# Evaluation and Control of Beryllium Exposure in Shipyards

**NSRP Risk Management Panel Project**
**NSRP Subcontract No. 2018-425**

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**Minneapolis, MN**

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# Evaluation and Control of Beryllium Exposure in Shipyards

Project Prime/Lead – BSI EHS Services and Solutions

Project Participants – US Navy, NAVMEDCEN Industrial Hygiene, Portsmouth, VA

Shipyard Participants – Bath Iron Works, Bath ME
Newport News Shipbuilding, Newport News, VA
Norfolk Naval Shipyard, Portsmouth, VA



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# Evaluation and Control of Beryllium Exposure in Shipyards


## Description / Background

2017 OSHA regulation, 29 CFR 1910. 1024, 29 CFR 1915.24

Occupational Exposure to Beryllium and Beryllium Compounds

- Complex health standard with impact on cost and productivity in the US shipbuilding and ship repair industry.
- Ten-fold reduction of the Permissible Exposure Limit (from 2.0 µg/m³ to 0.2 µg/m³ of air).
- Defines detailed requirements for medical surveillance, exposure monitoring, exposure control practices, regulated work areas, detailed recordkeeping and training.
- Since issued, many extensions, request for information
- PEL of 0.2 µg/m³ of air is in effect

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# Evaluation and Control of Beryllium Exposure in Shipyards

## Goals and objectives

- Define current uses of Be-containing products
- Collect and review existing representative occupational exposure data
- Evaluate abrasive blasting process efficiency (Conducted by Newport News Shipbuilding)
- Define additional air monitoring needs
- Prepare a summary report

## Completion Schedule

- March 1, 2018 – April 30, 2019

# Evaluation and Control of Beryllium Exposure in Shipyards

## Beryllium Use in US Shipbuilding

Be = lightweight but strong metal used principally in aerospace and defense

* beryllium-copper alloy = electrical and thermal conductivity, high strength and hardness, good corrosion and fatigue resistance, and nonmagnetic properties.

* beryllium oxide = excellent heat conductor, high strength and hardness, electrical insulator

**Primary Potential Source of Exposure** - Be as trace element (<0.1% by Wt) in coal and metal slags sold for use in abrasive blasting

**No participating shipyards identified use of welding or abrasive blasting materials classified as BCM**

(BCM =Beryllium-Containing Material)


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## OSHA Exemption

OSHA
Occupational Safety and Health Administration

❖For materials with <0.1% Be by weight

Applies:

- Where the employer has objective air monitoring exposure data

Field Evaluation Air Monitoring Data

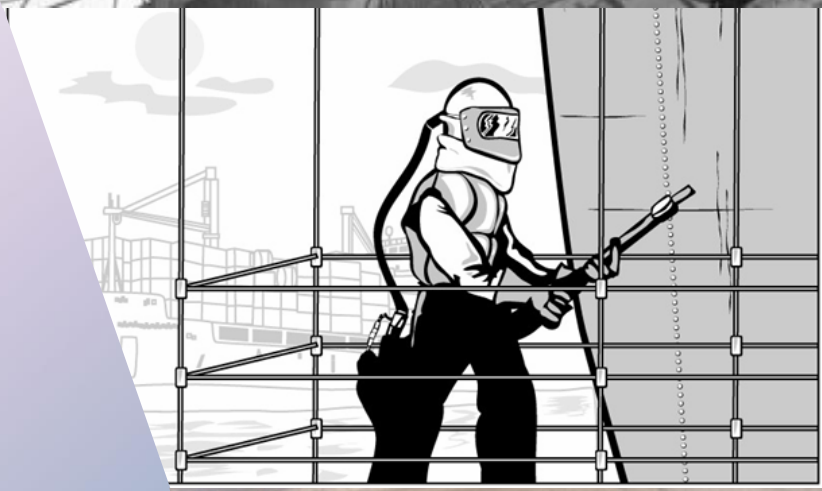
| Date | Trade | Operation | Abrasive | Exp * | Unit | Space |
|---|---|---|---|---|---|---|
| 11/15/2016 | Machinist | Hot Work | N/A | < 0.037 | µg/m$^3$ | Enclosed |
| 11/15/2016 | Fitter | Hot Work | N/A | < 0.037 | µg/m$^3$ | Enclosed |
| 12/6/2016 | Lab Tech | Welding | N/A | < 0.052 | µg/m$^3$ | Enclosed |
| 12/6/2016 | Supervisor | Observation | N/A | < 0.052 | µg/m$^3$ | Enclosed |

