixed dampers created additional challenges in controlling volumetric flow rates.

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

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Ventilation for Machining and Welding Beryllium

Case Studies from Los Alamos National Laboratory and Savannah River Site

Presented by: **Doug Brown, PE and Aaron Dickerson, PE**
Presented to: **Beryllium Health & Safety Committee (BHSC)**
November 08, 2023

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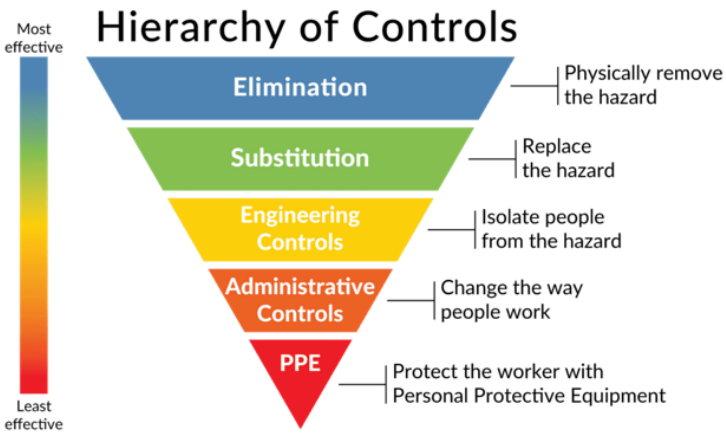
PROJECT SCOPE

- Replace Aging Equipment
  - Lathe
  - Welder
  - Transfer Box w/ Downflow Table

2

PROJECT REQUIREMENTS

- Protect Workers from Exposure
- 10 CFR 850
- Project System Design Descriptions



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ENGINEERING CONTROLS

CONFINEMENT

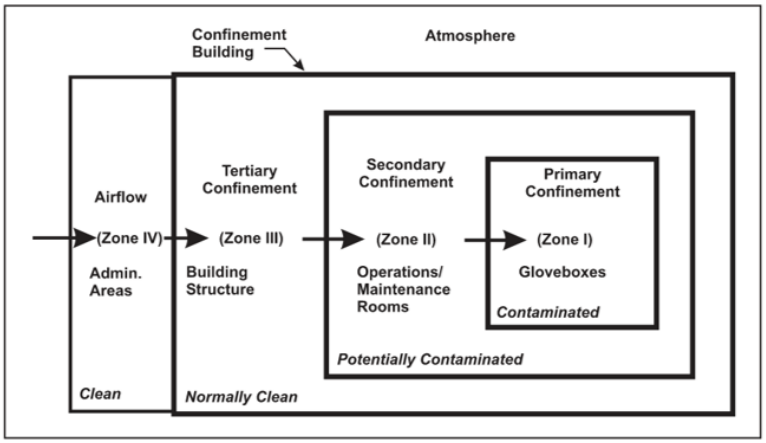


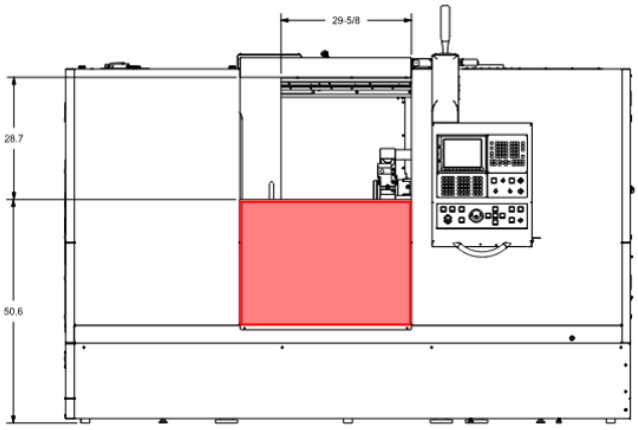
Figure 2.3 – Typical Process Facility Confinement Zones

4

ENGINEERING CONTROLS

PROCESS ENCLOSURE

- 60 – 100 fpm Face Velocity
- Limited Capacity of Local Exhaust System
- Added Blank-off Panels



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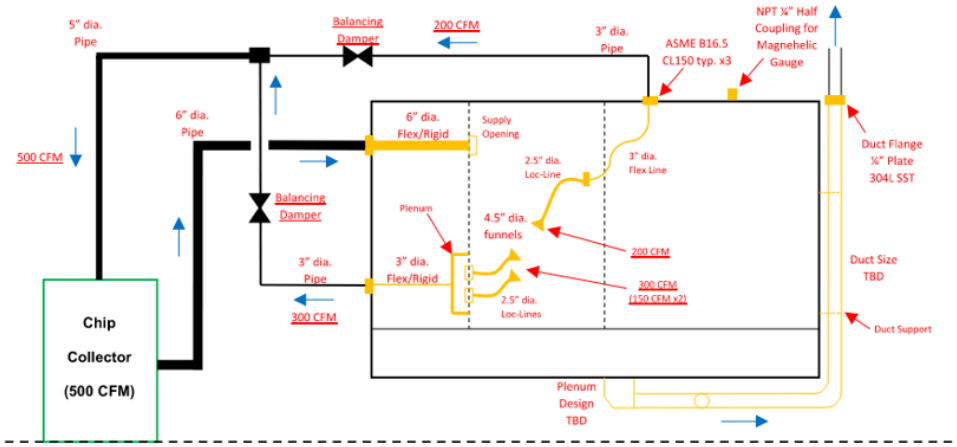
ENGINEERING CONTROLS

LOCAL EXHAUST SYSTEM

- HEPA Filtered
  - Vendor pressure drop
  - Bag-in/bag-out housing
- Flow Control – Active vs. Passive
  - Maintenance
  - Cost

6

ENGINEERING CONTROLS
DUST AND CHIP CAPTURE



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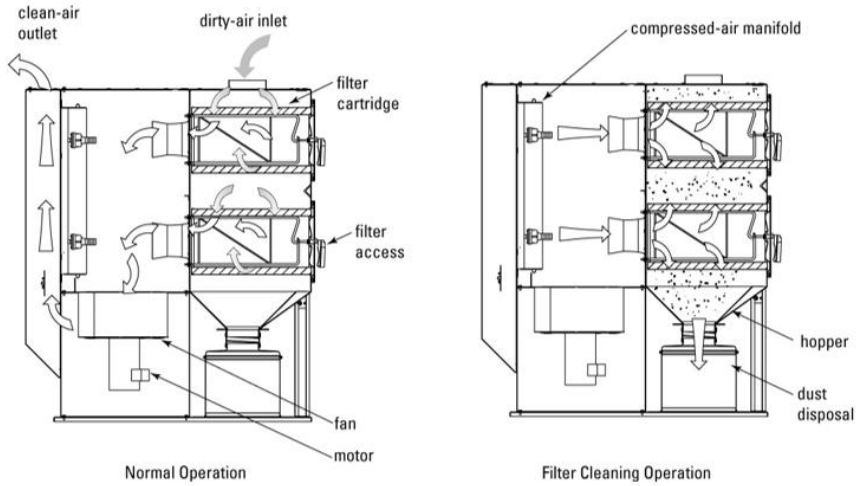
ENGINEERING CONTROLS
DUST COLLECTOR



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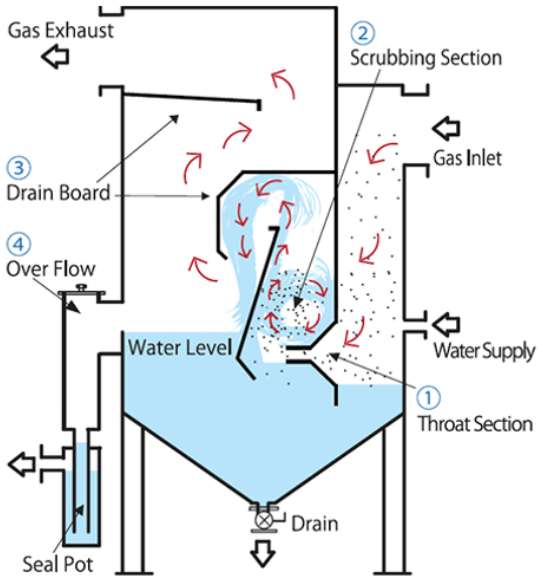
ENGINEERING CONTROLS

WET DUST COLLECTOR

- No reaction with water and Be
- Water extinguishes any sparks
- Sludge created in tank



9

EXPLOSION RISK

EXPLOSION RELIEF VENTS

- Prevent Vessel from Rupturing
- Contamination Risk
- Ducted Length Limitations

10

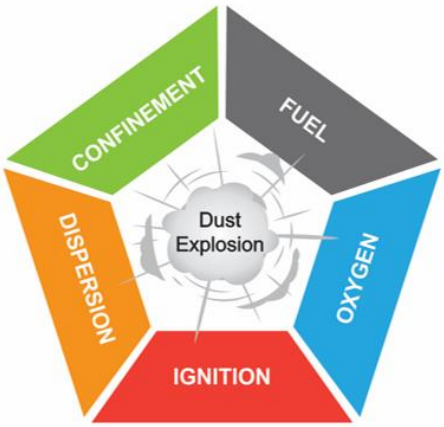
EXPLOSION RISK
INERT ATMOSPHERE

- Removes oxygen
- Asphyxiation hazard
- Higher operating cost

11

EXPLOSION RISK
DUST HAZARD ANALYSIS

- Energy of Ignition Source
- Dust Concentration
- Dust Cloud Turbulence Level
- Vessel Size and Geometry



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

Keith SMITH

Materion Brush Inc., Elmore, Ohio, USA

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

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

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

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The Manufacture of the Beryllium Mirror Segments for the James Webb Space Telescope
James Webb Space Telescope
JWST
NASA • ESA • CSA
IOT
Keith J Smith
Materion – Brush, Inc.
November 2023 BHSC – Washington, DC
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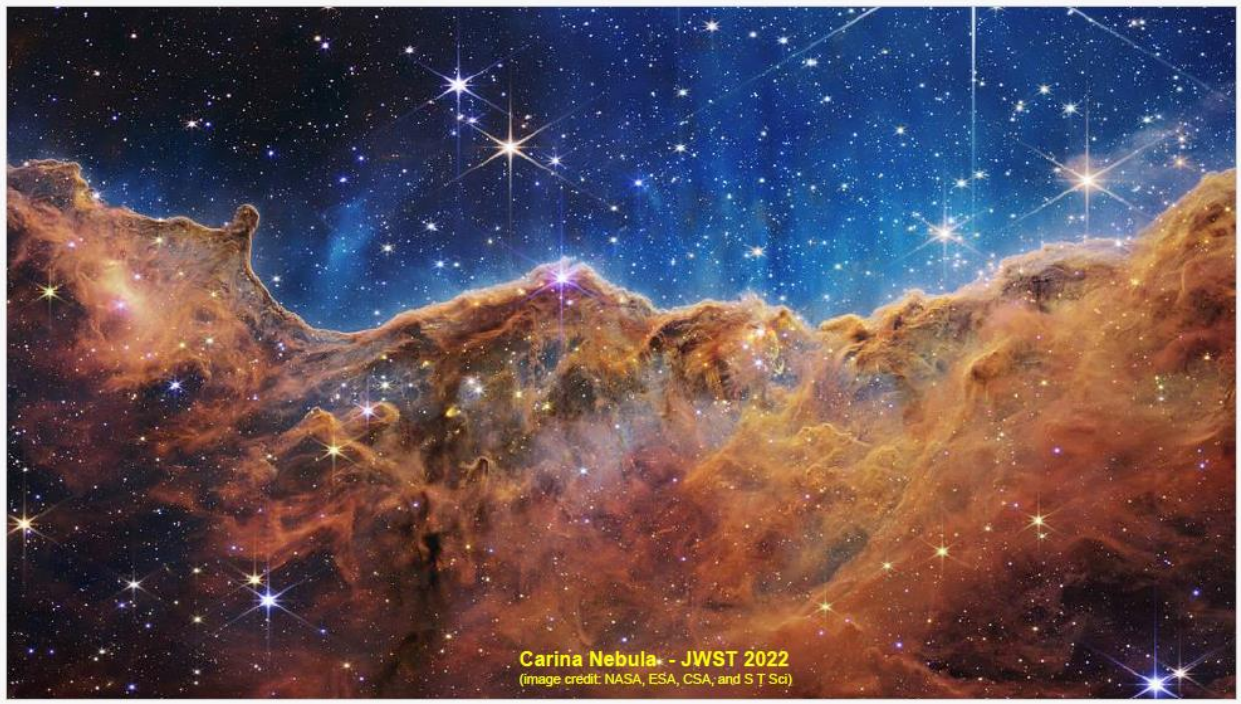
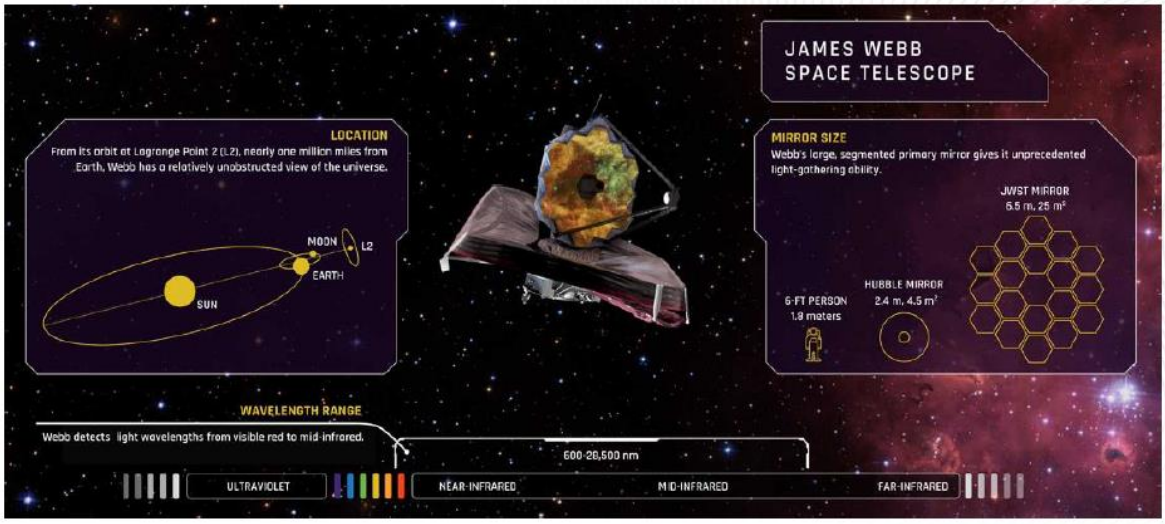

Carina Nebula - JWST 2022
(image credit: NASA, ESA, CSA, and S T Sci)



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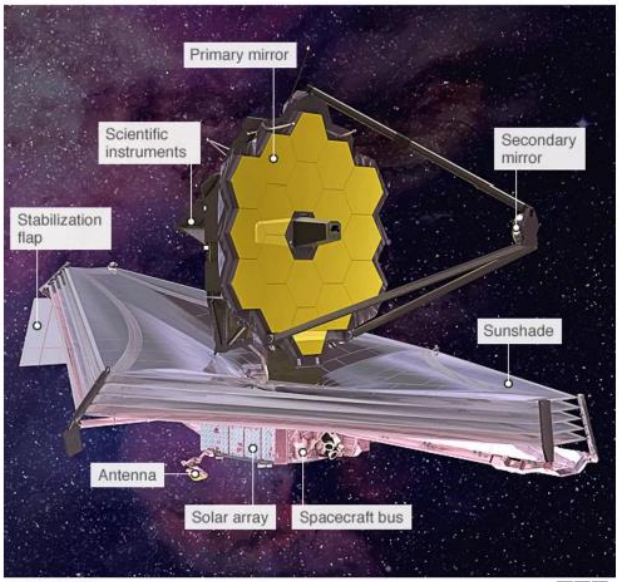
James Webb Space Telescope



Source: NASA

BBC

The largest telescope ever flown into space.

