Beryllium Sampling Issues and Practical Impacts for the Industrial Hygienist

Steven D. Jahn, CIH

Gary Whitney, CIH

November 18, 2008

Practitioner's Paradox:

Sampling for Beryllium

Disclaimer

Any reference to products, companies, or organizations is for information purposes only and does not represent any form of endorsement or criticism.

Opinions expressed are those of the author only and do not represent those of the Department of Energy.

Performance vs. Guidance

ABOUT
PRODUCTS
MEMBERSHIP
EDUCATION & EVENTS
TLV®/BEI® RESOURCES
FOUNDATION
RESOURCES

For the latest information on new products & discount offers, sign up for the ACGIH.ORG mailing list.

TLV®/BEI® Resources

Policy Statement on the Uses of TLVs® and BEIs®

The Threshold Limit Values (TLVs®) and Biological Exposure Indices (BEIs®) are developed as guidelines to assist in the control of health hazards. These recommendations or guidelines are intended for use in the practice of industrial hygiene, to be interpreted and applied only by a person trained in this discipline. They are not developed for use as legal standards and ACGIH® does not advocate their use as such. However, it is recognized that in certain circumstances individuals or organizations may wish to make use of these recommendations or guidelines as a supplement to their occupational safety and health program. ACGIH® will not oppose their use in this manner, if the use of TLVs® and BEIs® in these instances will contribute to the overall improvement in worker protection. However, the user must recognize the constraints and limitations subject to their proper use and bear the responsibility for such use.

OSHA

agency issued a formal request for information in 2002 (67 Fed. Reg. 70700 [2002]). Peer review of OSHA's health-effects and risk-assessment report is expected to be completed by November 2008 (73 Fed. Reg. 24723 [2008]).

Other agencies have taken action in re-evaluating their occupational exposure guidelines for beryllium. In 1999, DOE established an action

DOE HSS

??????????

Why Sample?

- Learn something
- Prove or disprove something
- Demonstrate compliance
- Assess performance…..

Issues

- Guiding Performance versus Assessing Compliance
- Surface Sampling
- Air Sampling
- Analytical Realities

Primer on Surface Sampling

- Source identification
- Housekeeping maintenance
- Decontamination adequacy
- Transfer mechanisms

Real Driver for Surface Sampling

Prevent beryllium exposure and contamination spread to workers, the community, and the environment !

Goals for Surface Sampling

- Collect contamination which might become airborne.
- Collect “removable contamination”.
- Collect all beryllium on surface.
- Collect all beryllium on surface including that under paint or surface finishes.

The many reasons and goals for surface sampling and the wide variety of workplace situations will tend to drive the use of multiple methods in the field and lab.

Standard Surface Sampling Methods

- OSHA ID-125G
- NIOSH 9100
- NIOSH 9102
- NIOSH 9105
- NIOSH 9110
- ASTM D6966
- ASTM E1216
- ASTM D5438
- ASTM D7144
- ASTM D7296
- ASTM E1728
- ASTM ES3094
- Others & Modifications

From the lists provided by Kevin Ashley and John Bishop.

List includes wipe, vacuum, and bulk methods. Wipe sampling is by far the most commonly used.

Ideal & Real Surface Sampling Situations

What you hope for.