- Demonstrate employee exposure to Be will remain below Action Level of 0.1 µg/m³ of air as an 8-hour TWA under any foreseeable conditions.

# Evaluation and Control of Beryllium Exposure in Shipyards

## Processes and Affected Trades in Shipyards (Maritime)

- Abrasive Blasting
- Welding



Reference:

OSHA Final Standard for Beryllium, Table VIII-Federal Register, January 9, 2017; p 2569

# Shipbuilding Blast Efficiency Study

- Task 1 - Created formal test plan which included, but was not limited to, media to evaluate, and validation of current production rate guide.
- Task 2 - Used real test areas (i.e., tank mock ups, etc.)

- Task 3 - Conducted air sampling to evaluate exposure control
- Task 4 - Correlated production rate and exposure control, as possible, for optimum cleaning efficiency with required Be exposure control

# Exposure Monitoring

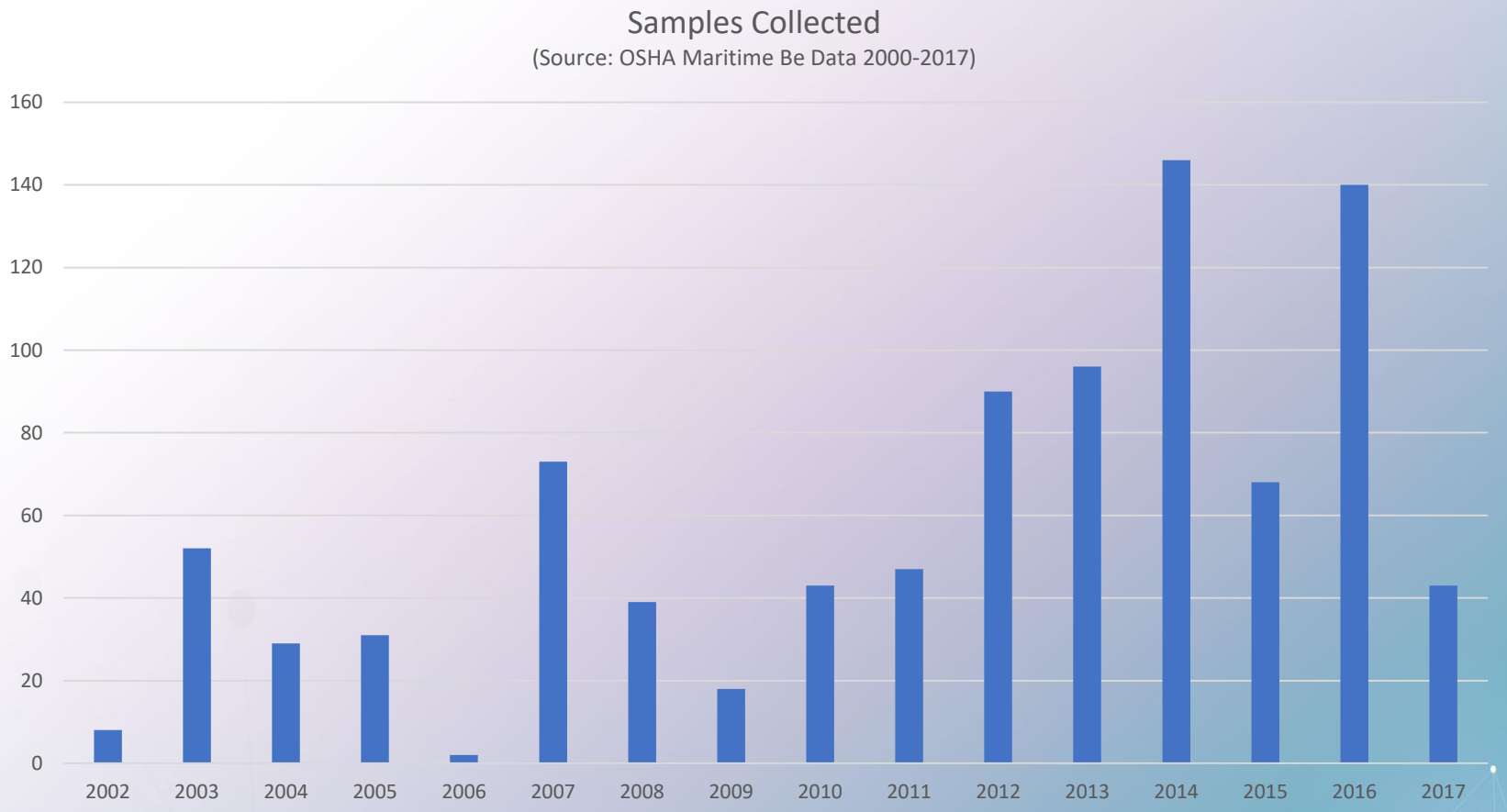
- Over 2400 air sample results provided from shipyard industry sources.
- New air sampling in three US shipyards
- Evaluation and testing addressed two priority/work categories:
  1. Abrasive Blasting and Surface Prep
  2. Welding, Cutting and Hot Work
- Found potential for Be contact as a "trace" contaminant.
- All current work tested well below OSHA limits