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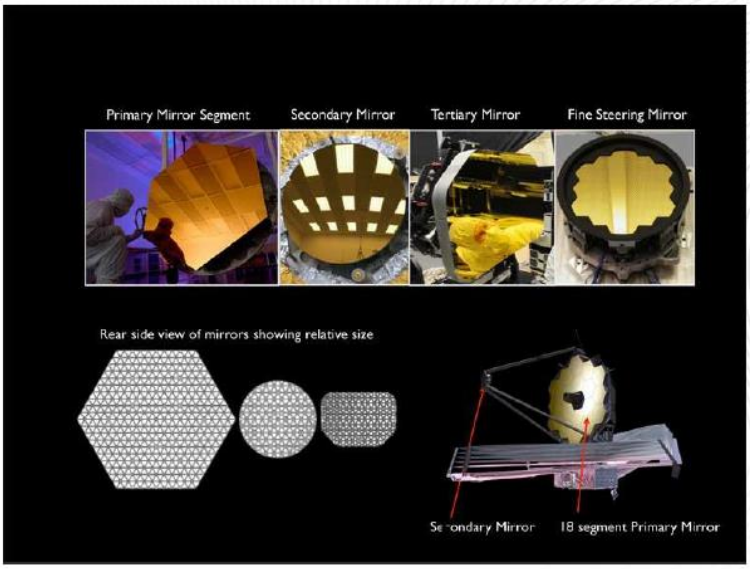
JWST Optics

- Primary Mirrors (18)
- Secondary Mirror (1)
- Tertiary Mirror (1)
- Fine Steering Mirror (1)



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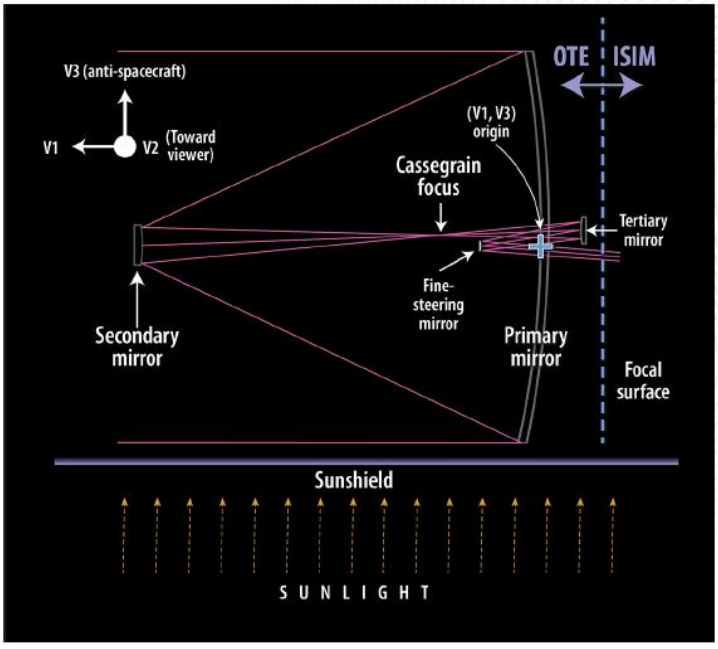
JWST



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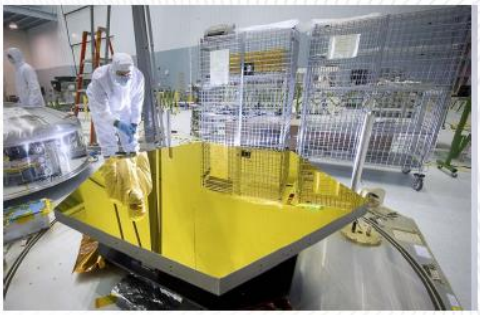
JWST Mirror Stats

- Mirror type: Segmented parabolic reflector
- Width: 6.6 m
- Area: 25 m^2
- Mass: 750 kg
- Individual mirror mass: 21 kg
- Focal Length: 131.4 m
- Optical resolution: 0.07arc-seconds
- Primary mirror: 18 segments
- Material: **Beryllium**, with thin gold coating
- Operating Temperature: -230C



NASA

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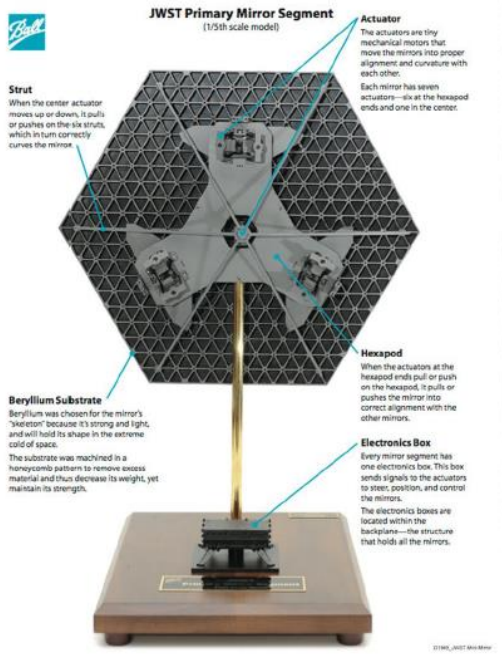
Primary Mirror

- Beryllium structural components.
- Each mirror can be aligned within 1/10,000 of the thickness of a human hair.



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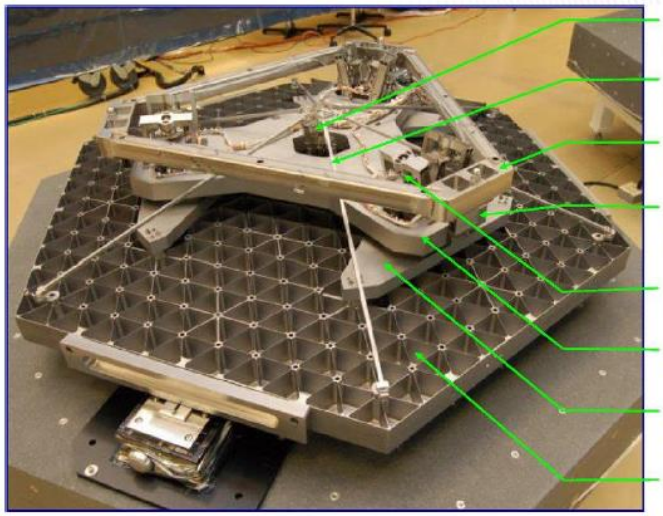
Primary Mirror – backing structures



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Material Selection

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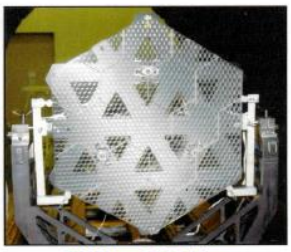
Material Selection

- **1996** – Initial material study (Be, Al, Mg, ULE)
  - Sub-scale Be Mirror Development (**SBMD**) Program
- **2000-2002** – Advanced Material System Demonstration (**AMSD**) Program
- **2003** – Be selected for JWST

Primary Mirror Optics

- **The JWST Primary Mirror is comprised of 18 light-weighted, semi-rigid, hexagonal mirror segment assemblies**
- **Two candidate Primary Mirror Substrate materials evaluated:**
  - **Beryllium** Developed by Beryllium Manufacturing Team Consisting of Ball, Brush Wellman, Axsys, Tinsley, Denton
  - **ULE® Glass** Developed by Eastman Kodak and Corning Incorporated

Beryllium AMSD Mirror



ULE Glass AMSD Mirror

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Why Beryllium?

- Be is a light-weight metal: **1.84 g/cc**
- High stiffness (elastic modulus): **3.1x 10^4 kg/mm²** (44x10^6 psi)
- Dimensionally stable to cryogenic temperatures
- High specific heat capacity: **1925 J/kg/K** (216 W/mK)

- Can be conventionally machined and polished
- No facilitation required
- Long history of use in space optical systems

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Why Beryllium?

"We had to pick a material we knew we could make at room temperature, and we knew it would change shape as it went cold but would do so in a predictable and consistent way every time," recalls Paul Geithner, a deputy project manager for Webb based at Goddard Space Flight Center. "Beryllium is a really good material for that. It's really stiff and, once it gets below about -300 °F, it basically stops shrinking."

Beryllium also has a higher stiffness-to-mass ratio than other materials, "which wasn't a selection criteria but is an advantage, as it means you get a lighter mirror, better able to withstand the high vibro-acoustic levels during takeoff," notes Lee Feinberg, the telescope manager for Webb at Goddard.

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Materion Overview

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Meet Materion
• A global high-tech solutions provider of electronic materials, performance materials and precision optics
• 100+ years of material sciences knowledge
• Publicly traded since 1972 – NYSE (MTRN)
• In excess of $1.7 billion in sales
• Based in Cleveland, Ohio
• 32 worldwide locations
• 3,700 employees
• 66 countries served
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Materion Locations Worldwide
Performance Materials
Electronic Materials
Precision Optics
Performance Materials:
Delta, Utah
Elmore, Ohio
Famborough, England
Lincoln, Rhode Island
Lorain, Ohio
Newton, Massachusetts
Reading, Pennsylvania
Singapore
Tucson, Arizona
Elmhurst, Illinois
Shanghai, China
Stuttgart, Germany
Tokyo Japan
Electronic Materials:
Albuquerque, New Mexico
Alzenau, Germany
Brewster, New York
Buffalo, New York
Limerick, Ireland
Milwaukee, Wisconsin
Newton, Massachusetts
Santa Clara, California
Singapore
Subic Bay, Philippines
Suzhou, China
Taoyuan City, Taiwan
Wheatfield, New York
Seoul, South Korea
Precision Optics:
Balzers, Lichtenstein
Jena, Germany
Penang, Malaysia
Shanghai, China
Tyngsboro, Massachusetts
Westford, Massachusetts
Eschborn, Germany
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Materion's Three Business

We operate in three reportable business segments.

Performance Materials

One of the world's leading suppliers of high-performance alloys, beryllium products, clad metals, metal matrix composites, and technical ceramics.

Electronic Materials

Specialty materials for thin film deposition, microelectronic packaging products and inorganic chemicals.

Precision Optics

One of the world's largest manufacturers of customized optical thin-film coatings and components

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Performance Materials

A leading global supplier of specialty metals, alloys and other advanced materials that enable design innovation and next-generation technologies.

Diverse product portfolio meets the most challenging needs of the Aerospace, Automotive, Consumer Electronics, Defense, Energy, Industrial and Telecom markets:

- Beryllium & beryllium-containing materials
- Clad metals
- High performance alloys
- Metal matrix composites
- Technical ceramics

Major end-use application groups:

- Avionics electronics, space and satellite structures, defense systems, X-ray equipment and acoustic beryllium
- EV battery connections and chargers
- Automotive connectors, electronic springs and connectors, cell phone voice coil motor springs, mining equipment and aerospace bushings and bearings, downhole drilling equipment components
- Commercial and defense aerospace structural components, space and defense optical systems, and on-highway automotive components
- Semiconductors, microwave equipment, laser systems and tubing, heatsinks and ceramic substrates

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Materion's History in Space

- Telstar – our first success
- Manned Spaceflight
  - Mercury, Gemini, Apollo, Space Shuttle
- Numerous Satellites (NASA, ESA)
  - Most Recent: Jupiter Icy Moon (JUICE – ESA)
- Tomorrow:
  - Nuclear Thermal Propulsion, Space Power (micro reactors)
  - Sats – environmental, astronomical (Nancy Roman)

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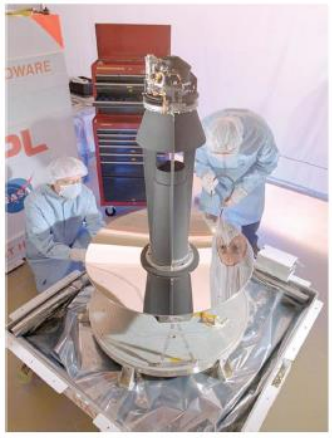
Beryllium Optics



Spitzer Space Telescope - NASA

VLT M2 @ ESO

Novanta – Precision Mirrors

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Beryllium Manufacturing

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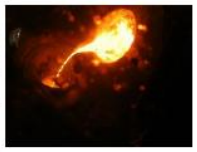
The only fully integrated manufacturer of Beryllium in the world

- Mining & Extraction – Delta, UT
- Conventional Metal Processing - CuBe/ CuNiSn/NiBe
- Ceramic processing (BeO, Al_2O_3, others)
- Powder metallurgy (Be, Al-Be, others)
- Metal Matrix Composites (Al-B4C, Al-SiC, others)
- Clad and Plated Metal Strip
- Machining - Fabrication





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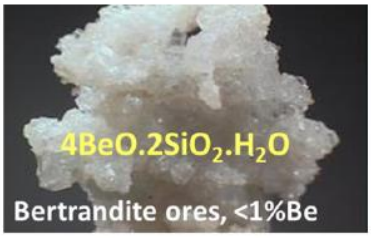
Beryllium Supply

- Materion operates a beryllium mine in the **Topaz-Spor Mountain** area of western Utah.
- The mineral is identified as **bertrandite**, a hydrous beryllium silicate ($Be_4Si_2O_7(OH)_2$)
- **Materion holds estimated ore reserves for 70 years of production.**
  - USGS estimates 21,000tons of Be reserves @ Utah.



Vertically Integrated Supply


Topaz-Spor Mountain, UT


Delta, UT


Elmore, OH

Delta, UT

Ore is calcined and concentrated via Aqueous extraction and conversion to beryllium hydroxide $Be(OH)_2$

Elmore, OH

Conversion of hydroxide to a halide. Reduction of the halide to beryllium metal.