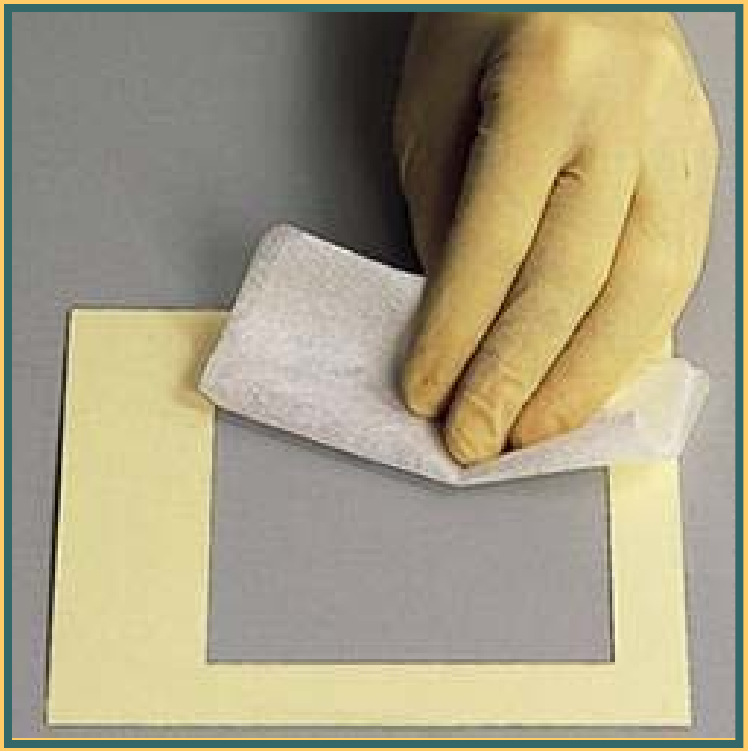
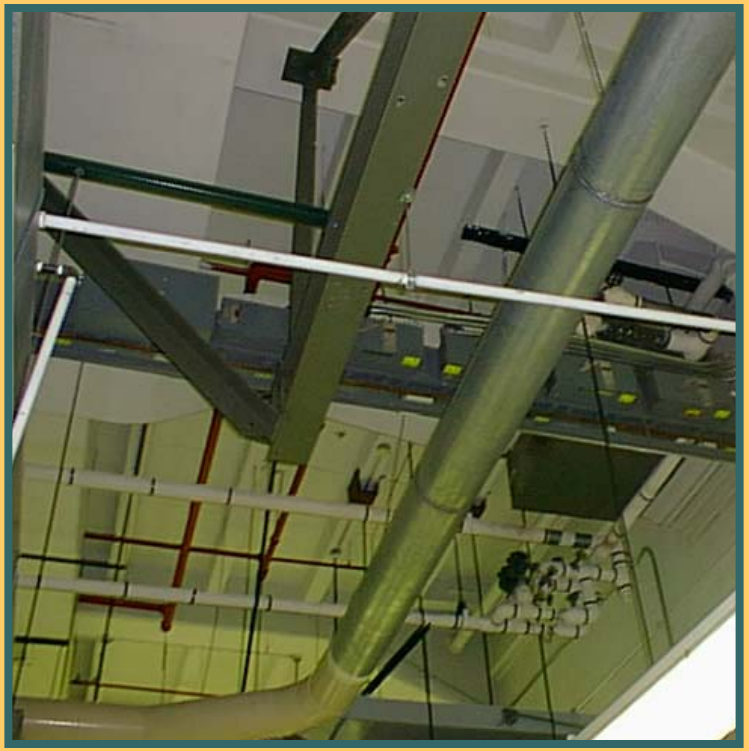


Photo from SKC Inc.

What you get.



Old machine shop.

Sampling Strategy Selection Factors

Situations:

- Small areas.
- Minimal quantities of beryllium.
- High level of control.
- Knowledgeable workers.

Approach:

