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Ohio Safety Congress & Expo

#333 OSHA case studies related to industrial hygiene

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Thursday, March 31, 2011
11 a.m. to Noon

2011 Ohio Safety Congress & Expo

OSHA Industrial Hygiene Case Studies

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Objectives and Format

- Objective: Present lessons learned and corrective actions used to mitigate hazards through the hazard identification and evaluation process
- Format:
  - Hazard Identification
  - Hazard Evaluation
  - Hazard Control
  - Lessons Learned

Selected Enforcement Cases

1. Crystalline silica exposure during a chipping operation at a grey iron foundry
2. Carbon monoxide exposure during consumer product packaging operations
3. Organic solvent exposure during spray finishing operation

Case Study 1:

Crystalline Silica Exposure
Grey Iron Foundry

Hazard Identification: The Contaminant

- Crystalline silica (SiO_2) is a major component of the earth's crust
- Colorless, odorless, non-combustible solid
- Exposure occurs through a wide array of industrial processes:
  - Mining
  - Quarrying
  - Stone cutting
  - Foundries
  - Ceramic mfg
  - Refractory

Hazard Identification: Process Description

- A pneumatic tool was used for rough removal of the mold sand from the product during finishing
- Finishing operations (chipping, grinding, shake-out, etc.) of foundry products can generate sand into the air
- Crystalline silica is commonly found in foundry sands used in the mold-making process

Hazard Identification: Health Effects

- Crystalline silica is a known human carcinogen (IARC Class 1)
- Pulmonary conditions of silicosis (fibrosis) and lung cancer can result
- Pulmonary function loss
- Decreased oxygen saturation
- Potential increased susceptibility for tuberculosis
- Acute effects – rapid decrease in pulmonary function, widespread fibrosis, often resulting in death in less than one year of diagnosis

Hazard Evaluation: Methodology

- Personal air sampling was conducted
- Medium-flow sampling pump
  - Calibrated to 1.7 liters/minute
  - 10 mm nylon Dorr-Oliver cyclone
  - Pre-weighed low ash polyvinyl chloride filter
- Sampling and Analysis Method – OSHA ID-142
- No interferences were noted in the work environment

Hazard Evaluation: Occupational Exposure Limits

- OSHA - Permissible Exposure Limit (PEL)

$$\frac{10mg/m^3}{\%SiO_2 + 2}$$

- ACGIH – Threshold Limit Value (TLV)
  0.025 mg/m^3
- NIOSH – Recommended Exposure Limit (REL)
  0.05 mg/m^3

Hazard Evaluation: Existing Controls

- A non-toxic anti-freeze was used intermittently as a wetting agent
- Personal Protective Equipment:
  - ½ mask, tight-fitting respirator with P100 cartridge

Hazard Evaluation: Sampling Results

- Bulk sample of the sand yielded 29 – 34% silica content by weight (weighted average was 31.65%)
- 8-hr time weighted average (TWA)- 1.034 mg/m^3
- OSHA PEL - 0.297 mg/m^3
- Severity - 3.481
- Sampling and Analytical Error (SAE) - 0.193

Employee exposure was at 348% of the applicable PEL!

Hazard Evaluation: Regulatory Violations

- 29 CFR 1910.1000(c)
  - Over-exposure to crystalline silica
- 29 CFR 1910.1000(e)
  - Failing to implement control for exposure to crystalline silica

Hazard Control: Abatement

- Initially a new wetting agent was introduced to reduce dust generation, by offering better bonding than the anti-freeze
- Air sampling results following the implementation of this control were as follows:
  - 8-hr TWA – 0.581 mg/m^3
  - PEL – 0.683 mg/m^3
  - Severity – 0.851

Exposure reduced down to 85% of the applicable PEL

Hazard Control: Engineering Controls

- Decision to take additional steps
- Local exhaust ventilation system designed and implemented
- Additional personal air sampling results were as follows:
  - 8-hr TWA – 0.16 mg/m^3
  - OSHA PEL – 0.50 mg/m^3
  - Severity – 0.32

Exposure was further reduced down to 32% of the applicable PEL

Lessons Learned

- Local exhaust ventilation (LEV) was the best method for reducing employee exposure
- The LEV unit was fit for the task at hand
  - Able to be molded to various size rolls
  - Able to be easily moved by the chipper operator
  - Adequately designed exhaust for the task

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Case Study 2:

Carbon Monoxide Exposure
Consumer Packaging Site

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Hazard Identification: The Contaminant

- Carbon monoxide (CO) is a flammable, colorless, and odorless gas
- CO is mainly encountered as a product of incomplete combustion
  - Internal combustion engines
  - Blast furnace operations
  - Space heaters, etc.
- Without proper ventilation, CO can accumulate in enclosed buildings and structures

Hazard Identification: Process Description

- Dozens of employees worked on a production line in a large industrial building
- Operation involved the packaging of consumer products
- Powered industrial trucks (LPG) were used to transport palletized product to warehousing and shipping