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Be Metal Processing

- **Beryllium Pebble Plant - final stage Extraction**
  - Conversion of $Be(OH)_2$ to Beryllium metal
    - Highly automated chemical plant
    - Dissolves $Be(OH)_2$ in ABF Solution – ABF Salt
    - Decompose the salt to BeF_2
    - Reduction of BeF_2 with Mg to produce Be Metal – "Pebble"

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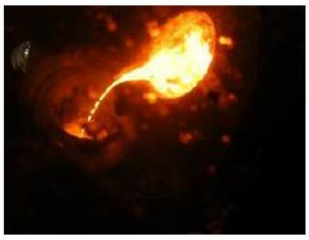
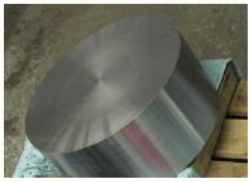
Be Metal Processing



- **Final Be processing:**
  - Vacuum melting - ingot
  - Metal powder production
  - Powder consolidation to generate parts
  - Machining



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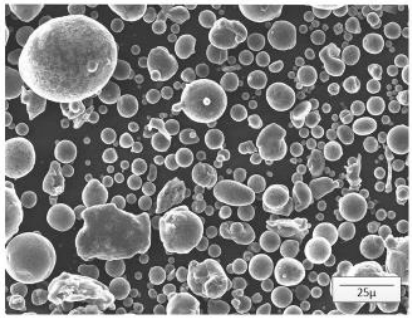
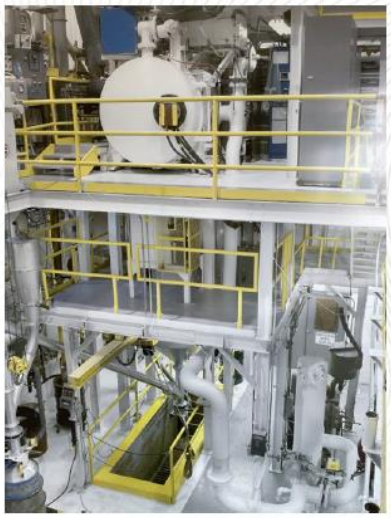
JWST Specific Processing

- Inert Gas Atomization:
  - Vacuum melt Beryllium
  - Atomize with inert gas to produce metal powder





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JWST – Hot Isostatic Pressing (HIP) - 1000C, 105 MPa

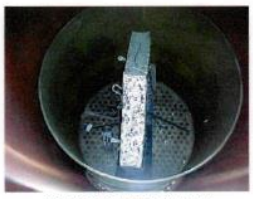

Loaded HIP Can


Protective Cover


Clearance between HIP can And protective cover


HIP Vessel being loading into chamber

Hot Isostatic Pressure Chamber


HIPed Blank inside protective cover


What Comes out, before machining

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JWST – Blank Initial Fabrication

- Post – HIP Processing
  - Can removal
  - Stress relief anneal 788C
  - Saw Billet into two mirror blanks
  - X-ray (Be transparent to X-rays)
  - Mechanical and chemistry testing
- Each blank approx. 200 kg

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Production Highwater Mark at Materion – late 2004

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Final Shipment of Blanks – 17 August 2005

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Manufacturing Process for the Beryllium Mirrors

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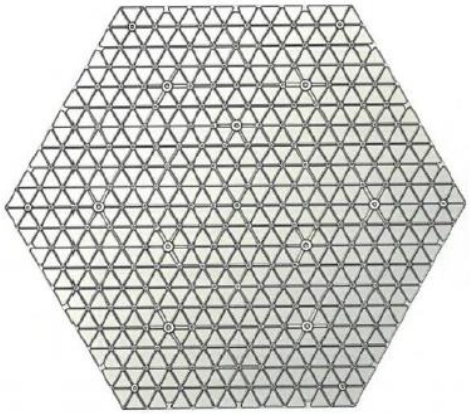
Primary Mirror Light Weighting



Mirror Feature	JWST PM Substrate Design
Hex Size (flat to flat)	1.315 m / 1.317 m
Design Mass Nominal (substrate)	20.70 kg
Not to Exceed Mass (substrate)	21.80 kg
Areal Density (design mass)	13.82 kg/m2
Areal Density (NTE mass)	14.55 kg/m2
Mirror Depth (nominal)	59.0 mm
# of Pockets per flat	10
Total # of pockets	600
Facesheet Thickness	2.5 mm +/- 0.3 mm
Pocket Aspect Ratio range (ICD / FS)	16.2 (min) to 19.0 (max)
Quilting Ratio range $(ICD)^4/(FS)^3$	235 m (min) to 302 m (max)
Rib thickness	Varies - all greater than 0.5 mm nominal with +/- 0.18 mm tolerance

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Blank Fabrication – AXYS Tech (now General Dynamics)

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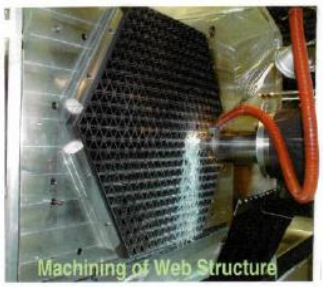
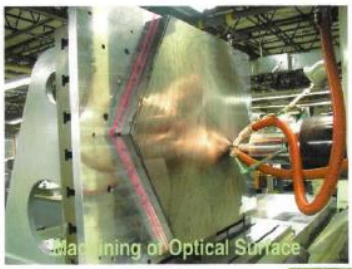
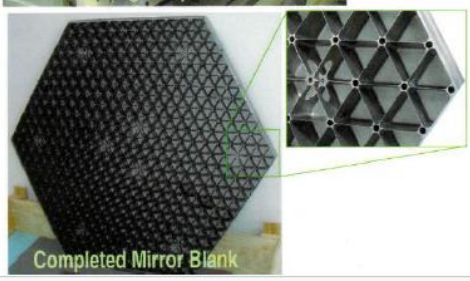
Blank Fabrication – AXYS Tech (now General Dynamics)





92% Material Removal

Cycle time = 1 yr/blank



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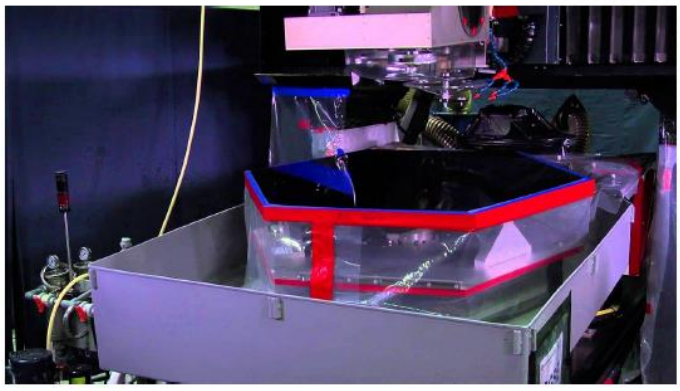
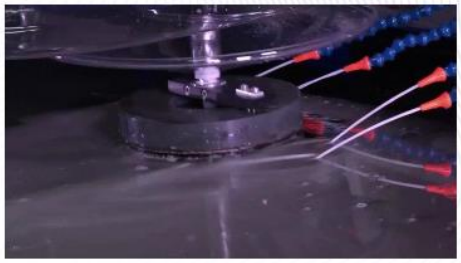
JWST Polishing – Tinsley Labs (Coherent Inc.)

- High precision optic polishing – process proprietary





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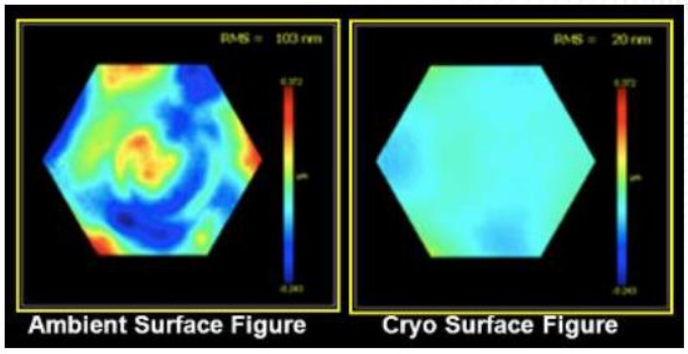
JWST Polishing – Tinsley Labs (Coherent Inc.)

- Unique polishing requirements – must meet surface figure at cryogenic temperature.
- Segment cryo-figure: 20 nm



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Engineers inspect one of the first two flight mirrors to arrive at NASA Goddard.

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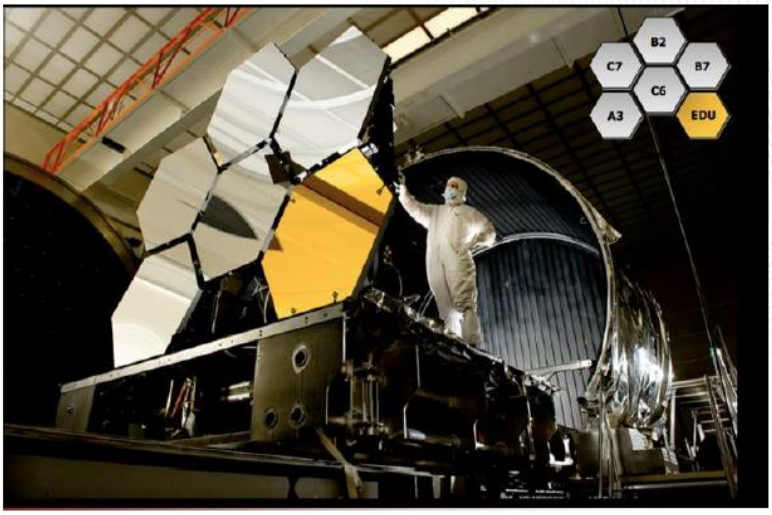
Flight Mirror Cryogenic Testing (complete 2011)



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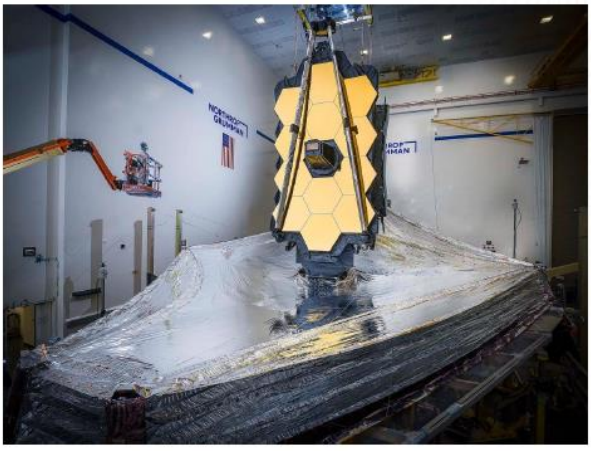
Final integration and Assembly @ Northrup Grumman



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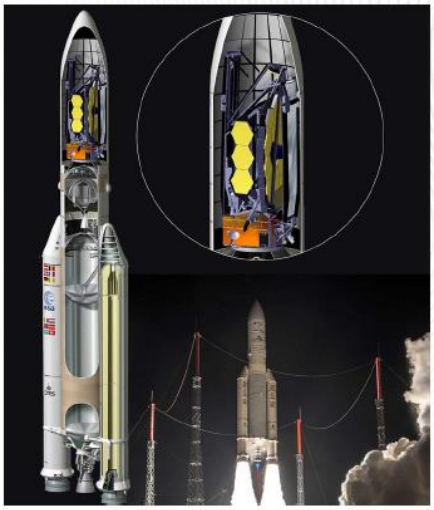
Telescope Needs to be Folded for Launch



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JWST Launch
25 December 2021

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The Fabrication Journey for JWST Mirrors

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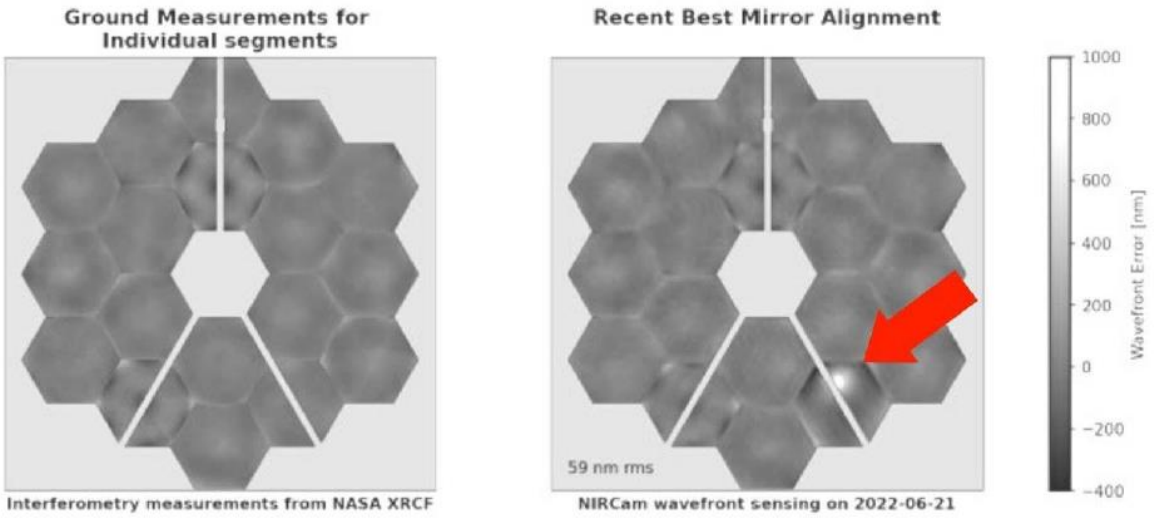
FIRST IMAGE OF MICROMETEOROID DAMAGE




Materion Enables What's Next™
We collaborate with our partners to identify megatrends, drive emerging technologies and advance scientific breakthroughs.
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Using Data Analytics to Monitor Health of Beryllium Health & Safety Programs
M. LUCKEY (National Nuclear Security Administration, District of Columbia, USA)

