Exposure Assessments: A How to Guide

Dave Huizen, CIH

Grand Valley State University

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

Exposure Assessment: A How to Guide

- 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

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

Saturation Vapor Concentration(ppm) = VP of Compound(mmHg)/760 X 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) = 89.7/760 X 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 cpature?

Exposure Assessment: Qualitative Assessment Tools

- Vapor Pressure Index or Vapor Hazard Ratio (VHR)
- $VHR = VP_{agent} / OEL_{agent}$
- 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

Vapor Hazard Ratio Scale	Vapor Hazard Ratio	Required Level of Control
1	< 0.05	General Ventilation 3 to 6 air changes/hour
2	0.05 to < 1	Good General Ventilation (GGV) 6 to 12 air changes / hour
3	1 to < 25	GGV with capture at emission sources
4	25 to < 500	Capture at Emission Sources and Containment where practical
5	500 to < 3000	Containment
6	≥ 3000	Primary and Secondary Containment

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

Particulate Hazard Ratio	Agent's OEL (mg/m^3)	Required Level of Control
1	>5	General Ventilation 2 to4air changes/hour
2	≤5 to 1	Good General Ventilation (GGV) 4 to 6 air changes/hour
3	≤1 to 0.1	Good General Ventilation (GGV) 6 to 8 air changes/hour
4	≤0.1 to 0.01	Capture at Emission Sources and Containment where practical
5	≤0.01 to 0.001	Containment
6	≤ 0.001	Primary and Secondary Containment

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 the temperature
    - Most VPs for a substance are at 25° C
  - Antoine's Law
    - Can calculate a vapor pressure for a substance at different 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

Exposure Control Ratings *		Cutoff (%OEL)	Confidence level
	0	$X_{0.95} \leq 1\%$	High
	1	$1\% < X_{0.95} \leq 10\%$	Medium
	2	$10\% < X_{0.95} \leq 50\%$	Low
	3	$50\% < X_{0.95} \leq 100\%$	
	4	$X_{0.95} > 100\%$	

Exposure Assessment: Exposure Assessment Checklist Tool

- The AIHA Checklist Tool
  - 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

- 1. Jahn SD, Bullock WH, Ignacio JS, eds. *A Strategy for Assessing and Managing Occupational Exposures*. Fourth edition. Falls Church, VA: AIHA; 2015.
- 2. Lavoue J, Friesen MC, Burstyn I. Workplace measurements by the U.S. Occupational Safety and Health Administration since 1979: Descriptive analysis and potential uses for exposure assessment. *Ann Occup Hyg*. 2013;57(5):681. doi:10.1093/annhyg/met027
- 3. Arnold. S. An Error In Judgment: Improving Exposure Assessment. *Essentials Of Exposure Assessment.* Falls Church VA: AIHA; 2016.