- Selective Sampling
- Professional Judgment
- Common Sense
- Graded Approach

Suitability of Limits

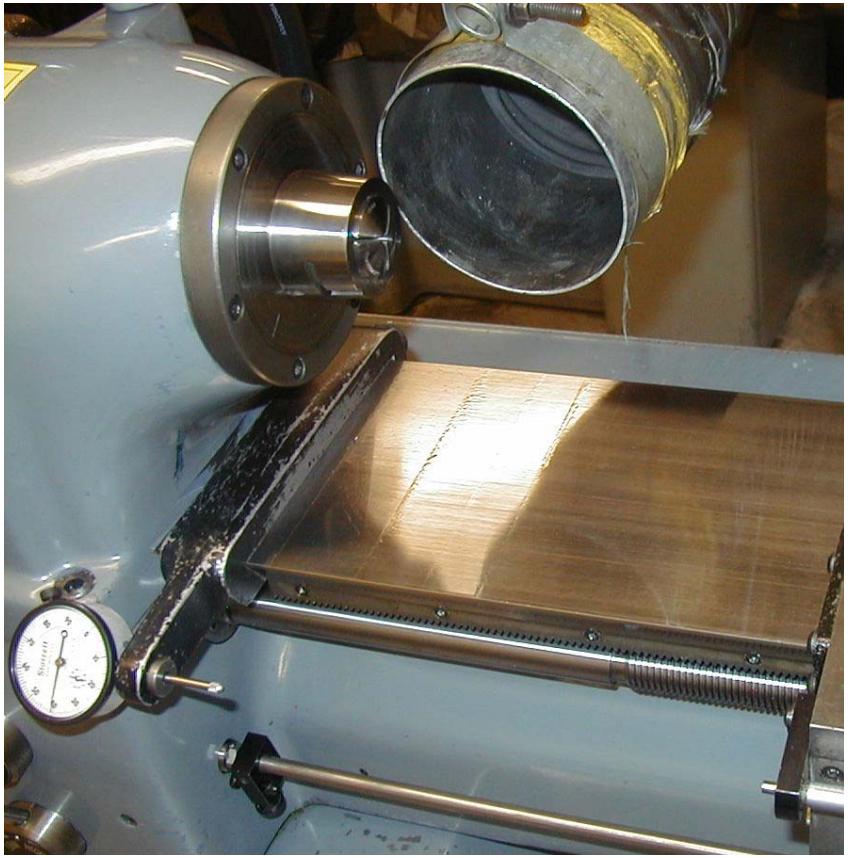
- Surface contamination limits established by the rule may not be appropriate for all situations.

- Three hypothetical surface sampling examples:
  - Beryllium machine shop.
  - Building utility area.
  - Engineer’s office space.

Example 1: Lathe in Beryllium Shop

- Easily accessible and within normal reach of worker.
- Surface contamination on ways ranges from 10 to 30 ug/100 cm^2.

- **Rule interpretation:**
  - **UNACCEPTABLE**
- **IH interpretation:**
  - **ACCEPTABLE**



Example 2: Facility Structures

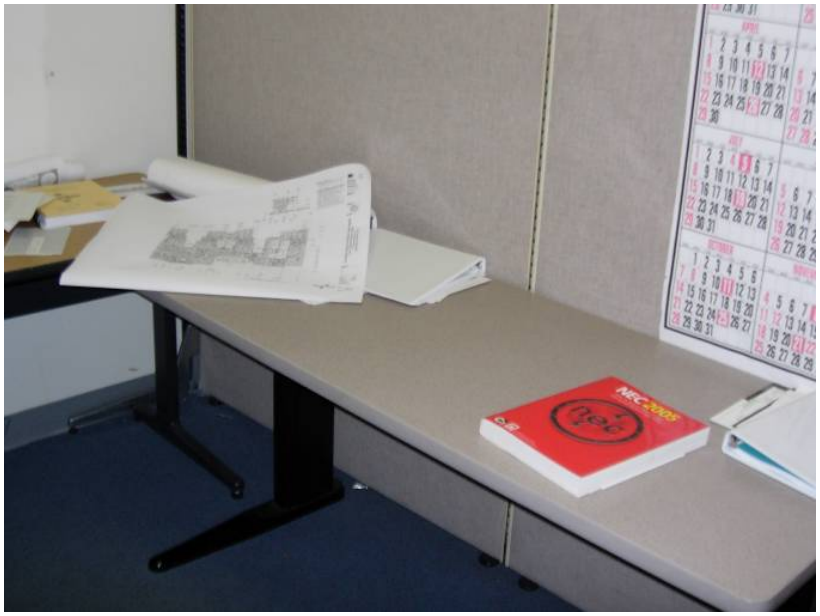
- Accessible and within reach, but area not occupied and surfaces not normally contacted.
- Surface contamination ranges from 0.1 to 0.3 ug/100 cm^2.

- **Rule interpretation:**
  - **UNACCEPTABLE**
- **IH interpretation:**
  - **ACCEPTABLE, but only within restraints.**

Example 3: Engineer's Desk

- Easily accessible and within normal reach of worker; surfaces normally contacted.
- Surface contamination ranges from 0.03 to 0.10 ug/100 cm^2.