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

Morgan LUCKEY

National Nuclear Security Administration, USA

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

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

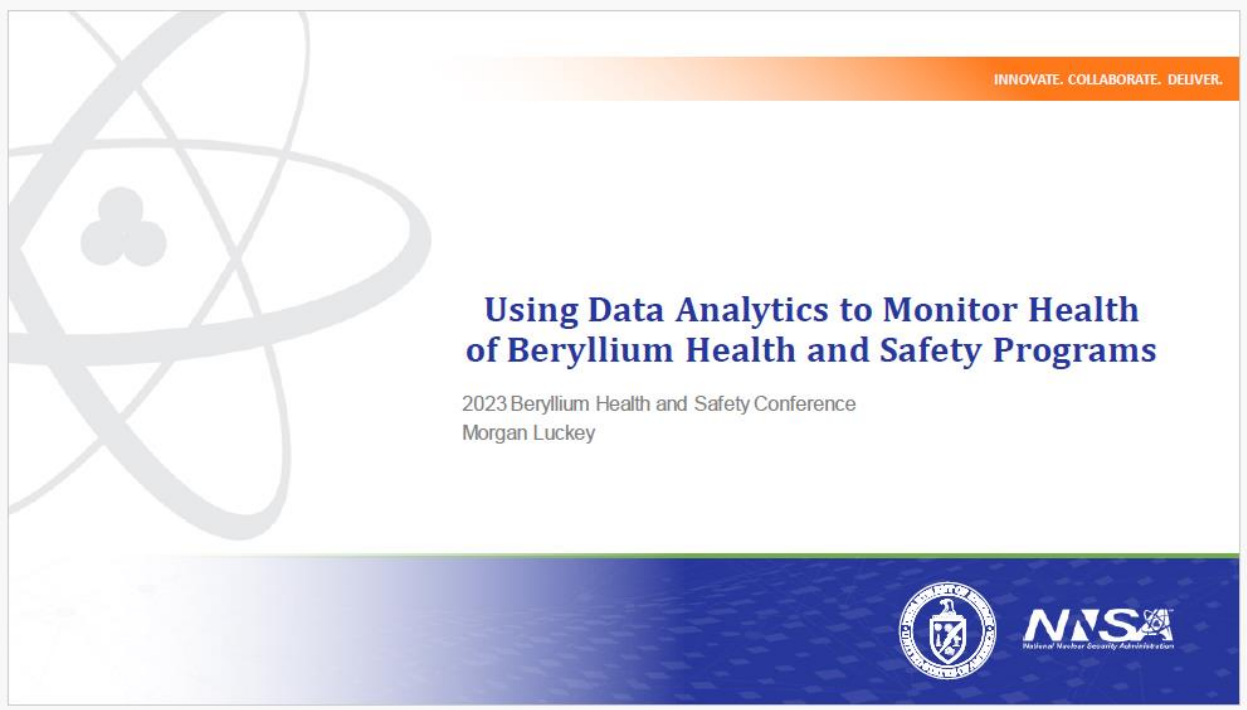
The DOE is investing in data analytics software across all areas of business. These tools leverage the data that DOE collects to glean systems-level insights. Some of these tools are available, at no cost, to DOE federal staff and management and operating contractor (M&O) partners. The Safety Analytics,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

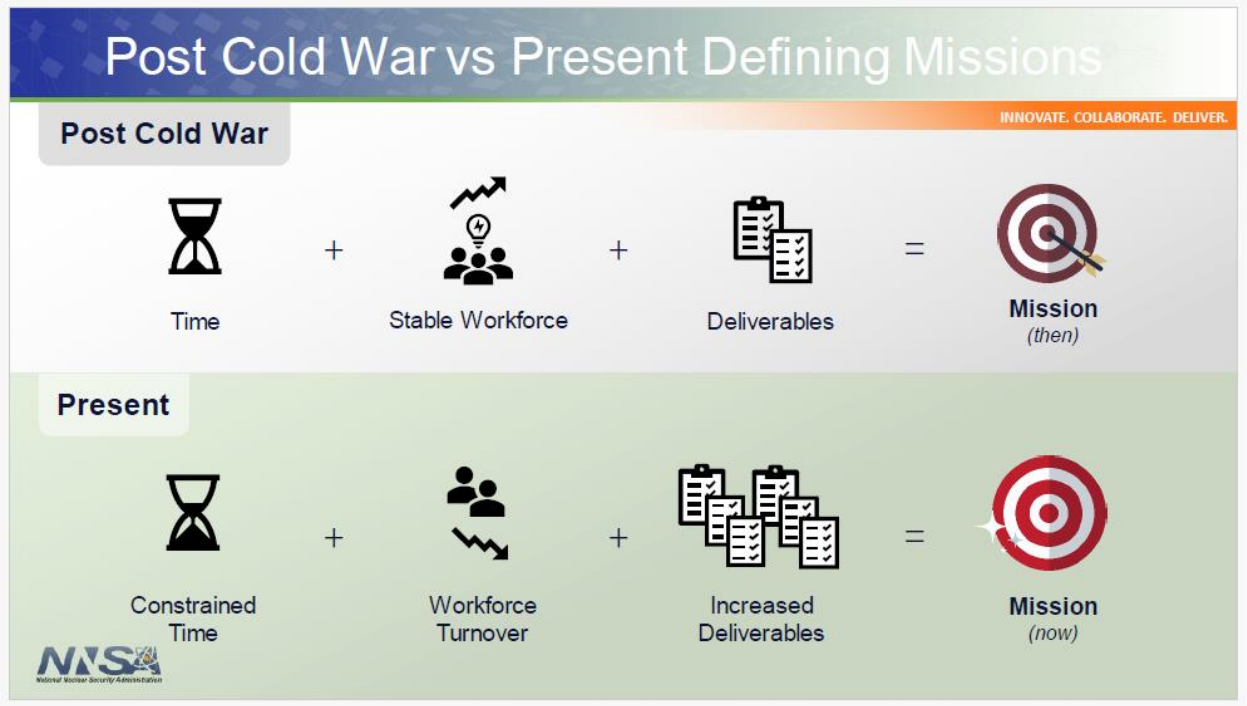
NA-ESH is developing SAFER to

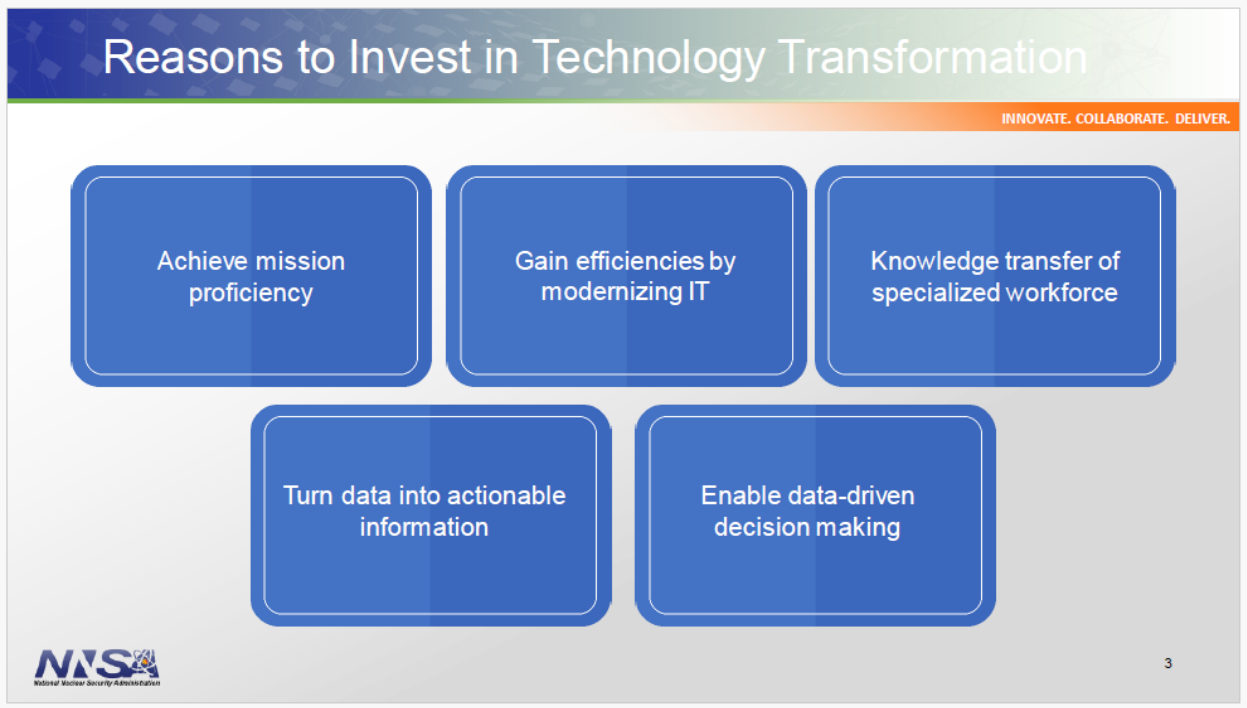
- More efficiently and effectively collect, process, analyze, and disseminate data,
- Improve the ability to measure, track, communicate, and manage safety risks, and
- Capture the knowledge of the NNSA workforce ensuring its availability across the enterprise and for the future.

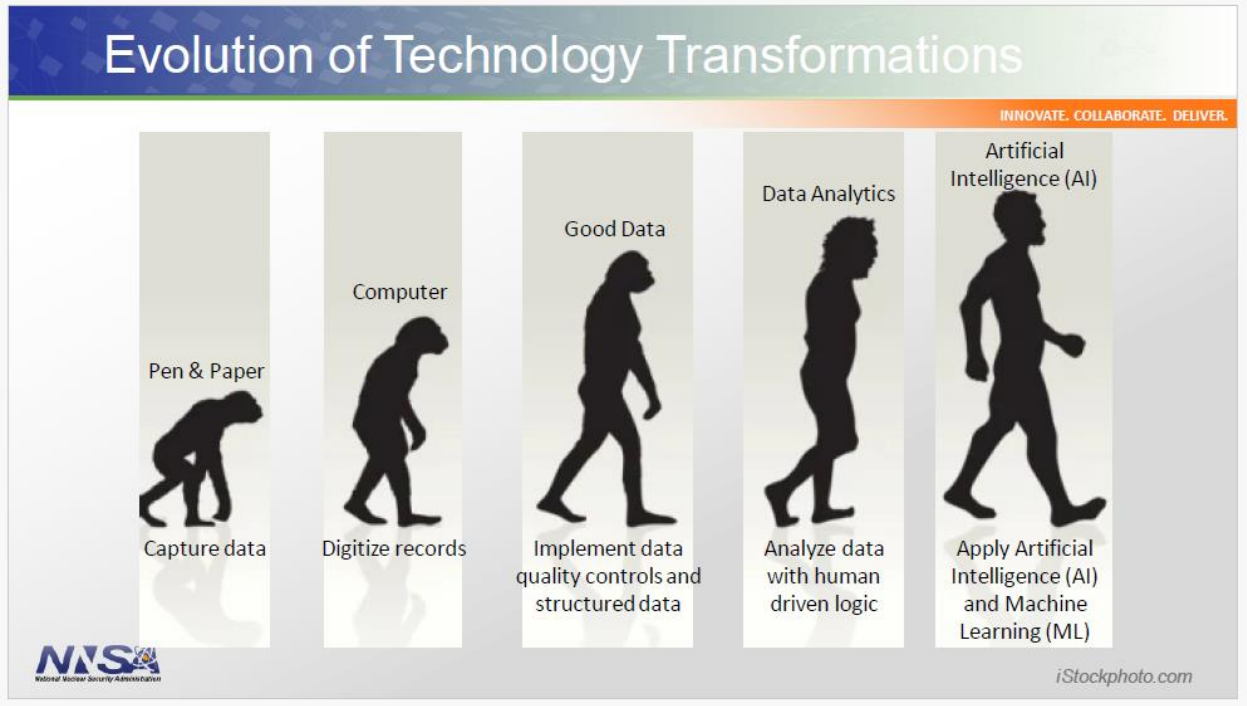
SAFER does this by bringing together site and enterprise data, mapping it to universal concepts, and displaying it in a way that reflects subject matter experts think about and use the data. The tools in SAFER can be used by all NNSA safety professionals and DOE safety professionals from select offices.

Corresponding Author:
Ms. Morgan LUCKEY
National Nuclear Security Administration
EMAIL: morgan.luckey2@nnsa.doe.gov


INNOVATE. COLLABORATE. DELIVER.
Using Data Analytics to Monitor Health of Beryllium Health and Safety Programs
2023 Beryllium Health and Safety Conference
Morgan Luckey
NNSA


Post Cold War vs Present Defining Missions
INNOVATE. COLLABORATE. DELIVER.
Post Cold War
Time
+
Stable Workforce
+
Deliverables
=
Mission
(then)
Present
Constrained Time
+
Workforce Turnover
+
Increased Deliverables
=
Mission
(now)
NNSA


Reasons to Invest in Technology Transformation
INNOVATE. COLLABORATE. DELIVER.
Achieve mission proficiency
Gain efficiencies by modernizing IT
Knowledge transfer of specialized workforce
Turn data into actionable information
Enable data-driven decision making
NNSA
3


