Lawrence Livermore National Laboratory

A Comparison of Airborne Beryllium Exposures using an IOM Sampler and "Total Dust" Sampler During Beryllium Cleaning Operations

Samuel Paik, ES&H Team 1 Industrial Hygienist, Site 300
David Zalk, ES&H Team 1 Deputy Team Leader, Site 300

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Overview – Be exposures: IOM vs. "Total Dust"

- Introduction to the Site 300 Contained Firing Facility (CFF)
- Chamber Re-entry and Cleaning Operations
- Purpose of Study
- Personal & Area Monitoring
- Results and Conclusions

CFF – Key to Stockpile Stewardship Program

- Constructed in 2001 as premier experimental facility for gathering implosion data of the primary stage
- CFF Firing Chamber: Volume = 2,880 m^3 (16 X 18 X 10 meters)
- Contains a 60 kg high explosive (HE) blast with walls 2 meters thick
- Minimizes environmental issues for hazardous & radioactive waste
- Maximizes potential occupational issues for Be, DU, and more.
- Internal chamber monitoring post shot (no workers): Be ≥ 24,000 $\mu g/m^3$

Chamber monitoring system

Initial Chamber Re-entry - Sequence

- Explosive test assembly detonation; contains beryllium
  - With water barrels (~450 gallons) to initiate control techniques
- Chamber purge: min. 10 air exchanges (+ settling time)
- Water spraying + HE check for 'all clear'
  - Potential for beryllium exposure begins
- Data retrieval
  - X-ray film cassette
  - Other items of interest

Chamber Cleaning - Sequence

- After initial re-entry is completed, chamber cleaning begins with both chamber and vestibule as RBWA
- Sequence of chamber clean-up operations
  - Setup & placement of “dogwasher” (high-pressure automatic spray device)
  - Manual spraying of chamber interior with low-pressure water hoses
  - Selective encapsulant (Fiberset PM®) spraying of chamber components
  - Collection of bulk debris
  - Floor cleanup/squeegee
  - Vacuuming of camera ports
  - Pushing water into chamber weir
  - Encapsulating chamber floor, walls, & ceiling
  - Surface swiping of chamber and vestibule
  - Downgrade to BWA based on surface results
  - Begin shot set-up procedures for next experiment

Purpose of Study - Personal and Area Sampling

- All chamber re-entry workers & direct chamber support wear personal Be samplers (100% sampling strategy)
- From 2002 to 2010, workers at CFF were monitored using 37-mm "Total Dust" cassette sampler: >1,000 samples
- 2009 ACGIH Be TLV (LLNL has not adopted this)
  - 8-hr TLV-TWA 2 $\mu g/m^3$ to 0.05 $\mu g/m^3$
  - "Inhalable" designation given
- Investigate change with side-by-side

"Total dust" sampler

"Total dust" sampler →

VS

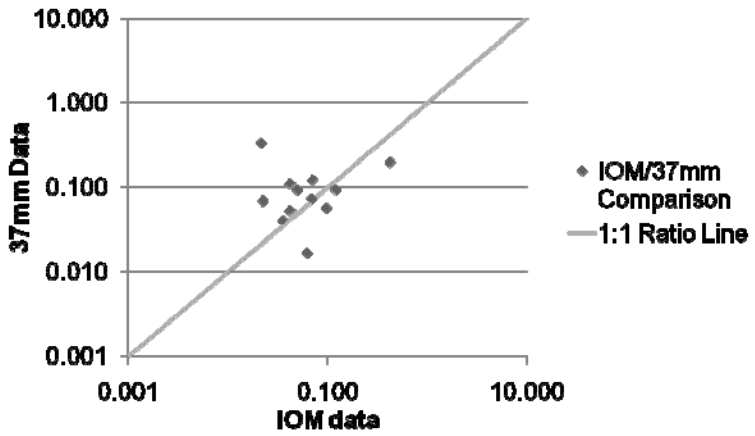
← IOM Inhalable Aerosol Sampler

Personal Sampling Results – 2 week duration

- Personal Sampling: 12 pairs of samples from five different workers (non-detectable results excluded)
- IOM sampler/37mm sampler ratio ranged from 0.064 to 3.7, with an average ratio of 1.1:1 (8-hr TWA)

Date	Activity	IOM sampler (mcg/m3)	37mm (mcg/m3)	IOM/37mm Ratio
5/20/2010	Initial Chamber Re-entry (Worker A)	0.071	0.120	0.59
5/20/2010	Initial Chamber Re-entry (Worker B)	0.050	0.093	0.53
5/25/2010	Chamber Cleanup - Day 1 (Worker C)	0.062	0.017	3.7
5/25/2010	Chamber Cleanup - Day 1 (Worker D)	0.036	0.041	0.88
5/26/2010	Chamber Cleanup - Day 2 (Worker B)	0.097	0.057	1.7
5/26/2010	Chamber Cleanup - Day 2 (Worker D)	0.022	0.069	0.32
6/2/2010	Chamber Cleanup - Day 3 (Worker E)	0.12	0.093	1.3
6/2/2010	Chamber Cleanup - Day 3 (Worker C)	0.069	0.073	0.95
6/2/2010	Chamber Cleanup - Day 3 (Worker D)	0.42	0.20	2.1
6/3/2010	Chamber Cleanup - Day 4 (Worker E)	0.042	0.11	0.38
6/3/2010	Chamber Cleanup - Day 4 (Worker C)	0.042	0.053	0.79
6/3/2010	Chamber Cleanup - Day 4 (Worker D)	0.021	0.34	0.064