## Historical Air Monitoring Data for Maritime Welding and Abrasive Blasting

(Sources: OSHA Compliance Data, participating shipyards)

- Over 2000 air sample results reviewed
- Collected over 25-year period, 1993-2018
- Over 70 % of samples were “less than” values
- OSHA historical Be compliance data for Maritime included 925 results

# Evaluation and Control of Beryllium Exposure in Shipyards



# Evaluation and Control of Beryllium Exposure in Shipyards

## Field Evaluations

Testing in participating shipyards during representative production work

86 air samples

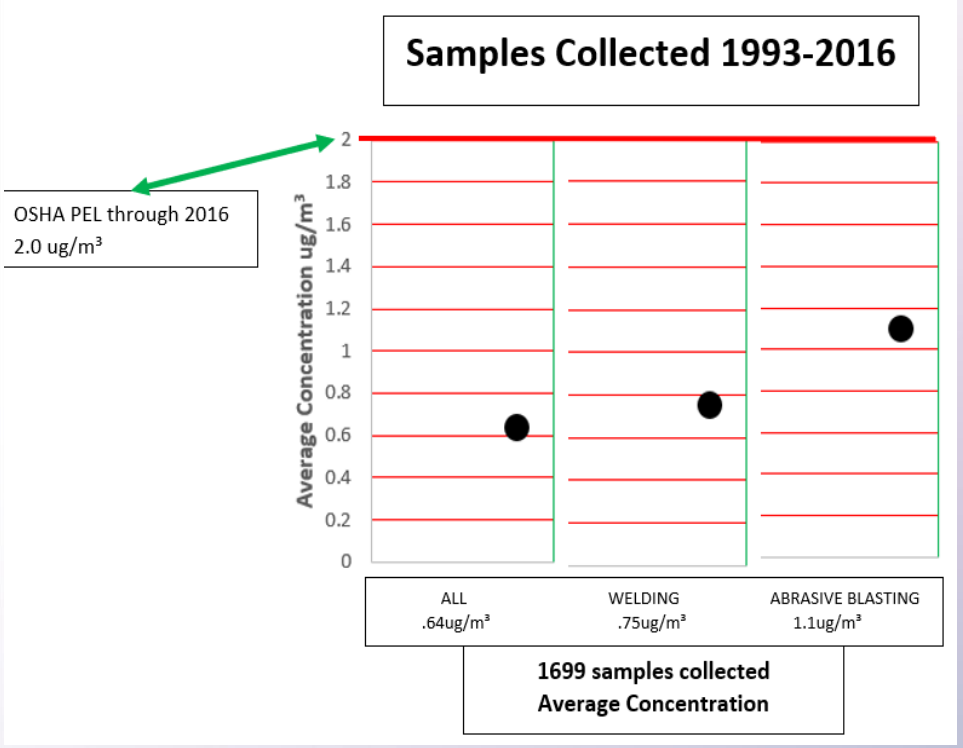
- Abrasive blasting – Garnet, Coal Slag, Olivene JetMag, steel shot
- Welding and Hot Work