Evolution of Technology Transformations
INNOVATE. COLLABORATE. DELIVER.
Pen & Paper
Capture data
Computer
Digitize records
Good Data
Implement data quality controls and structured data
Data Analytics
Analyze data with human driven logic
Artificial Intelligence (AI)
Apply Artificial Intelligence (AI) and Machine Learning (ML)
NNSA
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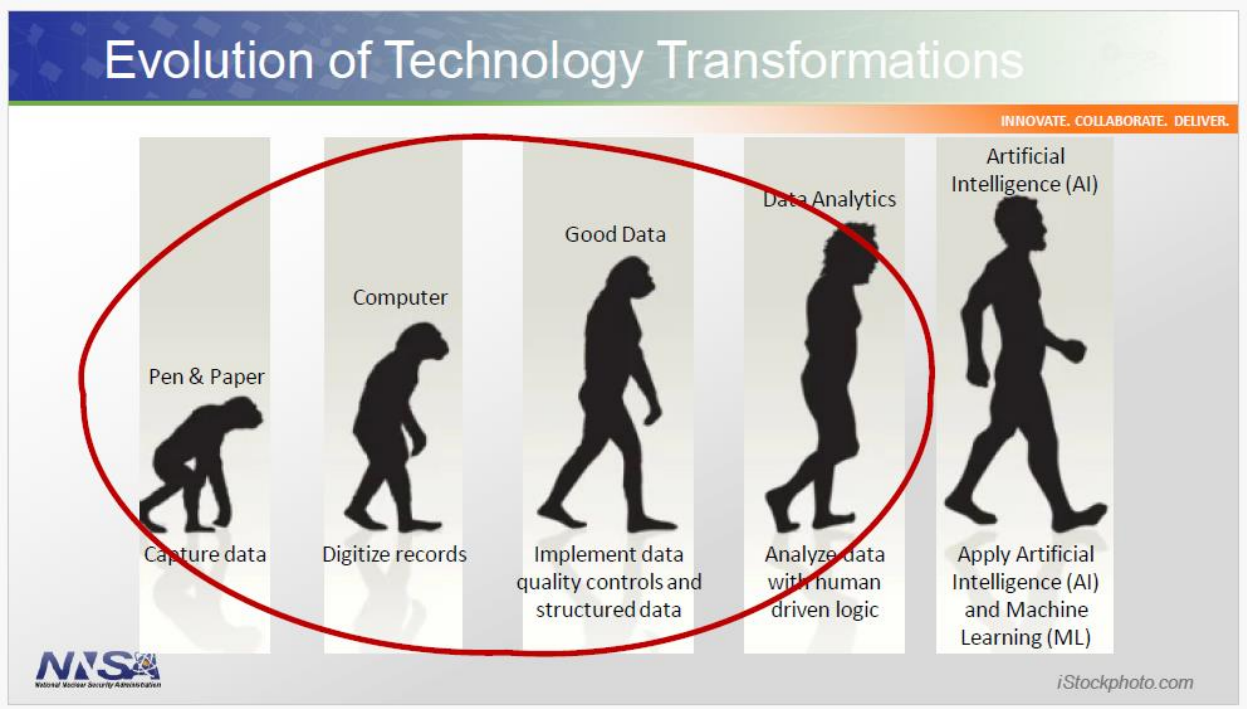
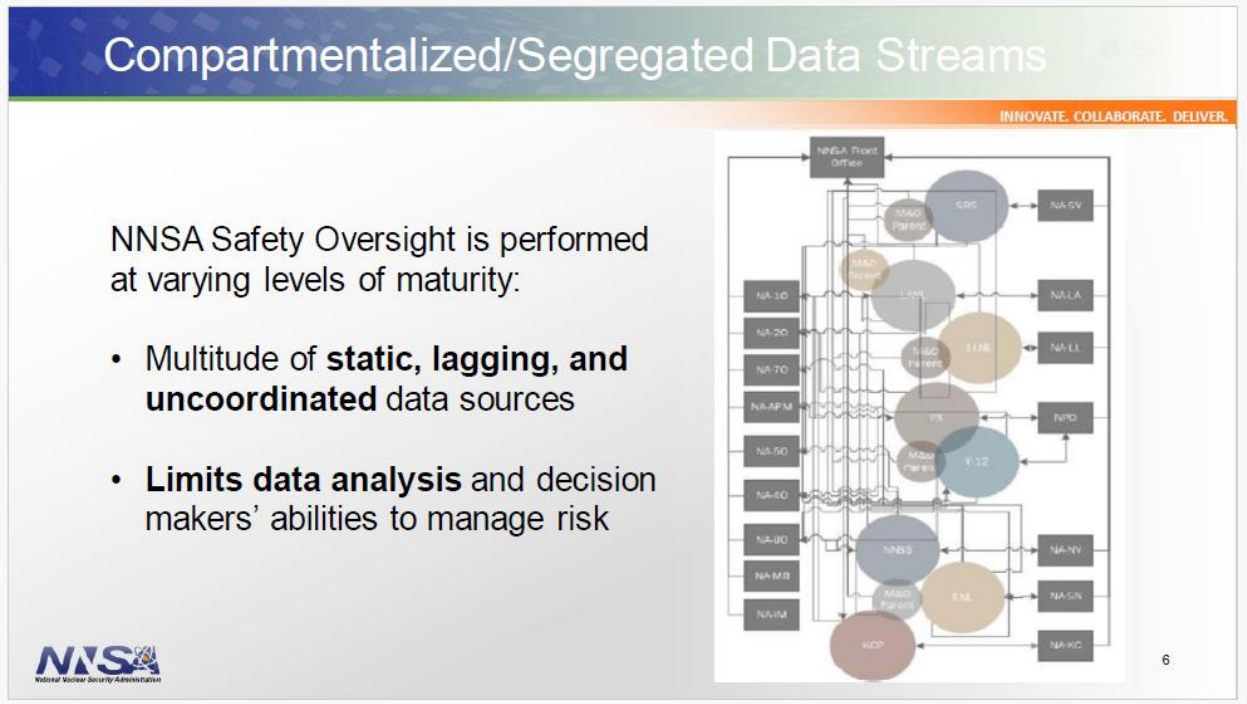

Evolution of Technology Transformations
INNOVATE. COLLABORATE. DELIVER.
Pen & Paper
Computer
Good Data
Data Analytics
Artificial Intelligence (AI)
Capture data
Digitize records
Implement data quality controls and structured data
Analyze data with human driven logic
Apply Artificial Intelligence (AI) and Machine Learning (ML)
iStockphoto.com

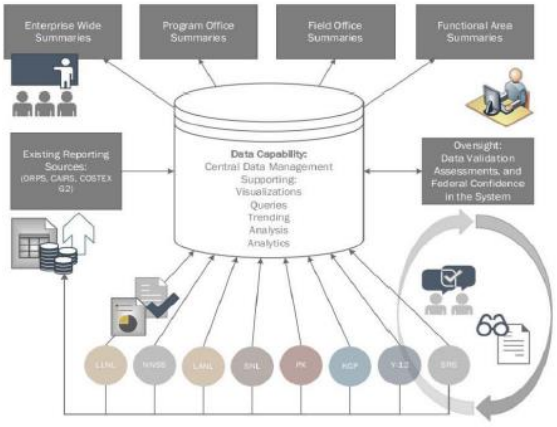

Compartmentalized/Segregated Data Streams
INNOVATE. COLLABORATE. DELIVER.
NNSA Safety Oversight is performed at varying levels of maturity:
• Multitude of **static, lagging, and uncoordinated** data sources
• **Limits data analysis** and decision makers' abilities to manage risk
6

Desired State

INNOVATE. COLLABORATE. DELIVER.

Deploy **new data driven, risk informed, tools** to:

- Include **data, analysis, and visualizations** to inform decision makers
- **Improve our communication**

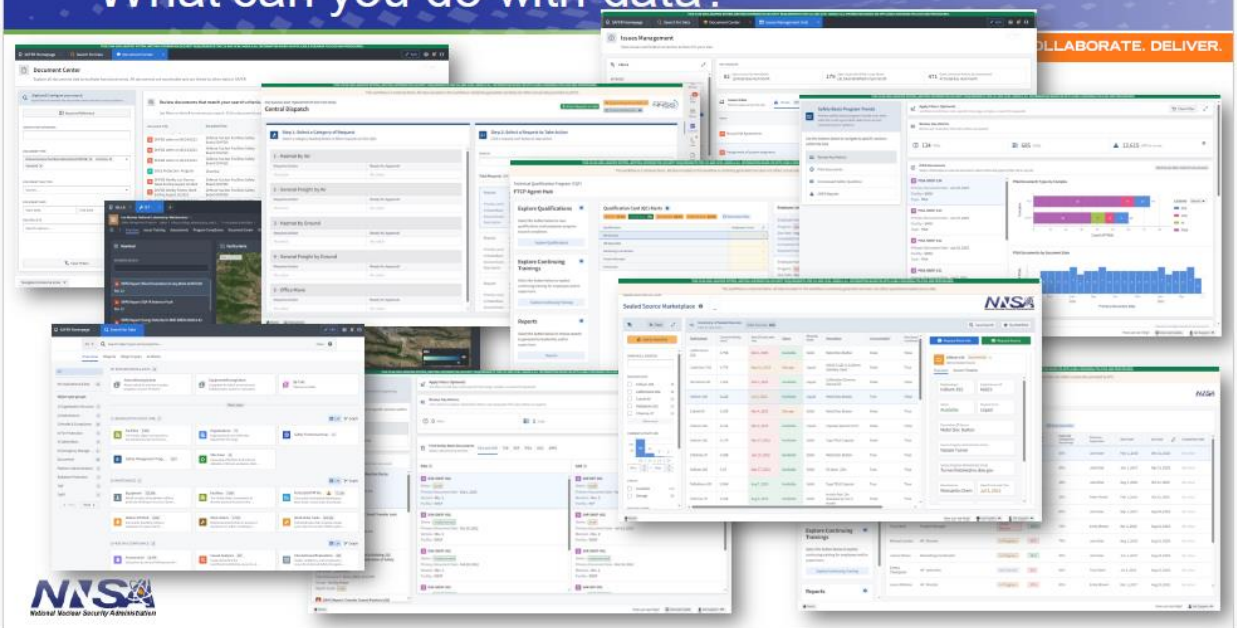


Desired future state of Central Data Management and increased Data Capability

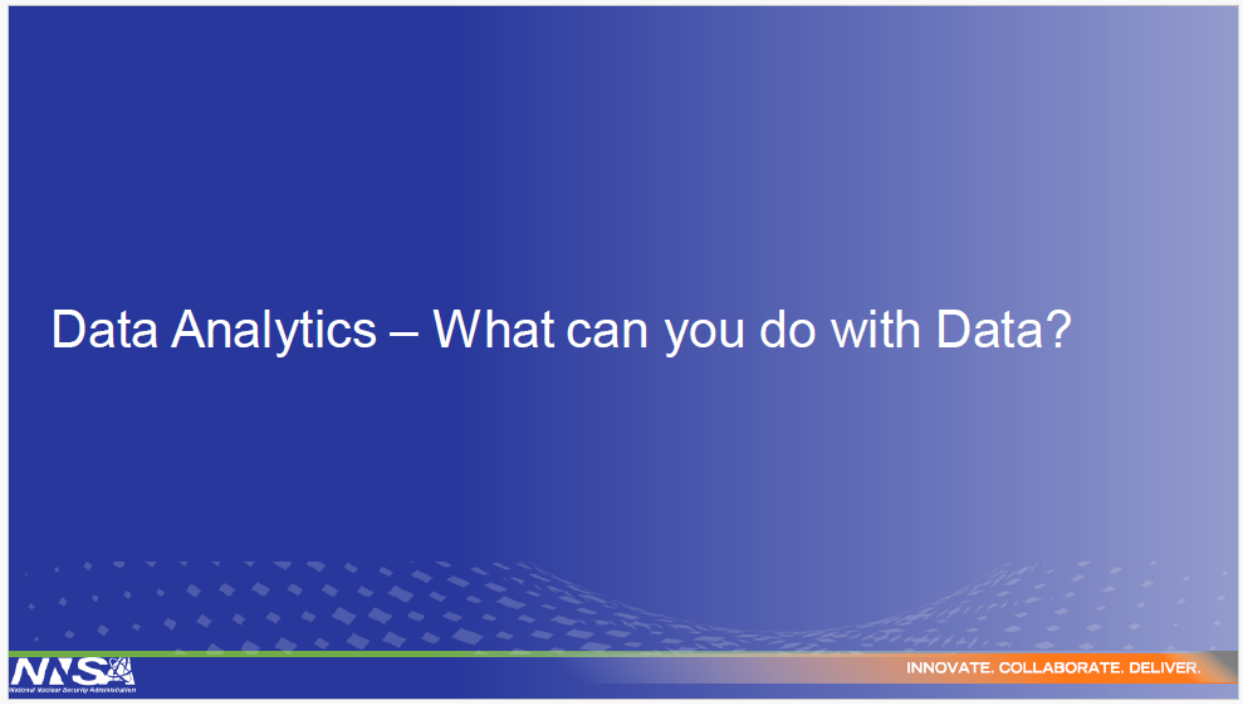
National Nuclear Security Administration

7

What can you do with data?



National Nuclear Security Administration



What can you do with Data?

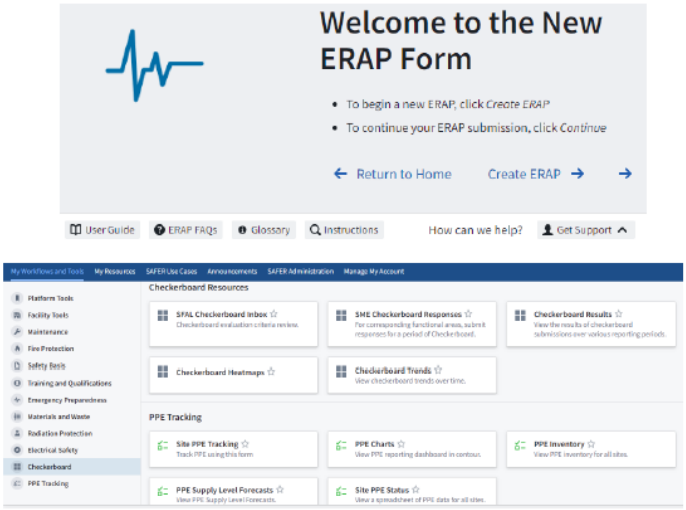
INNOVATE. COLLABORATE. DELIVER.

- SAFER = "Safety Analytics, Reporting, Evaluation, and Forecasting"
- What we can do with data analytics and SAFER-like tools is:
  - Reporting
  - Analytics
    - Evaluation
    - Optimization
    - Forecasting
  - Operations
  - Communication

Reporting

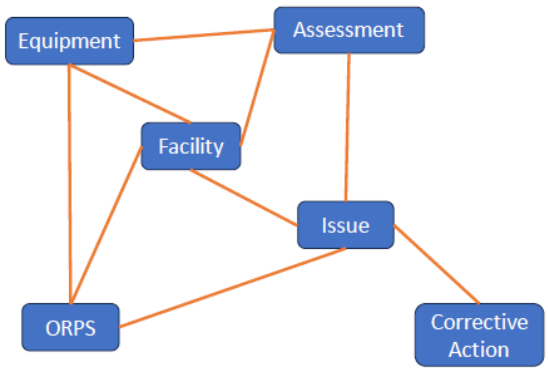
INNOVATE. COLLABORATE. DELIVER.