Hazard Identification: Health Effects

- CO enters the body through inhalation
- CO binds with hemoglobin in the body, reducing the capacity of blood to carry oxygen to other cells
- Cells are starved of oxygen, resulting in:
  - Headache/dizziness
  - Fatigue
  - Neurological deficits
  - Decreased psychomotor function
  - Ultimately, death

Hazard Identification: Methodology

- The media reported multiple employees being taken to the hospital on third shift, due to apparent CO poisoning
- One employee lost consciousness, and multiple others were light-headed and dizzy
- No direct readings were able to be taken by OSHA
- Blood test results were used to assist in determining the CO TWA exposure for the employees working on the line

Hazard Evaluation: Occupational Exposure Limits

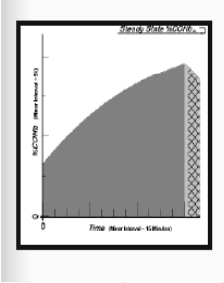
- OSHA - Permissible Exposure Limit (PEL)
  50 parts per million (ppm)
- ACGIH – Threshold Limit Value (TLV)
  25 ppm
- NIOSH – Recommended Exposure Limit (REL)
  35 ppm
  IDLH – 1200 ppm

Hazard Evaluation: Existing Circumstances and Controls

- Interviews indicated that PIV traffic in the area had nearly doubled in the two weeks prior to the incident, due to starting a second production line
- Some PIV maintenance was being conducted
- Basic industrial heating and ventilation units were used
- Overhead doors were kept closed during 3rd shift for security reasons

Hazard Identification: Exposure Determination

- The calculation method uses the Coburn-Forster-Kane (CFK) relationship
- This relationship is expressed as a differential equation that models the uptake of CO into the body during occupational exposure, as well as the elimination of CO from the body following exposure



Hazard Identification: Methodology

- Calculations are made based on many measurements, and uncertainties, found during the investigation:
  - Occupational duration
  - Post-exposure duration
  - Weight of worker
  - Smoking status
  - Elevation of exposure
  - Supporting measurements
  - %COHb in blood
  - Gender
  - Height of worker
  - Activity levels

Hazard Evaluation: Sampling Results

- Three employees were found to have 8-hr TWA exposures to CO in excess of the OSHA PEL:

Employee 1 – 128 ppm, equivalent to 256% of the PEL
Employee 2 – 158 ppm, equivalent to 316% of the PEL
Employee 3 – 143 ppm, equivalent to 285% of the PEL

Hazard Evaluation: Regulatory Violations

- 29 CFR 1910.1000(a)(2)
  – Over-exposure to CO
- 29 CFR 1910.1000(e)
  – Failure to control the CO exposure
- 29 CFR 1910.1200(h)(3)(i)
  – Training on physical hazards of CO
- 29 CFR 1910.1200(h)(3)(ii)
  – Training on health hazards of CO

Hazard Control: Abatement

- Post-exposure evaluation of the PIVs found that multiple forklifts had elevated CO in the exhaust
- Aggressive maintenance plans were initiated for the PIVs to ensure elevated levels of CO would no longer be emitted
- Basic hazard communication training was conducted to ensure recognition of health and physical hazards of CO

Hazard Control: Engineering Controls

- All PIVs in the area underwent a thorough maintenance review and were corrected
  – Emission testing indicated readings between 36,000 – 62,000 ppm on multiple PIVs at idle (normal range at the source ~ 5,000 ppm)
- The company established a quarterly emissions testing schedule for the PIVs
- The HVAC system was inspected and serviced
- Stop the source of generation

Lessons Learned

- Increased PIV activity can increase CO emission
- Failing to maintain PIVs can increase CO emission

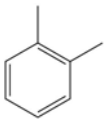
  Preventive and Predictive Maintenance
- Closing doors and other avenues of ventilation can increase CO concentrations
- Failing to provide hazard communication training can allow CO exposure symptoms to go unrecognized

Case Study 3:

Organic Solvent Exposure at a Spray Finishing Operation

Hazard Identification: The Contaminants

- Benzene, Xylene, Ethyl benzene
  - All are colorless, flammable, aromatic hydrocarbon
- The contaminants were contained in spray paint products in use at the facility, which are common in petroleum-based products



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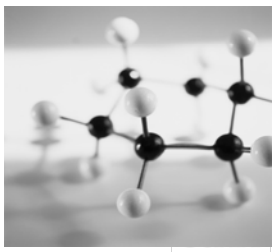
Hazard Identification: Process Description

- Employees performed spray finishing operations in an enclosure
- The spray paint contained organic solvents, including benzene, ethyl benzene and xylene
- Employees used tight-fitting ½ mask respirators with N95/Organic Vapor cartridges

Hazard Identification: Health Effects

- Benzene is a known human carcinogen (IARC Class 1)
  - Leukemia
  - CNS depression
  - Reproductive toxicity
- Ethyl benzene and Xylene
  - CNS depression
  - Nausea, vomiting
  - Renal, hepatic, and hematopoetic effects