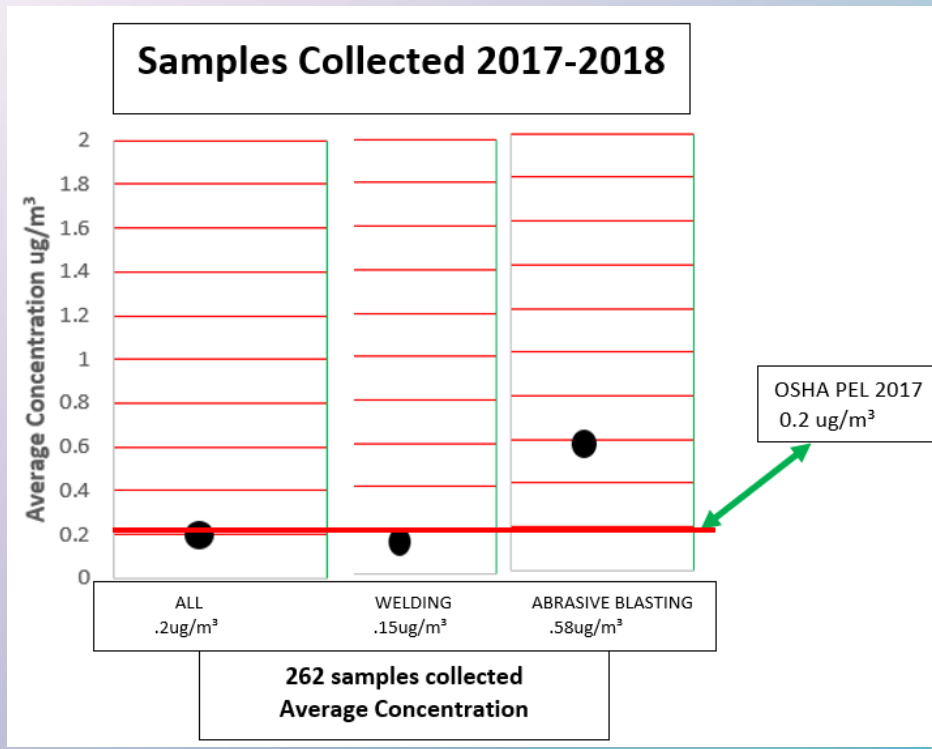
All Be results below OSHA PEL of 0.2 µg/m³

84 of 86 samples were Below Detection Limits

(0.03 µg/m³ in two abrasive blast samples)

# Evaluation and Control of Beryllium Exposure in Shipyards




Reference : Evaluation and Control of Beryllium Exposure in Shipyards
NSRP Risk Management Panel Project
NSRP Subcontract No. 2018-425
FINAL REPORT April 2019
Pages 16-18

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# Evaluation and Control of Beryllium Exposure in Shipyards

METAL AND METALLOID PARTICULATES IN WORKPLACE ATMOSPHERES
(ICP ANALYSIS)