- Create forms
  - ERAP
  - PVD
  - Checkerboard
  - PPE Tracking
- Analyze data from Forms
- Automate reports
  - Hardcoded by programmer
  - Custom by user

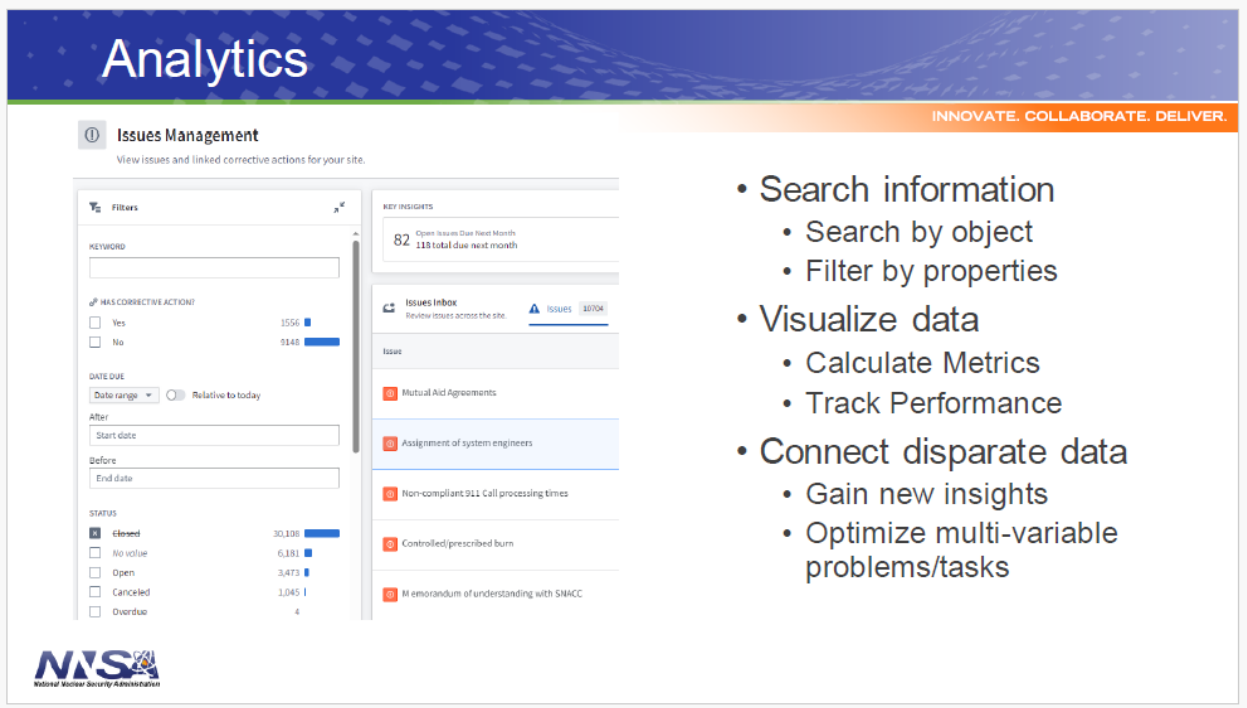


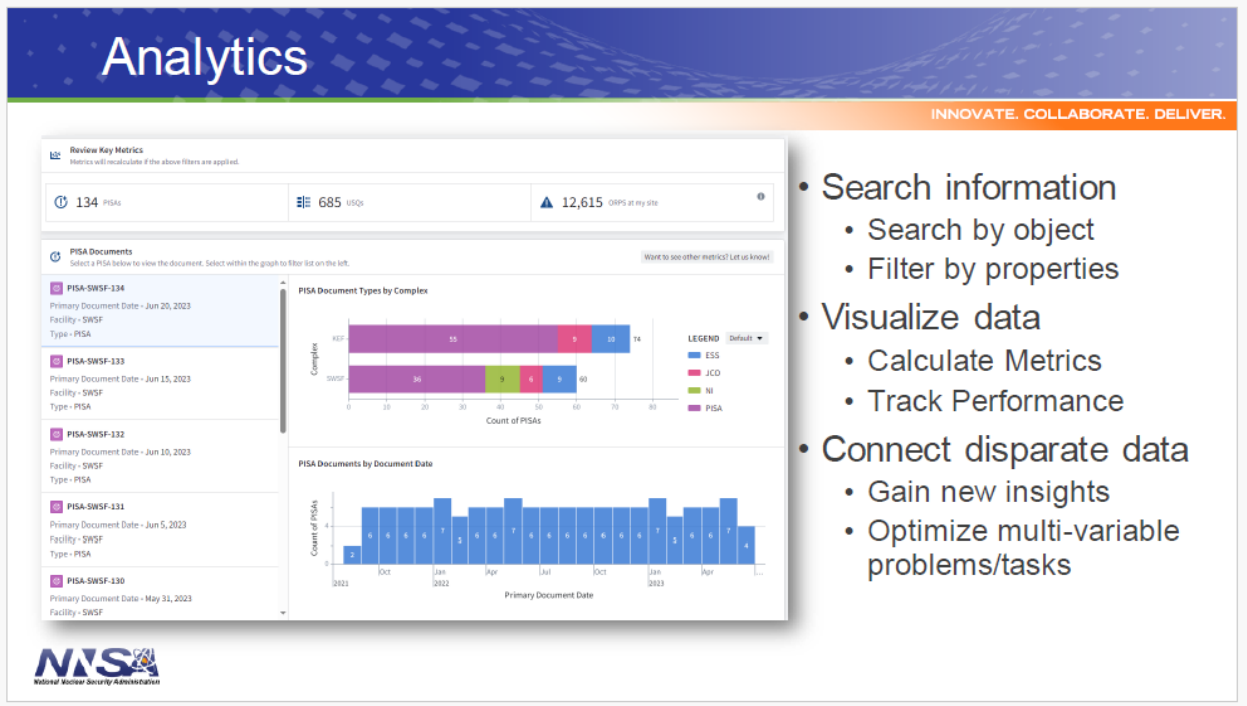
Analytics

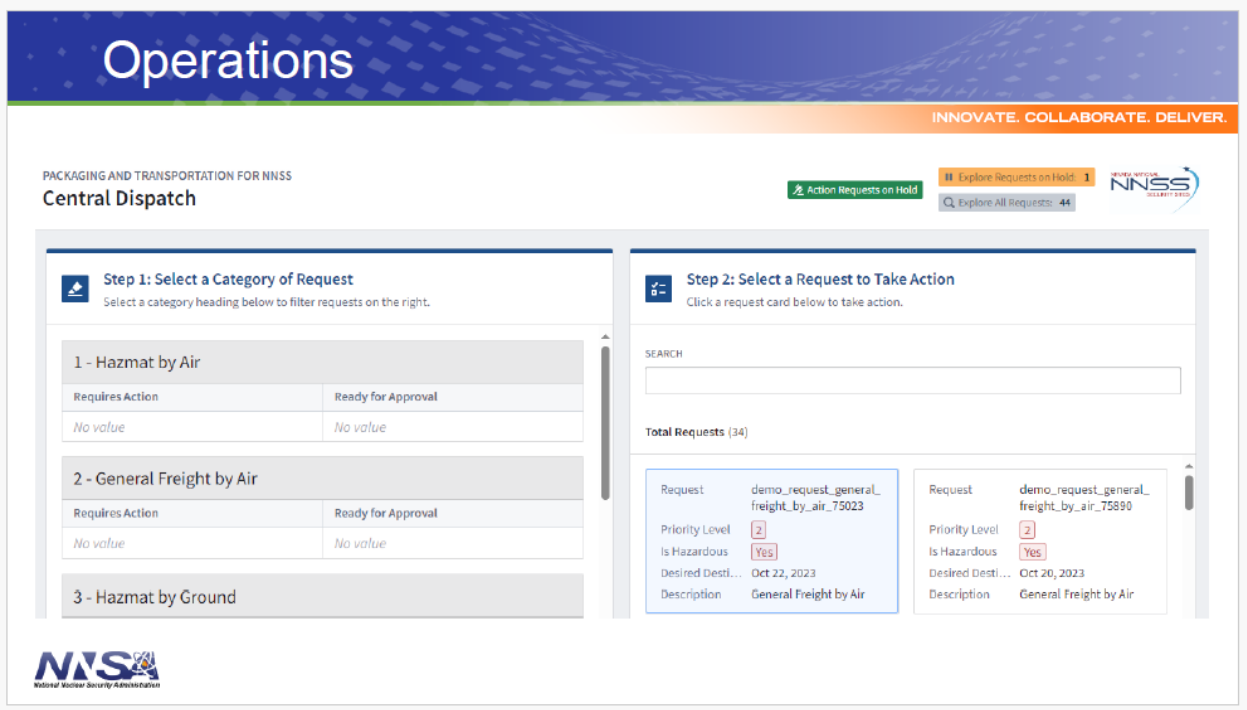
INNOVATE. COLLABORATE. DELIVER.



- Search information
  - Search by object
  - Filter by properties
- Visualize data
  - Calculate Metrics
  - Track Performance
- Connect disparate data
  - Gain new insights
  - Optimize multi-variable problems/tasks

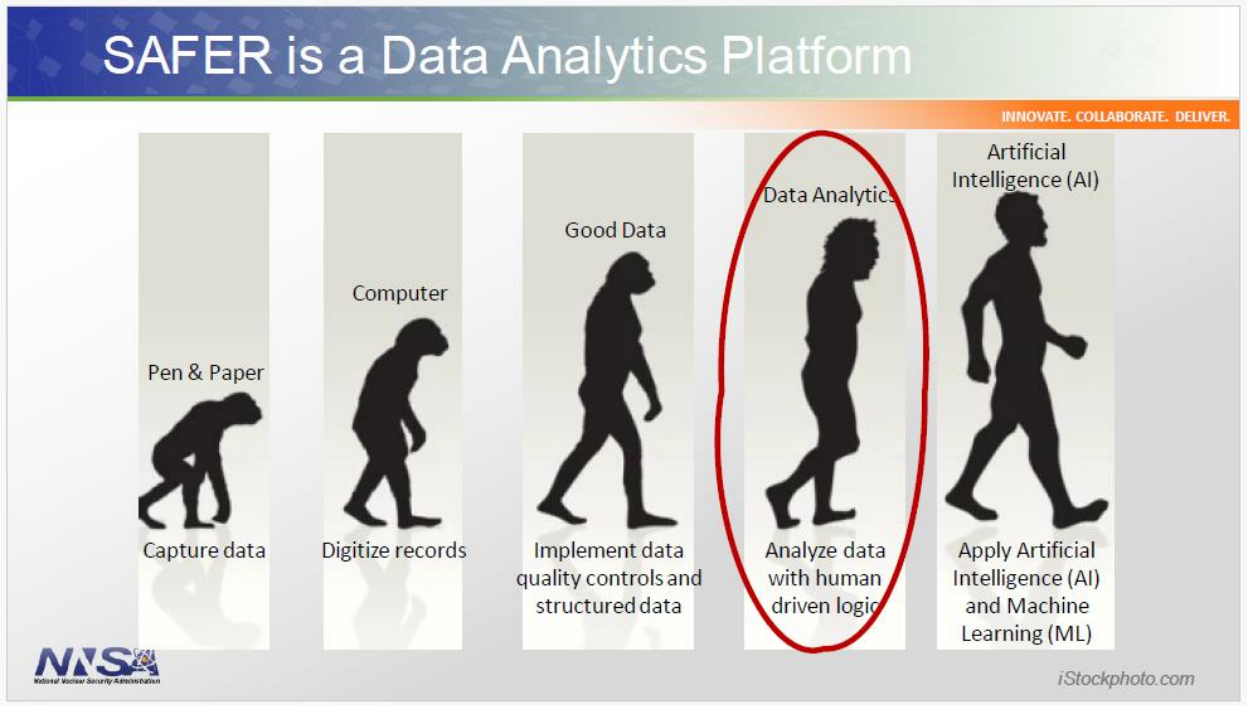

Analytics
INNOVATE. COLLABORATE. DELIVER.
Issues Management
View issues and linked corrective actions for your site.
Filters
KEYWORD
HAS CORRECTIVE ACTION?
Yes 1556
No 9148
DATE DUE
Date range
Relative to today
After
Start date
Before
End date
STATUS
Closed 30,108
No value 6,181
Open 3,473
Canceled 1,045
Overdue 4
KEY INSIGHTS
82 Open Issues Due Next Month
118 total due next month
Issues Inbox
Review issues across the site.
Issues 10704
Issue
Mutual Aid Agreements
Assignment of system engineers
Non-compliant 911 Call processing times
Controlled/prescribed burn
Memorandum of understanding with SNACC
• Search information
• Search by object
• Filter by properties
• Visualize data
• Calculate Metrics
• Track Performance
• Connect disparate data
• Gain new insights
• Optimize multi-variable problems/tasks


Analytics
INNOVATE. COLLABORATE. DELIVER.
Review Key Metrics
134 PISAs
685 USQs
12,615 ORPS at my site
PISA Documents
Select a PISA below to view the document. Select within the graph to filter list on the left.
Want to see other metrics? Let us know!
PISA-SWSF-134
Primary Document Date - Jun 20, 2023
Facility - SWSF
Type - PISA
PISA-SWSF-133
Primary Document Date - Jun 15, 2023
PISA-SWSF-132
Primary Document Date - Jun 10, 2023
PISA-SWSF-131
Primary Document Date - Jun 5, 2023
PISA-SWSF-130
Primary Document Date - May 31, 2023
PISA Document Types by Complex
Complex
Count of PISAs
LEGEND
ESS
JCO
NI
PISA
PISA Documents by Document Date
Count of PISAs
Primary Document Date
• Search information
• Search by object
• Filter by properties
• Visualize data
• Calculate Metrics
• Track Performance
• Connect disparate data
• Gain new insights
• Optimize multi-variable problems/tasks


Operations
INNOVATE. COLLABORATE. DELIVER.
PACKAGING AND TRANSPORTATION FOR NNSS
Central Dispatch
Action Requests on Hold
Explore Requests on Hold: 1
Explore All Requests: 44
NNSS
Step 1: Select a Category of Request
Select a category heading below to filter requests on the right.
1 - Hazmat by Air
Requires Action
Ready for Approval
No value
No value
2 - General Freight by Air
Requires Action
Ready for Approval
No value
No value
3 - Hazmat by Ground
Step 2: Select a Request to Take Action
Click a request card below to take action.
SEARCH
Total Requests (34)
Request demo_request_general_freight_by_air_75023
Priority Level 2
Is Hazardous Yes
Desired Desti... Oct 22, 2023
Description General Freight by Air
Request demo_request_general_freight_by_air_75890
Priority Level 2
Is Hazardous Yes
Desired Desti... Oct 20, 2023
Description General Freight by Air
NNSA


Communications
INNOVATE. COLLABORATE. DELIVER.
• Alerts in platform and by email
• Chat and tag people in platform
• Access the same data as counterparts at M&Os, field offices, and headquarters
• Collaborate on notepads, spreadsheets, and reports
• Complex-wide marketplaces
NNSA


SAFER, NNSA's Data Analytics Platform for Facility and Operational Safety
INNOVATE. COLLABORATE. DELIVER.


SAFER is a Data Analytics Platform
INNOVATE. COLLABORATE. DELIVER.
Pen & Paper
Capture data
Computer
Digitize records
Good Data
Implement data quality controls and structured data
Data Analytics
Analyze data with human driven logic
Artificial Intelligence (AI)
Apply Artificial Intelligence (AI) and Machine Learning (ML)
iStockphoto.com

What is SAFER?

INNOVATE. COLLABORATE. DELIVER.

- Funded and developed by NNSA
- Focused on tools that improve safety in NNSA facilities
- Deployed at NNSA sites and NA-ESH
- Available to DOE sites and HQ upon request

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SAFER is a Business Intelligence Platform

INNOVATE. COLLABORATE. DELIVER.

- Aggregates data from site-specific and enterprise systems
  - Improve access to data that users should already have access to
  - Allow comparison of data sources
    - Site issues management system vs ORPS
    - Site master equipment list vs BUILDER
    - Site dosimetry vs REMS
- Calculates and display program performance
  - Calculate program health based on performance metrics
    - # of overdue issues, backlog of workorders
  - Display visual performance indicators
    - Ratio of corrective to preventative maintenance, # of incidents over time, etc

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20

Data Permissions and Controls

INNOVATE. COLLABORATE. DELIVER.

- Reviewed and approved by NA-IM
- Approved up to CUI/UCNI
- Approved to hold PII
- Users only have access to information that they should already have access to
  - Site users only see information about their site
  - HQ users see information from across the complex
  - Need-to-know is established by approvers (user access requires OneID and approval by the user's site or HQ representative)
- Data governance decisions are made by Steering Committee
- Reviewed periodically by NA-70 to verify aggregated information remains unclassified

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21

Who is SAFER for?

