Beryllium, Industrial Hygiene Sampling Issues

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Disclaimer

- The views expressed in this presentation are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U.S. Government

Standard Industrial Hygiene Practice

- Maintain exposures below the occupational exposure limit
- However, it appears –
  - Rates of sensitization and CBD could be related to work areas where particle sizes are small
  - Total mass measurement of beryllium in air is a poor marker of biological risk of chronic beryllium disease

Review Relevant Toxicological Characteristics

- CBD mainly occurs in alveolar region
- CBD is an immuniological-based disease
- Macrophage/particle interactions
- Toxicity based on solubility of the Be

Beryllium Particle Issues

- Relationship between ultra-fine (0.01 – 0.05 μm) particles and high risk of CBD
  - Deposited Submicrometer Particulate
- Particle morphology
  - Particles entering alveolar space
  - Smaller particles have greater surface area per unit mass
  - Total mass exposure made up from large and/or small particles

Beryllium Particle Issues (Cont.)

- Normal pulmonary clearance of inhaled particles
- For equal mass – dramatic increase in number of small particles:

Beryllium Particle Issues (Cont.)

- Particle number for a given mass (Illustrative)

Aerodynamic Diameter (um)	Number of Particles
100	1
10	1,000
1	1,000,000
0.1	1,000,000,000

Workplace Evaluations and Risk Assessment

- Putting together what is suspected so far:
  - Sensitization and CBD related to particle size and relative to surface area
  - Sensitization and CBD related to chemical form

Workplace Evaluations and Risk Assessment (Cont.)

- Is measuring total beryllium mass concentration obscuring the exposure-response relationship?
- Evaluating the relationship of particle size and CBD
  - Are we currently using an exposure standard with the wrong metric?

Workplace Evaluations and Risk Assessment (Cont.)

- **Current Occupational Exposure Limits**
  - **OSHA (29 CFR 1910.1000 Table Z-2)**
    - **2 ug/m3 8-Hour TWA**
    - **5 ug/m3 Ceiling**
    - **25 ug/m3 Acceptable Maximum Peak (30 Min)**
  - **NIOSH**
    - **0.5 ug/m3 any time**
  - **ACGIH**
    - **0.05 ug/m3 TWA Inhalable**
  - **DoE (10 CFR 850)**
    - **2 ug/m3 8-Hour TWA with an Action Level of 0.2 ug/m3**

Airborne Assessment

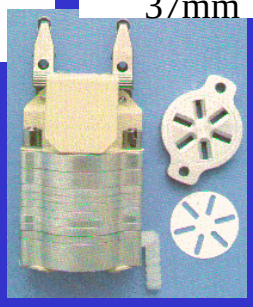
- Current airborne assessment technique
  - 37 mm cassette – 0.8 um MCEF
- Other available assessment techniques
  - IOM Sampler – Inhalable mass
  - Cyclone – Respirable mass
  - Anderson (Marple)
  - MOUDI – Micro orifice uniform deposit impactor

Airborne Assessment Techniques

IOM

Cyclone

37mm

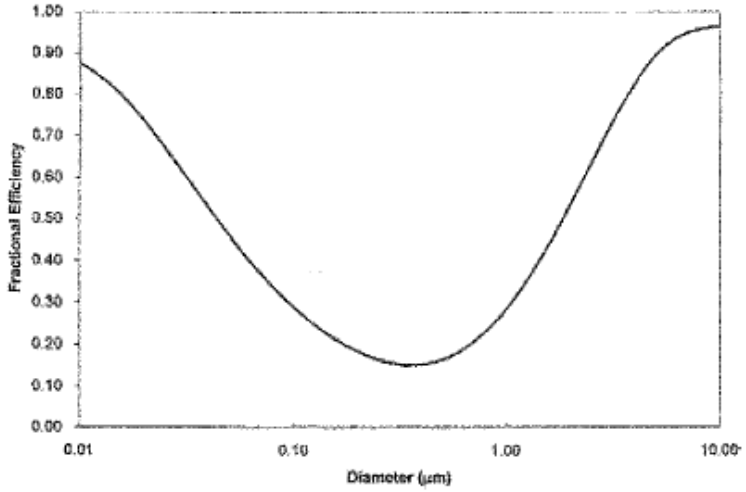


Marple

MOUDI

Airborne Assessment Issues

- Fraction of Deposited Particulate



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Airborne Assessment Issues

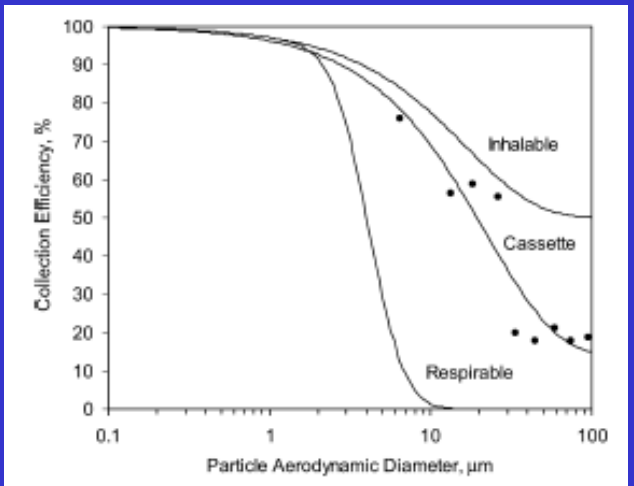

FIGURE 4. Collection efficiency curve of the closed-face cassette relative to the collection efficiency values measured by Mark et al.[5] and the ACGIH respirable and inhalable curves[3]

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Airborne Assessment Issues

- **Should exposure be based on # particles deposited (particle number concentration) as it relates to risk?**
- **#Deposited Be Particles = (#Deposited Particles) (% Be)**

Ultrafine Particles

Contributing Factors for Concern

- Long residence time in air
- High deposition efficiency in gas exchange region of lung
- Greater particle number per mass causing higher specific surface area

What OEL to Use?

- Define a safe air concentration limit? "Not likely" (K. Kreiss, 2007)
  - Need to know physicochemical characteristics of the aerosols
  - Characterized by:
    - Chemistry
    - Size
    - Surface area
    - Solubility in body fluid compartments

Conventional Aerosol Sampling & Analysis Issues

- Should air sampling for aerosols include the entire aspiration of particles no matter where they reside in the sampler?
- Can the use of the standard 37 mm closed face cassette (CFC) be used as a surrogate for sampling devices designed to match the "inhalable" sampling efficiency curve?

Conventional Aerosol Sampling & Analysis Issues Recommendations

- Include the additional step to rinse and wipe the interior surfaces of the cassette for the analysis of aerosol samples for metals (wall loss)
- Understand the issues/risks ****

Other Workplace Assessment Issues

- Surface Contamination
  - Regulated areas
  - Is there a correlation surface contamination and airborne exposures?
  - DoE surface contamination limits
    - Housekeeping (3 ug/100 cm2)
    - Release of equipment (0.2 ug/100 cm2)

Other Workplace Assessment Issues (Cont.)

- Skin Exposures (route of entry)
  - Particle penetration (S. Tinkle 2003)
- Soluble salts – hypersensitivity
- Being sensitized by the skin
  - Lung deposition with an already activated immune system

Other Workplace Assessment Issues (Cont.)

- Surface sampling
  - Wipe sampling
  - Microvacuum
  - Dermal

Questions?