| | |
|---|---|
| Method Number: | ID-125G |
| Matrix: | Air, Wipe, or Bulk |
| OSHA Permissible Exposure Limits: | Permissible Exposure Limits (PELs) are listed in Table 1 for elements commonly found in industrial environments. This method has the capability of sampling and analyzing more than these elements, the number being limited by instrumental capability, as well as digestion solubility and stability. |
| Collection Procedure: | A calibrated personal sampling pump is used to draw a known volume of air through a mixed-cellulose ester membrane filter contained in a styrene cassette. |
| Minimum Recommended Air Volumes: | Time Weighted Average Samples - 480 L<br>Short-Term Exposure Limit Samples - 30 L*<br>Ceiling Samples - 30 L |
| Recommended Sampling Rate: | 2 L/min |
| Analytical Procedure: | Filters are digested with nitric acid, sulfuric acid and hydrogen peroxide. Dissolution of the elements is facilitated by addition of hydrochloric acid. Analysis is performed using Inductively Coupled Argon Plasma-Atomic Emission Spectroscopy (ICAP-AES). |
| Detection Limits: | See Table 2 |
| Validation Level: | See Table 3 |
| Precision and Accuracy: | See Table 3 |
| Method Classification: | Validated analytical method |
| Chemists: | Jerry Septon, Ray Abel, Michael Simmons |
| Date:<br>Revised: | November, 1988<br>September, 2002 |
| * | Take 60-L samples when evaluating STEL exposures to beryllium. |

Commercial manufacturers and products mentioned in this method are for descriptive use only and do not constitute endorsements by USDOL-OSHA. Similar products from other sources can be substituted.

Division of Physical Measurements and Inorganic Analyses
OSHA Technical Center
Salt Lake City, Utah



T-ID125G-FV-03-0209-M

## Sampling & Analysis Methods: OSHA ID 125G

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# Evaluation and Control of Beryllium Exposure in Shipyards

## BERYLLIUM and compounds, as Be: METHOD 7102, Issue 2, 15 August 1994

Be MW: 9.01 CAS: 7440-41-7 RTECS: DS1750000

**METHOD:** 7102, Issue 2 **EVALUATION:** FULL **Issue 1:** 15 February 1984 **Issue 2:** 15 August 1994

**OSHA :** 2 µg/m³; C 5 µg/m³; P 25 µg/m ³/30 min
**NIOSH:** not to exceed 0.5 µg/m ³ (suspect carcinogen)
**ACGIH:** 2 µg/m³ (suspect carcinogen)

**PROPERTIES:** hard, light metal; valence +2; MP 1284 to 1300 °C

### SAMPLING

**SAMPLER:** FILTER (0.8 µm cellulose ester membrane)

**FLOW RATE:** 1 to 4 L/min

**VOL-MIN:** 25 L @ 2 µg/m ³
**-MAX:** 1000 L

**SHIPMENT:** routine

**SAMPLE STABILITY:** stable

**BLANKS:** 2 to 10 field blanks per set

### ACCURACY

**RANGE STUDIED:** 2.7 to 11.8 µg/m ³ [1] (40-L samples)

**BIAS:** • 0.39%

**OVERALL PRECISION ($\hat{S}_{rT}$):** 0.064 [1]

**ACCURACY:** ± 12.42%

### MEASUREMENT

**TECHNIQUE:** ATOMIC ABSORPTION, GRAPHITE FURNACE

**ANALYTE:** beryllium

**ASHING REAGENTS:** $HNO_3$, 10 mL; $H_2SO_4$, 1 mL

**CONDITIONS:** 150 °C until brown fumes disappear; 400 °C to dense fumes of $H_2SO_4$

**FINAL SOLUTION:** 2% $Na_2SO_4$/3% $H_2SO_4$; 10 mL

**GRAPHITE FURNACE:** 110 °C dry 20 sec; 900 °C char 10 sec; 2800 °C atomize 18 sec

**WAVELENGTH:** 234.9 nm

**BACKGROUND CORRECTION:** $D_2$ or $H_2$ continuum

**INJECTION VOLUME:** 10 µL

**CALIBRATION:** $Be^{2+}$ in 2% $Na_2SO_4$/3% $H_2SO_4$

**RANGE:** 0.05 to 1 µg per sample [2]
**ESTIMATED LOD:** 0.005 µg per sample [2]

**PRECISION ($S_r$):** 0.008 [2]

**APPLICABILITY:** The working range is 0.5 to 10 µg/m ³ for a 90-L air sample. The method is applicable to ceiling measurements using a 25-L air sample.