INNOVATE. COLLABORATE. DELIVER.

Functional Area SMEs	Facility Users (Facility Managers, CSE, FRs, SSOs)	Leadership at Sites & HQ
		
Responsible for: • Tracking and trending performance • Ensuring controls and processes are adequate and effective • Addressing and/or elevating emerging issues	*Responsible for:* • Identifying and resolving day-to-day operational issues • Coordinating with multiple SME groups • Identifying and addressing potential risks to facility operations	*Responsible for:* • Tracking and trending performance across all areas • Assessing competing needs • Acquiring additional resources or reallocating existing resources
Field Office, M&O, and HQ	**Field Office and M&O**	**Field Office, M&O, and HQ**

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...and more, including assessors and database owners across the Complex

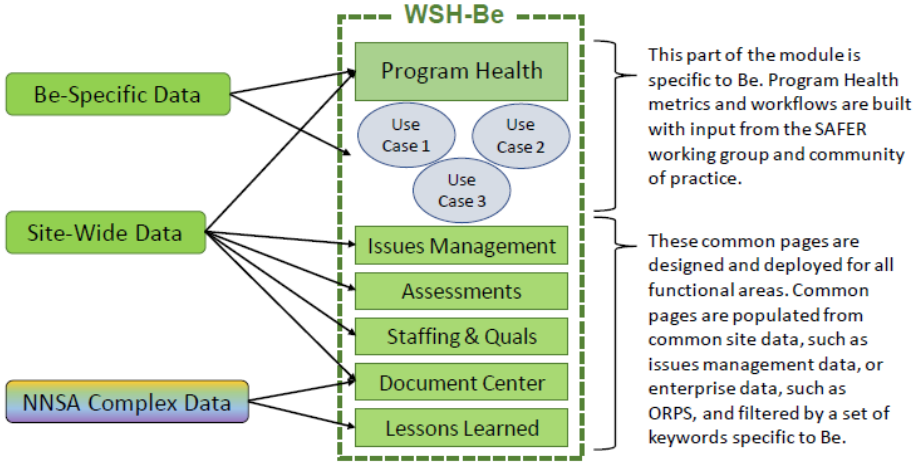
22

SAFER Modules – What tools will SAFER provide the BeHS community?

INNOVATE. COLLABORATE. DELIVER.

Modules consist of common and SMP-specific pages

INNOVATE. COLLABORATE. DELIVER.



24

What is Built and What is Coming

INNOVATE. COLLABORATE. DELIVER.

Common Pages

Built:

- Issues Management
- Document Center
- Assessments
- Lessons Learned/Newsfeed

Slated:

- Staffing & Qualification

Modules

Built:

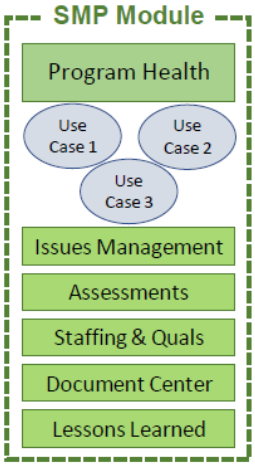
- Maintenance
- Safety Basis
- Fire Protection

Slated:

- Radiation Protection
- Electrical Safety
- Criticality Safety
- Worker Safety & Health*
- Explosive Safety

Other Potential Modules:

- Infrastructure
- Utilities
- Packaging and Transportation
- Waste Management
- Quality Assurance
- Contractor Assurance
- Oversight
- Conduct of Operations

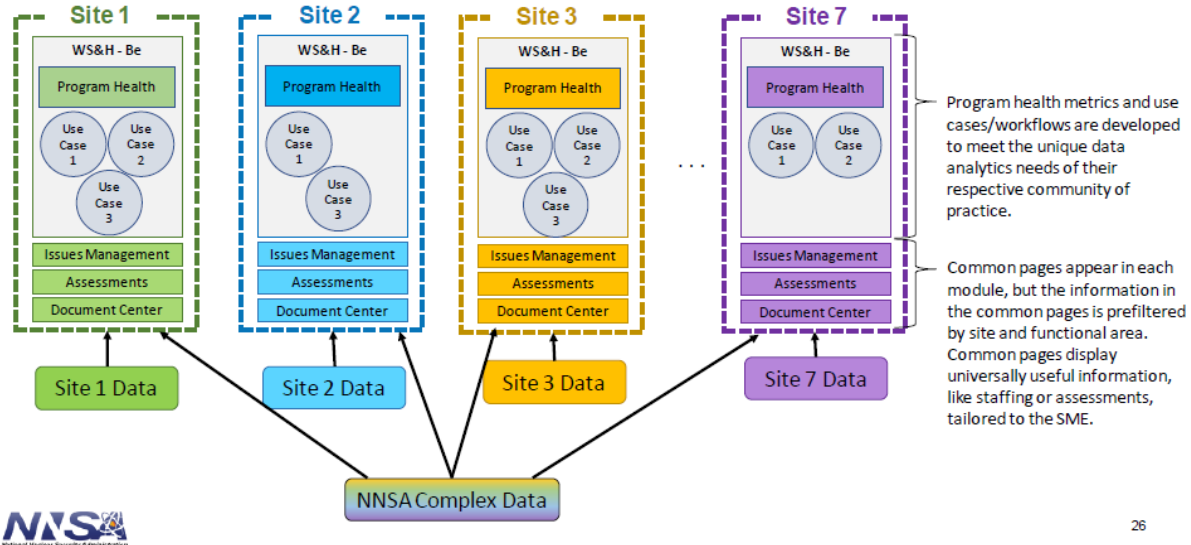


* Worker Safety & Health will include industrial hygiene, beryllium, asbestos, and other subtopics

25

Site and Complex data feeds SAFER Modules

INNOVATE. COLLABORATE. DELIVER.



26

Questions for you

INNOVATE. COLLABORATE. DELIVER.

- What metrics would you like in SAFER?
- What data do you want to put in SAFER?
- Who owns that data?
- What do you want to do with that data?

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INNOVATE. COLLABORATE. DELIVER.

THANK YOU!

GET IN TOUCH

→ Morgan Luckey, SAFER Project Manager (NA-ESH-24)
morgan.luckey2@nnsa.doe.gov

→ Joseph Sobieraj (NA-ESH-23)
jospeh.sobieraj@nnsa.doe.gov

→ Technical Support:
doe-support@palantir.com

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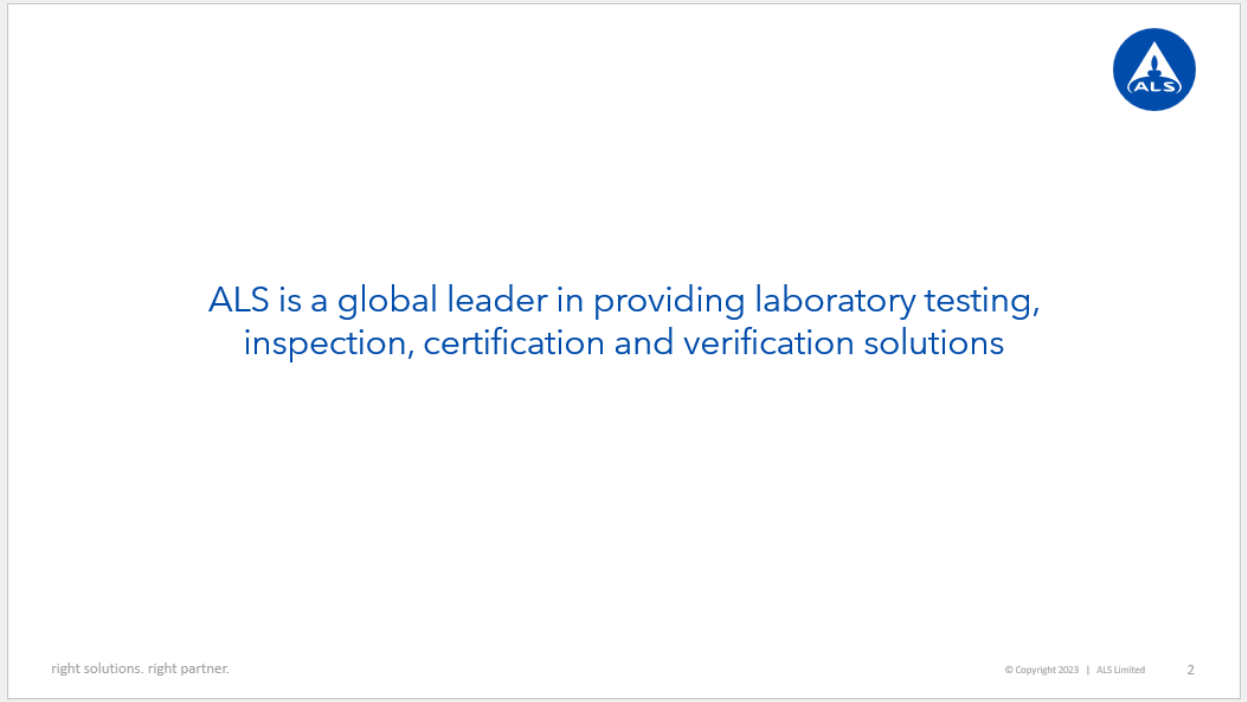
28

Day 2: Vendor Technical Presentations

ALS Testing Services, Salt Lake City, Utah, USA

Bevan MEADE



right solutions.
right partner.

ALS Salt Lake City

 3

ALS Salt Lake City

right solutions. right partner.

 4

ALS Salt Lake City

- History of Quality and Innovation
  - NIOSH Industry Partner (32 years)
  - AIHA Accreditation (1974): 300+ air/wipe methods
  - ISO 17025 Compliant
  - DOECAP-AP: 100+ methods
  - DoE, DoD, EPA Projects

right solutions. right partner.

 5

ALS Salt Lake City

- Expertise and Customer Service
  - Project Management
  - Sampling Media and Equipment
  - Level 1 – 4 Reporting and custom EDDs
  - 30+ chemists (15 year average tenure at ALS)

right solutions. right partner.

 6

ALS Salt Lake City – Testing Capabilities

- Full-service Laboratory - Industrial Hygiene
  - Metals Analysis:
    - ICP-AES/MS
- Beryllium/Beryllium oxide
  - 7,500+ workorders processed since 2018
  - BePAT Program (10+ years)
    - AIHA PAT (Be/BeO)

right solutions. right partner.

 7

ALS Salt Lake City – Testing Capabilities

- Full-service Laboratory - Industrial Hygiene
  - Whole-air sampling (Summa canister or Helium Diffusion Sampler)
    - VOCs
    - Mercaptans/Sulfur gases
    - Light Hydrocarbons
    - Fixed gases

right solutions. right partner.

 8

ALS Salt Lake City – Testing Capabilities

- Full-service Laboratory - Industrial Hygiene
  - Pesticide/Herbicide Analysis (comprehensive screen of 200+ compounds)
  - Home Inspection/Remediation
    - Illicit Substances (surface testing of Methamphetamine, Fentanyl, and other illicit drugs)
    - Asbestos / Mold / Lead
- ALS Lab Network Advantage – ALS Cincinnati
  - Cross-Lab Capability
  - Continuance of work
  - Equivalent Quality System

right solutions. right partner.

 9

Thank You

- Bevan Meade (DOE Contact)
  - Office: +1 (801) 266-7700 ex 277
  - Bevan.Meade@alsglobal.com
- Patrick Noteboom
  - Office: +1 (801) 266-7700 ex 381
  - Patrick.Noteboom@alsglobal.com
- Meredith Edwards
  - Office: +1 (801) 266-7700
  - Meredith.d.edwards@alsglobal.com
- Lisa Reid (DOE Contact)
  - Office: +1 (801) 266-7700
  - lisa.reid@alsglobal.com
- Stella Hanis
  - Office: +1 (801) 266-7700
  - stella.hanis@alsglobal.com
- Jessica Cofrancesco
  - Office: +1 (801) 266-7700 ex 302
    Jessica.Cofrancesco@alsglobal.com

History – Quality – Flexibility - Reliability

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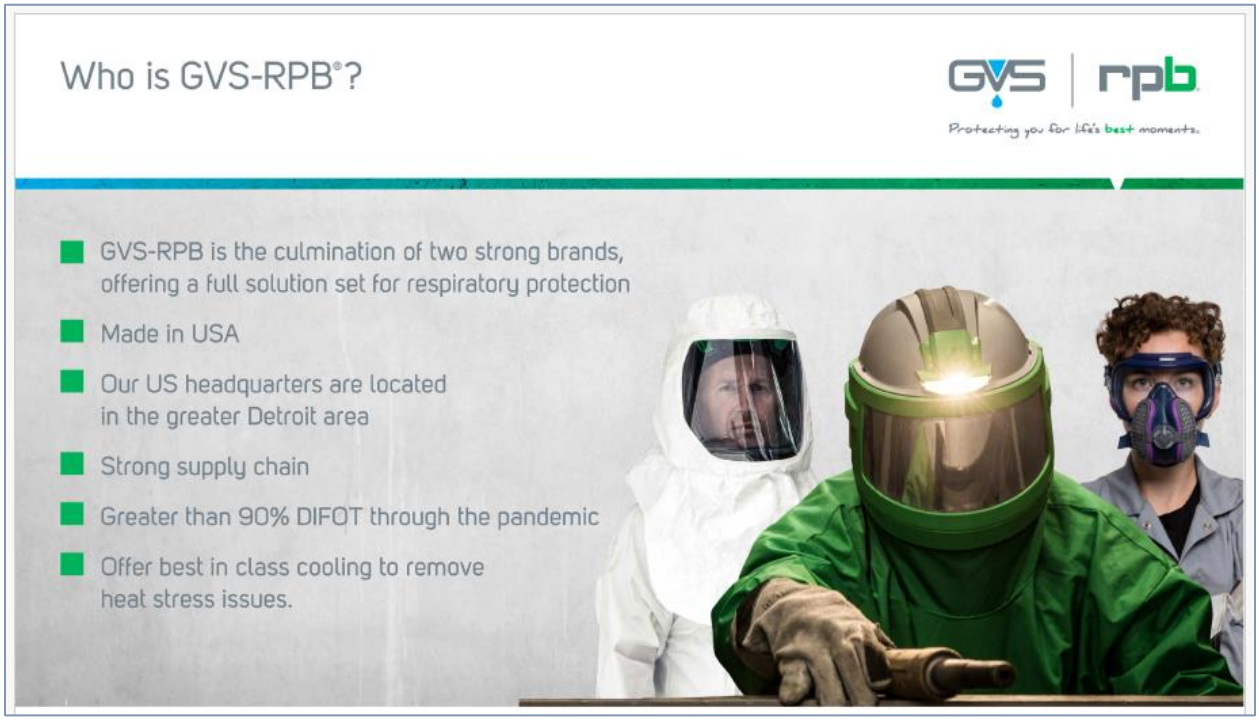
 10

GVS-RPB Respiratory Protection Solutions, Michigan, USA

Jeremy KENIMER



GVS-RPB Product Offering

GVS | rpb
Protecting you for life's best moments.