Hazard Identification: Methodology

- Full-shift personal air sampling was conducted
- Low-flow pumps were used with charcoal tubes as collection media
- OSHA Analytical Method – OSHA 1005

Hazard Evaluation:
Occupational Exposure Limits - Benzene

- OSHA - Permissible Exposure Limit (PEL)
  - 1 parts per million (ppm)
  - Short Term Exposure Limit (STEL) – 5 ppm
- ACGIH – Threshold Limit Value (TLV)
  - 0.5 ppm
  - STEL – 2.5 ppm
- NIOSH – Recommended Exposure Limit (REL)
  - 0.1 ppm
  - STEL – 1 ppm
  - IDLH – 500 ppm

Hazard Evaluation:
Occupational Exposure Limits – Ethyl Benzene

- OSHA - Permissible Exposure Limit (PEL)
  - 100 parts per million (ppm)
- ACGIH – Threshold Limit Value (TLV)
  - 100 ppm
  - STEL – 125 ppm
- NIOSH – Recommended Exposure Limit (REL)
  - 100 ppm
  - STEL – 125 ppm
  - IDLH – 800 ppm

Hazard Evaluation:
Occupational Exposure Limits - Xylene

- OSHA - Permissible Exposure Limit (PEL)
  - 100 parts per million (ppm)
- ACGIH – Threshold Limit Value (TLV)
  - 100 ppm
  - STEL – 150 ppm
- NIOSH – Recommended Exposure Limit (REL)
  - 100 ppm
  - STEL – 100 ppm
  - IDLH – 900 ppm

Hazard Evaluation:
Existing Controls

- A visqueen enclosure was erected around the spraying area
- Employees were required to wear ½ mask tight-fitting respirators with N95/OV cartridge
- Tyvek suites and nitrile gloves were also required to be worn

Hazard Evaluation: Air Sampling Results

- Benzene
  - Two painters over-exposed:
    - 8-hr TWA - 1.3 ppm
    - 8-hr TWA - 2.9 ppm
- Organic Solvent Mixture (example)
  - Benzene 8-hr TWA – 2.9 ppm
  - Ethyl Benzene 8-hr TWA – 21 ppm
  - Xylene 8-hr TWA – 78 ppm

Hazard Evaluation: Air Sampling Results

- For mixtures with similar toxic effects, use the formula:

$$E_m = \frac{C_1}{L_1} + \frac{C_2}{L_2} + \ldots \frac{C_n}{L_n}$$

Where,

- E_m = Equivalent exposure for the mixture
- C = Concentration of particular contaminant
- L = Exposure limit for that substance

- This yields: $E_m = \frac{2.9}{1} + \frac{21}{100} + \frac{78}{100} = 3.89$

Hazard Evaluation: Air Sampling Results

- E_m = 3.89
- When the E_m exceeds unity, the full-shift mixture exposure limit is considered to be exceeded
- The sampling and analytical error (SAE) is calculated on a weighted average for the mixture, at the 95% confidence limit

Hazard Evaluation: Regulatory Violations

- 29 CFR 1910.1000(d)
  - Over-exposure to mixture of organic solvents
- 29 CFR 1910.1000(e)
  - Lack of engineering/administrative controls
- 29 CFR 1910.1028(c)(1)
  - Over-exposure to benzene
- 29 CFR 1910.134(d)(1)(iii)
  - Failure to conduct exposure assessment
- 29 CFR 1910.1028(e)(2)(i)
  - Failure to monitor for benzene exposure

Hazard Evaluation: Regulatory Violations

- 29 CFR 1910.1028(d)(1)
  - Lack of regulated areas - benzene
- 29 CFR 1910.1028(f)(1)(i)
  - Lack of engineering controls and work practices
- 29 CFR 1910.1028(f)(2)(i)
  - Lack of a compliance program
- 29 CFR 1910.1028(g)(2)(ii)
  - Failing to discard/replace respirator cartridges
- 29 CFR 1910.1028(i)(1)(i)
  - Lack of medical surveillance

Hazard Evaluation: Regulatory Violations

- 29 CFR 1910.1028(j)(3)(i)
  - No communication of benzene hazards
- 29 CFR 1910.1200(h)(3)(ii)
  - No communication of xylene/ethyl benzene hazards
- 29 CFR 1910.134(c)
  - No respirator protection program in place
- 29 CFR 1910.134(e)
  - No medical evaluations for respirator users
- 29 CFR 1910.134(f)(2)
  - No fit-testing for respirator users

Hazard Control: Abatement

- Shortly after the inspection, and following settlement of the case, a fire destroyed the building and the operation was moved to a new location
- Subsequently, the spray finishing operation was ceased

Lessons Learned

- Benzene was found in the air sample, even though it was *not* listed on the MSDS by the chemical manufacturer
- In addition to IH issues, electrical, spray finishing, forklift and other safety issues were also addressed with the company
- We need to stay cognizant of the potential for additive effects of mixtures of similar contaminants
- Management and front-line supervisors need to be trained in basic hazard awareness/recognition of hazards in their workplaces

Questions?

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