### EVALUATION OF METHOD:

This method was evaluated using NTIS Standard Reference Material No. 2675 for Be over the range of 0.1 to 0.4 µg Be/filter (equivalent to one-half to two times the OSHA PEL). Beryllium recovery was 98.2% with a measurement precision, $S_r$, of 0.008 [2]. This method is an improvement of S339 [3], which was validated over the range of 2.68 to 11.84 µg/m ³ using a 40-L sample. Mean recovery was 106.9% with overall precision of 0.064 [1].

### REFERENCES:


[1] Documentation of the NIOSH Validation Tests, S339, U.S. Department of Health, Education and Welfare, Publ. (NIOSH) 77-185 (1977).
[2] NIOSH Manual of Analytical Methods, 2nd ed., V. 5, P&CAM 288, U.S. Department of Health, Education and Welfare, Publ. (NIOSH) 79-141 (1979).
[3] Ibid., V. 3, S339, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-C (1977).
[4] Criteria for a Recommended Standard...Occupational Exposure to Beryllium, U.S. Department of Health, Education and Welfare, Publ. (NIOSH) 72-10268 (1972); and as revised in August, 1977 in NIOSH testimony at OSHA hearing.


## Sampling & Analysis Methods: NIOSH 7102

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# Evaluation and Control of Beryllium Exposure in Shipyards

Beryllium and Compounds (as Be)

| | |
|---|---|
| Method Number: | 1023 |
| Version: | 1.0 |
| Target Concentration: | 0.2 µg/m$^3$ |
| OSHA PEL: | 0.2 µg/m$^3$ 8-hour time-weighted average (TWA)<br>2.0 µg/m$^3$ short-term exposure (STEL) |
| ACGIH TLV: | 0.00005 mg/m$^3$ (8-hour TWA)<br>Skin; dermal sensitizer; respiratory sensitizer |
| Procedure: | Collect air samples by drawing workplace air through a 37-mm diameter, 0.8 micron pore size, mixed-cellulose ester (MCE) filter contained in a closed-face polystyrene cassette, using a personal sampling pump. Collect wipe samples on Smear Tabs. Bulk samples may also be collected. Digest the samples in nitric acid using microwave digestion and analyze by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) instrumentation. |
| Recommended Sampling Time and Sampling Rate: | 240 minutes at 2 L/min (480 L)<br>15 minutes at 2 L/min (30 L) STEL |
| Reliable Quantitation Limit: | 0.03 µg/m$^3$ |
| Standard Error of Estimate at the Target Concentration: | 5.4% |
| Status of the Method: | Fully validated. This method has been subjected to the established validation procedures of the Methods Development Team. |

June 2018

Michelle Paradise

Methods Development Team
Industrial Hygiene Chemistry Division
OSHA Salt Lake Technical Center
Sandy UT 84070-6406

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## Sampling & Analysis Methods: OSHA Method 1023

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## Project Accomplishments

- Summarized current uses of Be-containing products in current US shipyard work.
- Collected and reviewed historical industry occupational exposure data for comparable work with Be-containing products to characterize potential exposures and define effective control measures for work above and below regulatory thresholds.
- Evaluated abrasive blasting process efficiency for control of potential Be exposure during surface preparation and coatings work.
- Conducted air monitoring to validate effective exposure control methods.
- Completed a summary report to fulfill the industry need for Historical Objective Data.
- Summarized best current practices for effective exposure control methods in shipyard work.

## Summary

- Abrasive Blasting and Welding listed by OSHA for potential Be exposure in Shipbuilding
- No current abrasive blasting or welding materials were classified as Beryllium-Containing Material (>0.1% by Wt) by participating shipyards
- Review of historical air monitoring data offers limited evidence of predictable exposure
- Exposure at or above OSHA PEL appear linked to trace contaminants in blast media
- OSHA Maritime Industry air monitoring data for Be was 99.5% Below Detection Limits (5 out of 925 samples)
- Field evaluations found no exposures at or above OSHA Action Level or PEL
- Recommend elimination of Be-contaminated abrasives in future surface preparation work

# Questions??

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