APR
Air Purifying Respirators

PAPR
Powered Air Purifying Respirators

Pair with the headtops below

SAR
Supplied Air Respirators

Peripheral Product Range

GVS | rpb
Protecting you for life's best moments.

- Blasting suit
- GX4® Gas Monitor - Can detect CO, O_2 and H_2S
- The Radex® is fitted with a 6-stage filter cartridge that removes moisture, odor and particulates to 0.5 micron
- Airlines and Fittings.

Past Performance

Our products protect operators at the following facilities

GVS | rpb
Protecting you for life's best moments.

Pacific Northwest National Laboratory

The welders at the Pacific Northwest National Laboratory are using our Z4 PAPRs and they find them perfect. The ADF Lens is super clear, and it's greatly improved their visibility.

Los Alamos National Laboratory

Los Alamos National Laboratory has a team of industrial hygiene professionals right on-site. Some of them are generalists, while others specialize in fabrication. They've got 12 of our PAPRs and are big fans of our product line. One of them learned about our products in a previous job and introduced them here.


Thank You
Want to know more?
Email Jeremy at jeremy.kenimer@gvs.com
or call at (614) 599-7274
Identifiers:
Cage Code: 8PFS3
Duns: 117609270
gvs-rpb.com

Day 2: BHSC Business Meeting

Led by Roland CHRETIEN, BHSC Chair

Business Meeting Minutes compiled by Jack BENNETT, BHSC Recording Secretary

AGENDA – BHSC 2023 Fall Business Meeting

8 November 2023
13:30-14:30 Eastern Standard Time

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

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

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

1. Approval of this agenda – The meeting has a quorum. Motion to approve the draft agenda, which was seconded, approved.

2. By-Laws Revisions – Discussed results of vote, which approved the revision to Section 1.5. The revised by-laws will be uploaded to the website. Lisa noted that there was a typo in the section included below. The voted version is correct.

   Proposed (new): *Section I.5: Ethical conduct. It is expected of all participants in BHSC and its subcommittee activities that members and guests will openly and willingly share experiences and information that advance the BHSC mission as outlined in the charter. In order to do so, no member or participant shall pursue details of worker, worker affiliation, employer, employer affiliation or any other attribute that would uniquely identify a situation, scenario or exposure event such that undue influence (marketing opportunity for health services to a worker, communication of the event to a regulatory authority as examples) may occur. Occasions where such undue influence occurs may be called out by the subcommittee chair, BHSC board members or other participants. Repeat offenses shall be referred by the subcommittee chair to the BHSC executive committee for consideration of further action.*

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

vii. The Sampling and Analysis Sub-committee is very active. Kul Garg is chair and Dan Jensen is co-chair.
viii. Josef noted that there is information on the website about the vacancies.

- Roland noted that the BHSC has been revitalized since COVID and encouraged people to get involved because it is a good opportunity for networking.
- Jackie Rogers still supports BHSC, such as helping with the non-profit license and other ways.

4. Other new business requiring a vote today – None.

5. Chairman's Brief Report (R. Chretien)
   - Review of activities since Spring 2023:
     i. There has been more activity on the website, with people looking for information.
     ii. The last three meetings have been very successful.
     iii. We are doing better from a financial perspective.
   - Succession planning
     i. We need to look at people who can fill our roles and encourage them to participate. Look for your successor from day 1.

6. Status of Funds (D. Jensen)
   - Pay Pal: $4,939.69
   - Wells Fargo: $7,913.14
   - There are a few upcoming expenses anticipated to cost approximately $500.
   - We need to look at polishing the website. Everything costs money, but this would be a worthwhile expense.
   - Symposium: We will start planning for a symposium to be held in the near future and possibly next fall. However, there will be a $10k upfront cost. The last symposium in Las Vegas was well attended, so it makes sense to go back there.

7. Membership Report (J. Fowler)
   - 47 active paid members.

8. Web Site Report (R. Chretien)
   - Significant improvements have already been made including board member bio-sketches. Julie & April did a good job updating the website, but there is still more to do.
   - Members currently have the ability to see presentations from these meetings. We are retrieving the historical backlog of documents that will be made available to paid members.

9. Plans for 2024 Spring Meeting (C. Dorn & J. Sobieraj)
   - Spring meeting, ad hoc planning team is meeting this afternoon. The meeting will be held in Oak Ridge in April, and more details will be provided later this afternoon.

10. Subcommittee Reports
    - **Risk Communication:** No updates

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

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

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

Appendices

BHSC 2023 Fall Meeting Participants List

Family Name	First Name	Organization	Country	Status
ADAMS	Eric	Oak Ridge Associated Universities	USA	Online
ADAMS	Karin	Idaho National Lab	USA	Online
ADAMS	Wes	National Nuclear Security Administration	USA	In person
ADEYEMI	Aminat	Dept of Energy	USA	Online
ALARCON	Charles	ITER Organization	France	Online
AL-DAOUK	Ahmad	National Nuclear Security Administration	USA	In person
ALLISON	Elise	DOE Portsmouth/Paducah Project Office	USA	Online
ARTHUR	Brandon	DOE Portsmouth/Paducah Project Office	USA	Online
ASHLEY	Kevin	Ashley & Associates	USA	Online
BAILEY	Brian	NNSA Production Office	USA	Online
BANTA	Gregory	Dept of National Defence	Canada	Online
BARKER	Lisa	National Jewish Health	USA	Online
BARTHEL	Caroline	Commonwealth Fusion Systems	USA	In person
BENNETT	Jack	Lawrence Livermore National Lab	USA	In person
BERNHOLC	Nicole	Dept of Energy Brookhaven National Lab	USA	Online
BOYLE	Eric	Dept of Energy	USA	In person
BRADLEY	Adam	DOE Portsmouth/Paducah Project Office	USA	Online
BROUNSTEIN	Robert	TerranearPMC LLC	USA	In person
BROWN	April	Dept of Energy HQ	USA	In person
BROWN	Cassie	Environmental Mgmt. Los Alamos	USA	Online
BROWN	Douglas	Merrick & Company	USA	In person
BRYSON	Drew	National Nuclear Security Administration	USA	Online
BURAK	Adam	University of Michigan	USA	Online
CASALINA	Cynthia	National Nuclear Security Administration	USA	Online
CHAUHAN	Ankur	Bhabha Atomic Research Centre (BARC)	India	Online
CHRETIEN	Roland	Edgewater Technical Associates	USA	In person
CI	Hui	Princeton Plasma Physics Laboratory	USA	Online
CIBUZAR	Mike	Advanced Research Corp.	USA	Online
COUCHMAN-CATES	Taryn	Dept of Energy, Office of Environmental Management	USA	Online
COX	Douglas	General Dynamics Missions Systems	USA	In person
DANDENEAU	Christopher	Savannah River National Lab	USA	Online
DAVIS	Charles	Envirostat & Statistics Ltd.	USA	Online
DAVIS	Lindsay	National Nuclear Security Administration	USA	Online
DEVINE	Meghan	Commonwealth Fusion Systems	USA	In person
DICKERSON	Aaron	Merrick & Company	USA	In person
DOBBINS	Joseph	Dept of Energy	USA	In person

Family Name	First Name	Organization	Country	Status
DORN	Chris	Kyoto Fusioneering America Be4FUSION LLC	USA	Online
DOSHI	Jayesh	eSpin Technologies Inc.	USA	Online
DUMAS	Constantine	Materion Brush Inc.	USA	Online
FADEL	Gus	Dept of Energy Office of Science	USA	Online
FECHSER	Matthew	Lawrence Livermore National Lab	USA	Online
FIELD	Danny	National Nuclear Security Administration	USA	In person
FOWLER	Julie	National Nuclear Security Administration	USA	In person
FREIDERICH	Melissa	Y-12 National Security Complex	USA	In person
FRESCHI	Steve	General Dynamics Mission Systems	USA	Online
GARG	Kul	National Nuclear Security Administration	USA	In person
GILL	Joanne	UK Atomic Weapons Establishment	UK	Online
GOLDEN	Ashley	Dept of Energy ORAU/ORISE	USA	In person
GORDON	Will	Los Alamos National Lab	USA	Online
GRIEGO	Regina	Dept of Energy	USA	Online
GRIFFIN	Gary	GEG Consulting, LLC	USA	In person
HANEBUTH	Julie	Dept of Energy Argonne National Lab	USA	Online
HANIS	Stella	ALS Global	USA	Online
HECK	Lindsay	US Army Corps of Engineers	USA	In person
HELDT	Gregory	Materion Brush Inc.	USA	In person
HOLEY	Brandy	National Nuclear Security Administration	USA	Online
HOLLAND	Andrew	Fusion Industry Association	USA	In person
HOWE	Teresa	General Dynamics Mission Systems	USA	In person
HUNTLEY	Courtney	Y-12 National Security Complex	USA	In person
JENSEN	Daniel	National Nuclear Security Administration	USA	In person
KENIMER	Jeremy	GVS-RPB Respiratory Protection	USA	In person
KHAN	Mohammad	University of Michigan	USA	Online
KHECHFE	Alexander	Commonwealth Fusion Systems	USA	Online
KNUDSON	Ted	Materion Brush Inc.	USA	In person
KUBIAK	Karen	Dept of Energy Idaho	USA	Online
LEWIS	Gregory	Dept of Energy	USA	In person
LEWIS	Kelly	Idaho National Laboratory	USA	Online
LINDSAY	Laurie	Y-12 National Security Complex	USA	In person
LUCKEY	Morgan	National Nuclear Security Administration	USA	In person
MAESTAS	Lynn	National Nuclear Security Administration	USA	Online
MAHIMAIDOSS	Nimalan	Dept of Energy	USA	Online
McGREGOR	Drake	American Industrial Hygiene Association	USA	Online
MEADE	Bevan	ALS Testing Services	USA	In person
MEYER	Ken	Y-12 National Security Complex	USA	Online
MICHAUD	Keith	Merrick & Company	USA	In person

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MOORE	Chandler	Xcimer Energy	USA	Online
MORENO	Mario R.	DOE Occurrence Reporting & Processing	USA	Online
MORTON	Cheryl	American Industrial Hygiene Association	USA	Online
MROZ	Peggy	National Jewish Health	USA	In person
MURRAY	Kim	National Nuclear Security Administration	USA	Online
MUSGROVE	James	N/A	USA	Online
NEVILLE	Robert	Cameco Fuel Manufacturing	Canada	Online
NEYENS	Mallory	Dept of Energy	USA	Online
OLSON	Luke	Savannah River National Laboratory	USA	Online
PICKARSKI	Timothy	University of California at Berkeley	USA	Online
POLEK	Michael	US Army Corps of Engineers	USA	In person
PONTEFRACT	Wendy	Savannah River Site	USA	Online
PRICE	Regina	Dept of Energy	USA	Online
RHAMBAROSE	Harrichand	DOE Office of Enterprise Assessments	USA	Online
ROBICHAUD	Victoria	Cameco Corp.	Canada	Online
ROBERTS	Rachel	National Nuclear Security Administration	USA	In person
RODDY	Crystal	Cameco Corp.	Canada	In person
ROSCETTI	Christopher	Dept of Energy	USA	In person
SAMUELS	Joseph	DOE Hanford Nuclear Site	USA	Online
SENEVIRATNE	Sarath	Transportation Security Administration	USA	In person
SHAMBERGER	Connor	University of Michigan	USA	Online
SHIREY	Pamela	BWX Technologies, Inc.	USA	Online
SHOULTZ	Cori	Abilene Christian University	USA	Online
SMITH	Diane	DOE Kansas City Nat'l Security Campus	USA	Online
SMITH	Keith	Materion Brush Inc.	USA	Online
SOBIERAJ	Josef	National Nuclear Security Administration	USA	In person
STRICKLAND	Carly	National Nuclear Security Administration	USA	Online
SU	Guanyu	University of California at Berkeley	USA	Online
TURNQUEST	Eric	Dept of Energy Science Office	USA	Online
VANCE	John	Dept of Labor	USA	In person
VIRJI	Abbas	Center for Disease Control	USA	Online
VOLZA	Joe	National Nuclear Security Administration	USA	Online
WAGNER	Greg	Advanced Research Corp.	USA	Online
WAMBACH	Paul	Independent Consultant	USA	Online
WHALEN	Lance	General Dynamics Mission Systems	USA	In person
WHATLEY	Todd	National Nuclear Security Administration	USA	In person
WHITE	Annette	Atkins Global Nuclear Services	UK	Online
WILMOT	Zeke	Los Alamos National Laboratory	USA	In person
WILSON	Leah	National Nuclear Security Administration	USA	In person
WIRGAU	Tom	Dept of Energy	USA	Online

Family Name	**First Name**	**Organization**	**Country**	**Status**
WOLLER	Kevin	Massachusetts Institute of Technology	USA	Online
YADA	Shian	NNSA Production Office	USA	Online
ZHENG	Guiqiu	Commonwealth Fusion Systems	China	In person
ZHOU	Weiyue	Massachusetts Institute of Technology	USA	Online

Meeting & Venue Photos


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



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

In-person participants networking during a break in the program. Photo credit: J. BENNETT, LLNL.

In-person participants at the BHSC 2023 Fall Meeting gathered in the conference room in the Forrestal Building where the Meeting was held on Tuesday, 7 November 2023. Photo credit: DOE Staff.

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

Presenters from left to right: Andrew HOLLAND, CEO of the Fusion Industry Association; Doug BROWN and Aaron DICKERSON of Merrick & Company; April BROWN, CIH of the DOE Office of Environmental, Health, Safety & Security; and Dr. Eric BOYLE, DOE Chief Historian. Photo credits: Jack BENNETT, LLNL.

Left: Dr. Josef SOBIERAJ presented on behalf of the NNSA, responses from NNSA sites to an economic impact assessment questionnaire due to changes in the beryllium rules. Right: Josef SOBIERAJ in his role as First Vice Chair and Roland CHRETIEN, BHSC Chair, leading the BHSC Fall Business Meeting. Josef also serves on the BHSC Board as the Meetings & Symposia Sub-Committee Chair, and he was the leader for the organizing of the Fall Meeting. Photo credits: Jack BENNETT, LLNL.

Vendors play an important role in the BHSC mission, and their presence at the Fall Meeting gave them an opportunity to make our members and other practitioners in the field aware of their products and services. Left: Gary GRIFFIN, BHSC Vendor Liaison (on the right in the photo) introduces Jeremy KENIMER of GVS-RPB Respiratory Protection Solutions to the participants. Right: Bevan MEADE of ALS Testing Services, who also attended the BHSC 2023 Spring Meeting in May, tells attendees about the latest services being offered by his company. Photo credits: Jack BENNETT, LLNL.