Personal Sampling Results - continued

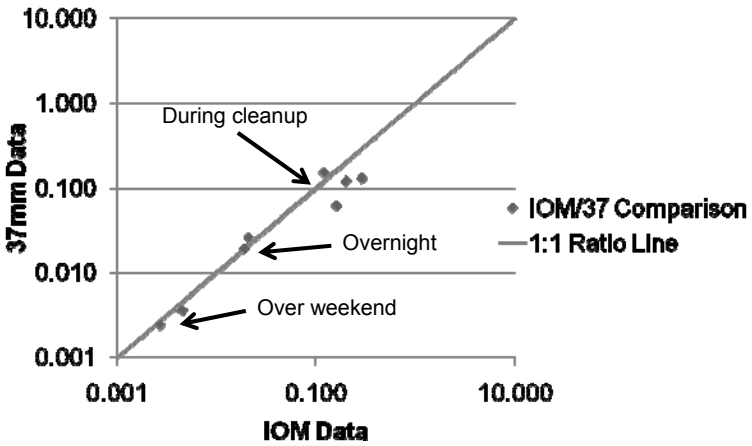


Area Sampling Results – 2 week duration

- Area Sampling: 8 pairs of samples collected during chamber cleanup and overnight (all samples had detectable beryllium)
- IOM sampler/37mm sampler ratio ranged from 0.80 to 2.6, with an average ratio of 1.4:1

Date	Activity	IOM sampler (mcg/m3)	37mm (mcg/m3)	IOM/37mm Ratio
5/25/2010	Chamber cleanup - Day 1	0.12	0.15	0.80
5/26/2010	Chamber cleanup - Day 1 overnight	0.019	0.019	1.0
5/26/2010	Chamber cleanup - Day 2	0.29	0.13	2.2
6/2/2010	Chamber cleanup - Day 2 over weekend	0.0027	0.0024	1.1
6/2/2010	Chamber cleanup - Day 3	0.20	0.12	1.7
6/3/2010	Chamber cleanup - Day 3 overnight	0.021	0.026	0.81
6/3/2010	Chamber cleanup - Day 4	0.16	0.061	2.6
6/7/2010	Chamber cleanup - Day 4 over weekend	0.0045	0.0036	1.3

Area Sampling Results - continued



Evaluation of Results – Personal sampling

- Variability in IOM/37mm ratio: 0.064 to 3.7. This was likely due to the nature of the tasks.
  - Spatial variability due to localized concentration from task
  - Spatial variability due to worker movement, worker's sampler position
- Given average IOM/37mm ratio was 1.1:1, variability in ratio not likely due to sampler performance differences
  - Paired t-test resulted in p-value of 0.62 (since p-value > 0.05, cannot reject null hypothesis)
  - While particle size analysis was not conducted, similarity in results between two samplers suggests fine particulate size. Data from numerous IOM sampler/37mm sampler comparison studies* show increase in this ratio for coarser particles

* Kerr et al, 2002; de Vocht et al., 2006; Tatum et al., 2001; Kenny et al., 1997

Evaluation of Results – Area sampling

- Variability in IOM/37mm ratio: 0.80 to 2.6. Less variable than personal sampling results.
  - Both samplers were in static location inside chamber. Not subject to worker movement, less subject to localized concentration.
  - Actual concentrations depended on whether sampling overnight or over weekend versus during cleaning
  - Paired t-test resulted in p-value of 0.15 (since p-value > 0.05, cannot reject null hypothesis).
  - While the average IOM/37mm ratio was 1.4:1, suggesting that the IOM sampler generally measured higher concentrations than the 37mm sampler, the difference was not statistically significant.

Conclusions

- Impact of changing Be TLV to inhalable standard
  - For the CFF operations assessed during this study, the change to IOM sampler from “total dust” sampler would not result in significantly difference results. Given the relative convenience of the “total dust” sampler (e.g., disposable, inexpensive, easier to analyze), one can argue that continuing to use the “total dust” sampler for this application would meet the requirements of the inhalable standard.
  - This may not be true for other types of operations, like machining Be parts, that may result in larger particle sizes.

For CFF operations, IOM sampler results were similar to “Total dust” sampler results

Conclusions - continued

- Additional considerations if using IOM sampler
  - Properly sampling all potentially exposed individuals, need > 100 IOMs at LLNL.
    - If 2+ major operations ongoing (e.g., CFF + 321C + NIF), may be > 200.
  - Be sample result turnaround may be affected by increased burden on ALAB to clean IOMs for re-use.
  - To suitably clean IOMs for re-use, are we potentially exposing more individuals?
    - ALAB employees, other IOM handlers?
    - Do we need to swipe them prior to release to non-BWA? Longer delays?
  - All considered, is using an IOM contrary to 10 CFR 850?
    - Consider ALARA and minimization of exposures
  - Over-collection potential (>100 μm) or 'basket' effect of larger opening

Conclusions - continued

- Impact of reducing Be TLV-TWA from 2 $\mu g/m^3$ to 0.05 $\mu g/m^3$
  - Current reporting limit is less than adequate. Reporting limit is about 34% of reduced TLV (ideally ≤10 % of TLV).
  - Out of the 38 personal samples (19 pairs of IOM and 37mm), none ≥ 2008 TLV-TWA of 2 $\mu g/m^3$ & 3 ≥ DOE Action Level of 0.2 $\mu g/m^3$.
  - If compared against the 2009 TLV-TWA of 0.05 $\mu g/m^3$, 18 (roughly half) met or exceeded the TLV-TWA. Many more DOE notifications.
  - Pinpointing control issues will be difficult since longer sample duration required to achieve sensitivity for comparison against TLV-TWA.
  - DOE setting an Action Level at 10% of the reduced TLV-TWA is not feasible - it would be below the reporting limit of the analytical method.

Reduced TLV may push the limits of technical feasibility (analytical limitations, engineering control limitations)

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