- **Rule interpretation:**
  - **ACCEPTABLE**
- **IH interpretation:**
  - **UNACCEPTABLE**



Range of Surface Sampling Situations

- Areas:
  - 80 sq. ft. research laboratory.
  - 350,000 sq. ft. multi-use building.
- Quantities:
  - Several micrograms of beryllium in a hood.
  - 150 kilograms of beryllium chips and dust removed from old ventilation system.

Author's Opinions and Recommendations

- There are many acceptable standard surface sampling methods available.
- Key point is consistent and proper use of an approved method that is appropriate to the situation.
- A qualified and experienced industrial hygienist should select sampling methods and develop strategy.
- For work within a DOE facility operating under an approved CBDPP, a graded approach using contamination guidelines appropriate for the operations and situations is more suitable than fixed surface contamination regulations.

Author's Opinions and Recommendations

- For release of equipment, facilities, and property to the general public or for non-beryllium use, the 0.2 ug/100 cm^2 regulatory limit may be the best approach. Samples must be collected, analyzed, and results interpreted using approved standard methods (*i.e.* DOE Technical Standard).
- The DOE must consider surface sampling issues when revising the beryllium rule and creating guidance and technical standards.
- Appropriate and consistent use of voluntary consensus standards for surface sampling is strongly recommended.

Speed
Limit
55

Remember:

Guiding
Performance
versus
Assessing
Compliance?

Primer on Air Sampling

- Source control
- Source migration
- Compliance (ARGHH!!!)
- Transfer mechanisms

$$I(D_a) = 0.5[1 + \exp(-0.06D_a)$$

What we seek to accomplish and issues:

- Relationship of what you are collecting to a health end point:
  - Sensitization
  - Chronic Beryllium Disease
- Relationship of analytical recovery to what was collected:
  - Wall losses/static charges/particle bounce

More Issues

- Ability of conventional sampling and analysis to see targets:
  - Mass
  - Particle size
  - Analytical Detection Limits

Interrelatedness

- Flow
- Time
- Mass Collected
- Particle Size Collected

Sampling Pump – What Flow Rates Are Needed?

Flow rate required (liter/min) to collect a measurable sample at 0.2 ug/m^3 airborne beryllium.

Sampling Time, minutes.	Limit of Quantitation, ug/sample. 0.005	0.01	0.03	0.05
15	1.7	3.3	10	17
60	0.4	0.8	2.5	4.2
240	0.1	0.2	0.6	1.0
480	0.05	0.1	0.3	0.5

Sampling Pump – What Flow Rates Are Needed?

Flow rate required (liter/min) to collect a measurable sample at 0.004 ug/m^3 airborne beryllium.

Sampling Time, minutes.	Limit of Quantitation, ug/sample. 0.005	0.01	0.03	0.05
15	83	167	500	833
60	21	42	125	198
240	5.2	10	31	50
480	2.6	5.2	16	25

Sampling Pump – How to Get Needed Flow?

- New Product:
  - SKC Leland Legacy® pump.
  - Measured Flows
    - 7.5 liter/min with one 0.8 um 37 mm filter.
    - 10 liter/min with two 0.8 um 37 mm filter.
  - Concerns:
    - physical size (8” high, 37 oz).
    - back-pressure limits (20” wg at 7.5 liter/min).
    - noise (without case, 78 dBA at ear).
    - vibration (without case).
- Other pumps available?

Sampling Pump – How to Get Needed Flow?

- Using Your Current Equipment:
  - Area sampling pump tethered to worker.
    - Only practical if work is performed in a small area.
    - Safety must be considered.
    - Worker may be willing to carry battery powered pump between locations.
  - Two standard sampling pumps connected in parallel.
    - Each pump set to 4 liter/min.
    - Connected to single 37 mm filter via a “Y” joint.
    - One pump “tuned” to stabilize flow.
    - Obtained flow of 7.4 liter/min. Stable over 1 hr; 1% drop.
    - Potential pump damage? Maximum sampling time?

