Exposure Assessment: A How to Guide

- Participant Take-Aways from this Presentation:
  - Understand why qualitative exposure assessments should be used
  - Describe AIHA’s Basic Workplace Characterization
  - Explore Qualitative Assessment Tools
  - Review AIHA’s new Exposure Assessment Checklist Tool
Exposure Assessment: A How to Guide

- How do we traditionally define industrial hygiene exposure assessment?
  - What do we think is done?
Exposure Assessment: A How to Guide

- We often think exposure assessment is primarily quantitative measurement.
  - Air sampling, noise measurements, etc.

- How good are quantitative measurements?
  - Of 1.4 million samples from OSHA nearly 50% are non-detects
  - 20% of the samples above are double the exposure limit\(^1\).

- Are we spending too many resources assessing exposure quantitatively?
Exposure Assessment: A How to Guide

- How much time do you spend with qualitative assessment tools before moving to quantitative methods?
Exposure Assessment: AIHA’s Basic Characterization of Workplace

- First Step in Exposure Assessment: Gather Information
  - Goal: Collect Information on workplace, work force, agents, etc.

- Sources of Information
  - SDSs
  - Workers
  - Walk-around Surveys
  - Engineers
  - Records - drawings, process, medical, employment, maintenance, monitoring
  - Literature search
  - OELs
Exposure Assessment: AIHA’s Basic Characterization of Workplace

- Questions to Ask:
  - What are the hazardous agents? In what quantities?
  - What are the health effects?
  - What are the OELs
  - What are significant sources of exposure and how do workers interact with them?
  - What processes, operations, tasks, and work practices pose significant sources of exposure?
  - What are the process conditions? Temperature? Operating speed? Transfer points?
  - What controls are in place?
Exposure Assessment: A How to Guide

- Learning the process is one of the most important assessment methods

- Process and Agent inputs
- Intermediates Produced
- Final Product
- Waste Produced
- Understand how Equipment Functions
- Understand Cleaning Methods
- Cleaning/Maintenance - Non Routine Tasks
Observations

- Sensory Perception - Eyes, Ears, Smell
- Controls in Place
- Employee Work Practices
- Routes of Potential Exposure
Exposure Assessment: Qualitative Assessment Tools

- Rule of 10s
  - Fraction of saturated Vapor Pressure to calculate approximate exposure
  - Fraction is based on the exposure controls in place

<table>
<thead>
<tr>
<th>Level of Control</th>
<th>Fraction of Saturated Vapor Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confined Space - No Circulation</td>
<td>1/10th of Saturation</td>
</tr>
<tr>
<td>Poor - Limited Circulation</td>
<td>1/100th of Saturation</td>
</tr>
<tr>
<td>Good - General - 6 air changes per hour</td>
<td>1/1000th of Saturation</td>
</tr>
<tr>
<td>Local Exhaust Ventilation Capture</td>
<td>1/10,000th of Saturation</td>
</tr>
<tr>
<td>Containment</td>
<td>1/100,000th of Saturation</td>
</tr>
</tbody>
</table>

Saturation Vapor Concentration (ppm) = \( \frac{\text{VP of Compound (mmHg)}}{760 \times 1,000,000} \)
Exposure Assessment: Qualitative Assessment Tools

- Rule of Ten Example
  - Methyl Ethyl Ketone (MEK) has a Vapor Pressure of 89.7 mmHg (at 25 °C)
  
  - Saturation Vapor Concentration (in ppm) = $\frac{89.7}{760} \times 1,000,000 = 118,000$ ppm

- What is the estimated concentration in air under “Good” control conditions?

- What is the concentration in air using local exhaust capture?
Exposure Assessment: Qualitative Assessment Tools

- Vapor Pressure Index or Vapor Hazard Ratio (VHR)

- $VHR = \frac{VP_{agent}}{OEL_{agent}}$

- This can be used for prioritization of quantitative measurements

- It is also a useful tool when comparing a possible substitution of one material in the process for another and not relying on OELs alone.
### Exposure Assessment: Qualitative Assessment Tools

