Beryllium Aerosol Exposure Characterization During Chemical Processing of Copper Beryllium Alloys

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BRUSH WELLMAN
ENGINEERED MATERIALS
Introduction

• Copper beryllium (CuBe) alloys (<2% Be) are widely used in electronic, telecommunication and automotive devices to improve:
  – Performance
  – Reliability
  – Miniaturization
• Electronic connectors are formed in the precision stamping industry.
• Beryllium exposure in the precision stamping industry is not well documented.
• A case study was conducted to fill the knowledge gap.
Precision Stamping Case Study

• Baseline study (2000)
  – 4 representative US precision stamping plants

• Follow up studies (2006-2007)
  • In one plant having chemical cleaning and plating operations
1. What processes and work tasks contribute to exposure?
2. What is the nature of work practices and engineering controls used to control airborne particulate?
3. What are the airborne Be exposure levels of workers in the CuBe precision stamping industry?
4. How do these exposure levels compare to the:
   - OSHA PEL
   - California OSHA PEL
Methods

- **Qualitative Assessment** - visual observation of operator tasks
- **Engineering Control Analysis** - ventilation velocities & flow rates measured using a Alnor Air Data Meter.
- **Quantitative Assessment** -
  - OSHA Technical Manual
  - National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods (Method 7300)
  - AIHA accredited laboratory used for air analysis.
- **Data Interpretation** - in accordance with the principles described in: American Industrial Hygiene Association’s text “A Strategy for Assessing and Managing Occupational Exposures”, 3rd Ed.
Plant 4
Similar Exposure Groups

Chemical Processing
- Pickling/Cleaning (open tank)
- Photoetching
- Plating (open tank)
- Racking
- Plating (selective)
- Deburring
- Wastewater Treatment
Baseline Study
Plant 4

Baseline 2000 - Personal Breathing Zone Sampling Results

Controlled, Uncertain, Uncontrolled comparison to Cal OSHA PEL of 0.2 ug/m³
Stamping Industry Case Study

– Observations from baseline study:
  • Local Exhaust Ventilation at:
    – Pickling/Cleaning Tanks
    – Plating Tanks
    – Photoetching
  • Compressed air used for cleaning
  • Poor chemical hygiene & containment from open surface tank operations
– Significant work practice and hygiene improvements were made.
– Leads us to Follow-Up studies (2006 & 2007)
Follow Up Study
Plant 4
(Post Work Practice & Housekeeping Improvements)

Follow Up 2006 - Personal Breathing Zone Sampling Results

Controlled, Uncertain, Uncontrolled comparison to Cal OSHA PEL of 0.2 ug/m³
10

2006 Follow-Up Study Observations

• Existing LEV, improved work practices and housekeeping are not sufficient in controlling exposure below the Cal OSHA PEL of 0.2 ug/m³:
  – Pickling/Cleaning Operations
  – Photoetching Operations
  – Plating (Selective) - uncontrolled buffing operation
  – Deburring co-location to Plating (Selective)

• Therefore:
  – LEV analysis and follow-up study (2007)
Pickling/Cleaning 2006

Crystallizer

Shut down automated picking/cleaning Line

Open tank pickling/cleaning line

Caustic Salts
Pickling/Cleaning 2006
Pickling/Cleaning 2007
Pickling/Cleaning LEV

• Removing automated pickling line increases flow rate by 68% (5300 cfm to 8900 cfm) to the open tank pickling line.

• Improved Ductwork & Hood Enclosures (ACGIH Ventilation Manual for Open Surface Tanks)

• Hood Ventilation Measurements:
  – Flow rates : 90 to 200 cfm/ft²
  – Average face velocities : 140 to 190 fpm

• Add exhaust to Crystallizer (20 cfm)
Plating (Selective) - Buffing 2006
Plating (Selective) - Buffing 2006
Plating (Selective) - Buffing

- System maintenance and filter change increases flow rate by 30% from 633 cfm to 830 cfm.
- Improved ductwork and hood designs
  - Increases capture velocity and efficiency
  (ACGIH Ventilation Manual for Buffing and Polishing)
**Photoetching**

**Old Hood**
- Flow: 140 cfm
- Face Vel Range: 140 – 274 fpm
- Avg: 190

**New Hood**
- Flow: 140 cfm
- Face Vel Range: 214 – 282 fpm
- Avg: 241 fpm
Follow Up Study
Plant 4

Follow Up 2007 - Personal Breathing Zone Sampling Results

- Controlled
- Uncontrolled

Post LEV improvements in Pickling/Cleaning, Photoetching, & Plating (Selective)
New observations in Deburring