Sampling Pump – Research & Development Needs

- Desired Features:
  - Flow Rate: 10 to 15 liter/min with 0.8 um, 37 to 47 mm filter.
  - Back Pressure: 25 inches water at 15 liter/min.
  - Operating Time: Up to 10 hours.
  - Weight: Less than 32 ounces.
  - Size: 5” x 4” x 2” maximum.
  - Noise Levels: Less than 70 dBA.
  - Cost: less than $1000.
  - Keep it simple, fast, and easy!

What we know

- *conductive cassette was introduced*. Peck et al (AIHAJ 46:14-16, 1985) showed high wall losses in polystyrene cassettes for asbestos
- *deposition on the conductive cassette studied* Seixas et al (AIHAJ 48:A242-A243, 1987) compared the two cassettes and found plenty of deposition on conductive cassette!

Opportunity

- No study has compared conductive and non-conductive 37 mm cassettes for metals aerosols (Harper to Hook email, 11-6-08)
- Proposal forwarded to UNC for funding such a demonstration project
- BHSC SAS committee position paper identifies others

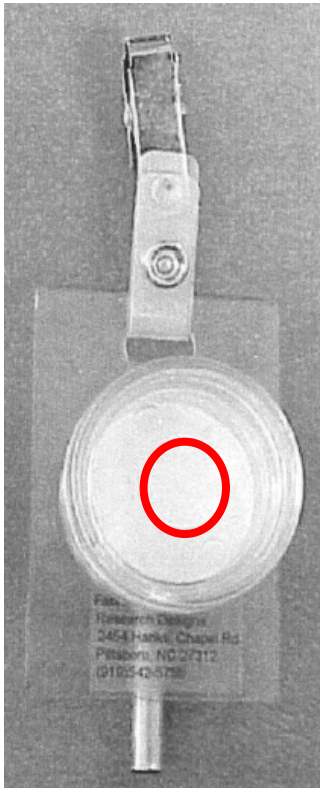
Sampler – What Is Available Now?

Inhalable Samplers:

Button
4 liter/min

RespiCon
3.1 liter/min

SKC Mod 37



Analytical Issues

- Reporting Limits
- Protocols

Reporting Limits

- 2 LPM X 15 minutes = 30 L or $0.03m^3$
- 0.2 micrograms/m^3 X $0.03m^3$ = 0.006 µg
- RL should be $1/10^{th}$ or 0.6 nanograms.