- **Vapor Hazard Ratio Link to Ventilation**

<table>
<thead>
<tr>
<th>Vapor Hazard Ratio Scale</th>
<th>Vapor Hazard Ratio</th>
<th>Required Level of Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt; 0.05</td>
<td>General Ventilation 3 to 6 air changes/hour</td>
</tr>
<tr>
<td>2</td>
<td>0.05 to &lt; 1</td>
<td>Good General Ventilation (GGV) 6 to 12 air changes / hour</td>
</tr>
<tr>
<td>3</td>
<td>1 to &lt; 25</td>
<td>GGV with capture at emission sources</td>
</tr>
<tr>
<td>4</td>
<td>25 to &lt; 500</td>
<td>Capture at Emission Sources and Containment where practical</td>
</tr>
<tr>
<td>5</td>
<td>500 to &lt; 3000</td>
<td>Containment</td>
</tr>
<tr>
<td>6</td>
<td>≥ 3000</td>
<td>Primary and Secondary Containment</td>
</tr>
</tbody>
</table>
Exposure Assessment: Qualitative Assessment Tools

- Vapor Hazard Ratio Example

  - Benzene - VP = 95.2 mmHg and OEL of 0.5 ppm
    - Vapor Hazard Ratio Benzene = 190.4

  - MEK - VP = 86.7 mmHg and OEL of 200 PPM
    - Vapor Hazard Ratio of 0.42

  - Toulene - VP = 28.4 mmHg and OEL of 20 PPM
    - Vapor Hazard Ratio of 1.42

- What are the Ventilation Requirements for each substance
Exposure Assessment: Qualitative Assessment Tools

- Particulate Hazard Ratio
- Control Bands Based on OEL of Substance

<table>
<thead>
<tr>
<th>Particulate Hazard Ratio</th>
<th>Agent’s OEL (mg/m³)</th>
<th>Required Level of Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt;5</td>
<td>General Ventilation 2 to 4 air changes/hour</td>
</tr>
<tr>
<td>2</td>
<td>≤5 to 1</td>
<td>Good General Ventilation (GGV) 4 to 6 air changes/hour</td>
</tr>
<tr>
<td>3</td>
<td>≤1 to 0.1</td>
<td>Good General Ventilation (GGV) 6 to 8 air changes/hour</td>
</tr>
<tr>
<td>4</td>
<td>≤0.1 to 0.01</td>
<td>Capture at Emission Sources and Containment where practical</td>
</tr>
<tr>
<td>5</td>
<td>≤0.01 to 0.001</td>
<td>Containment</td>
</tr>
<tr>
<td>6</td>
<td>≤0.001</td>
<td>Primary and Secondary Containment</td>
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Exposure Assessment: Qualitative Assessment Tools

- Particulate Hazard Ratio
  - Dustiness of a particulate
    - Function of:
      - Size
      - Shape
      - Electrostatic charge
      - Moisture content
      - Density
  - Rule of Thumb for very fine dust droplet size, engineering controls should be increased by one level
Exposure Assessment: Qualitative Assessment Tools

- Vapor Pressure and Temperature
  - Vapor Pressure is a function of the temperature
    - Most VPs for a substance are at 25° C
  - Antoine’s Law
    - Can calculate a vapor pressure for a substance at different temperatures if certain constants are known

- Mixtures
  - Raoult’s Law
    - Calculate a mixture as the vapor pressures are proportional to the amount of each substance - assumes ideal gas behavior.
Exposure Assessment: Exposure Assessment Checklist Tool

- Uses the tools discussed above and puts them in a tool to easily estimate the AIHA Exposure Control Ratings based on the 95th percentile exposure.

<table>
<thead>
<tr>
<th>Exposure Control Ratings *</th>
<th>Cutoff (%OEL)</th>
<th>Confidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>( X_{0.95} \leq 1% )</td>
<td>High</td>
</tr>
<tr>
<td>1</td>
<td>( 1% &lt; X_{0.95} \leq 10% )</td>
<td>Medium</td>
</tr>
<tr>
<td>2</td>
<td>( 10% &lt; X_{0.95} \leq 50% )</td>
<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>( 50% &lt; X_{0.95} \leq 100% )</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>( X_{0.95} &gt; 100% )</td>
<td></td>
</tr>
</tbody>
</table>
Exposure Assessment: Exposure Assessment Checklist Tool

- The AIHA Checklist Tool
  - [https://www.aiha.org/get-involved/VolunteerGroups/Pages/Exposure-Assessment-Strategies-Committee.aspx](https://www.aiha.org/get-involved/VolunteerGroups/Pages/Exposure-Assessment-Strategies-Committee.aspx)

- Demonstration
Exposure Assessment: A How to Guide

- Limitations
  - Best for pure volatiles or semi volatile compounds
  - Doesn’t take into consideration dermal exposure route
  - Dustiness issue

- Benefits
  - Can weed out the Non Detects and Obvious Overexposures before taking quantitative.
Exposure Assessments: A How to Guide
Questions?

Exposure Assessments: A How to Guide
Bibliography