Cal OSHA PEL of 0.2 ug/m³

Controlled, Uncertain, Uncontrolled comparison to Cal OSHA PEL of 0.2 ug/m³
## Industrial Hygiene Statistics

### Data Description: Deburring

<table>
<thead>
<tr>
<th>OEL</th>
<th>0.2</th>
</tr>
</thead>
</table>

### Sample Data (max n = 50)

<table>
<thead>
<tr>
<th>No less-than (&lt;) or greater-than (&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.084</td>
</tr>
</tbody>
</table>

### Descriptive Statistics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of samples (n)</td>
<td>7</td>
</tr>
<tr>
<td>Maximum (max)</td>
<td>0.084</td>
</tr>
<tr>
<td>Minimum (min)</td>
<td>0.02</td>
</tr>
<tr>
<td>Mean</td>
<td>0.041</td>
</tr>
<tr>
<td>Geometric standard deviation (GSD)</td>
<td>1.701</td>
</tr>
<tr>
<td>UTL\textsubscript{95%,95%}</td>
<td>0.217</td>
</tr>
<tr>
<td>UCL\textsubscript{1,95%} % &gt; OEL</td>
<td>5.940</td>
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</tbody>
</table>
Deburring

**Industrial Hygiene Statistics**

**Data Description:** Deburring

<table>
<thead>
<tr>
<th>OEL</th>
<th>0.2</th>
</tr>
</thead>
</table>

| Sample Data (max n = 50) | 0.084 | 0.023 | 0.032 | 0.034 | 0.020 | 0.027 | 0.064 | 0.410 | 0.290 | 0.100 |

**DESCRIPTIVE STATISTICS**

- Number of samples (n): 10
- Maximum (max): 0.41
- Minimum (min): 0.02
- Mean: 0.10840
- Geometric standard deviation (GSD): 2.873
- **UTL_{95\%, 95\%}**: 1.34211
- **UCL_{1, 95\%} %>OEL**: 33.892
Deburring

“Corn-Cob” Polishing

- 6 hr cycle time
- Screening
- Inspection

Requires LEV during cycle time and screening activities.
## Current Statistical Summary

<table>
<thead>
<tr>
<th>Similar Exposure Group</th>
<th>N</th>
<th>Min (ug/m3)</th>
<th>Max (ug/m3)</th>
<th>UTL 95/95 (ug/m3)</th>
<th>PEL % Exceedance (0.2 ug/m3)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickling/Cleaning</td>
<td>14</td>
<td>0.02</td>
<td>0.05</td>
<td>0.10</td>
<td>0.4</td>
<td>Controlled</td>
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<tr>
<td>Photoetching</td>
<td>15</td>
<td>0.01</td>
<td>0.08</td>
<td>0.18</td>
<td>3.9</td>
<td>Controlled</td>
</tr>
<tr>
<td>Plating (Tank)</td>
<td>16</td>
<td>0.01</td>
<td>0.05</td>
<td>0.07</td>
<td>0.2</td>
<td>Controlled</td>
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<tr>
<td>Racking</td>
<td>12</td>
<td>0.04</td>
<td>0.05</td>
<td>0.07</td>
<td>0.2</td>
<td>Controlled</td>
</tr>
<tr>
<td>Plating (Selective)</td>
<td>7</td>
<td>0.02</td>
<td>0.04</td>
<td>0.14</td>
<td>1.7</td>
<td>Controlled</td>
</tr>
<tr>
<td>Wastewater Treatment</td>
<td>17</td>
<td>0.02</td>
<td>0.11</td>
<td>0.13</td>
<td>1.4</td>
<td>Controlled</td>
</tr>
<tr>
<td>Deburring</td>
<td>10</td>
<td>0.02</td>
<td>0.41</td>
<td>1.35</td>
<td>33.9</td>
<td>Uncontrolled</td>
</tr>
</tbody>
</table>

**Controlled** - UTL 95/95 is less than 0.2 ug/m3 and % Exceedance is less than 5.0

**Uncontrolled** - UTL 95/95 is greater than 0.2 ug/m3 and/or % exceedance is greater than 5.0
Conclusions

• Chemical processing of CuBe alloys in the precision stamping industry:
  – can generate airborne beryllium in excess of the Cal OSHA PEL (0.2 ug/m\(^3\))
  – recognized work practice, housekeeping, and engineering controls are capable of reducing exposure to less than 0.2 ug/m\(^3\) with a high degree of confidence.

• “Corn-Cob” polishing requires work practice improvements & LEV and follow-up exposure assessment.
Questions?

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