Will require ICPMS or fluorescence method

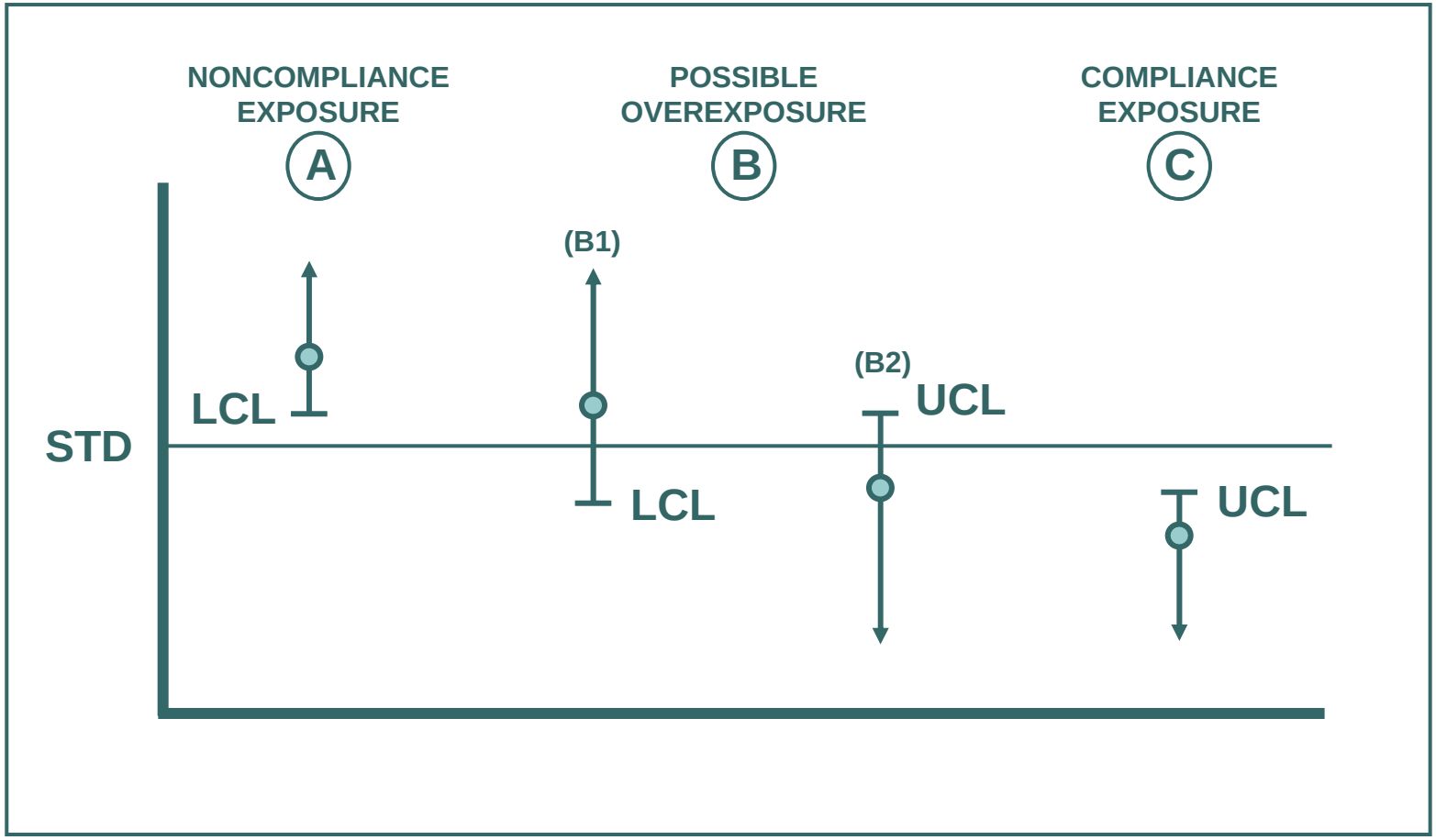
Detection Limits

- Instrument detection limit
  - Significantly different from lab blanks
- Quantitation limit
  - Achieves specified precision (i.e. ± 10%)
- Laboratory reporting limit
  - Accounts for day-to-day variation in media, interferences and instrument performance

Protocols & Wiping Walls

- NIOSH inference in NMAM
- OSHA SLC in four methods
- IOM protocol demands it
- DOE sites?
- Limited studies (see Clinkbeard et al, AOEH Journal, 17 (9) 622-627, 2002)

Figure 4.2. Classification according to one-sided confidence limits



Distance from OEL adds Confidence

- The greater the distance from a measured 8-hour TWAs to the OEL the fewer samples needed to prove compliance
- 95-95 UTL = Exp[ln(GM)+ K x ln(GSD)]
- K is a function of the number of samples - n

Ratio GM/OEL	GSD	K	n
0.01	3	4.19	6
0.1	3	2.10	45
0.2	3	1.46	∞

Laboratory Reporting Limit (RL) Near OEL

- With RL 1/10th the OEL most results from a non-compliant workplace are detectable
- With RL 2/5ths the OEL a high percentage of non-detectable results from a non-compliant workplace is possible.

OEL	% Exceeding OEL	GSD	RL	% Detected
0.2	5%	3	0.02	66%
0.05	5%	3	0.02	20%

Laboratory Reporting Limits

- Instrument detection limits and quantitation limits are established prior to analysis of field samples from relatively small number of blanks and spikes
- Can be improved over time if the lab QA program understands that this is an important goal
- IH and lab director should discuss data quality objectives to avoid unnecessarily high reporting limits

Guidance

- Define a system approach in writing
- Train people on it’s utility
- Seek peer review on process output before ever sampling
- Stick to the plan
- **DOCUMENT DOCUMENT DOCUMENT**
- Do the Right Thing