N.C. Department of Labor
OSH Division

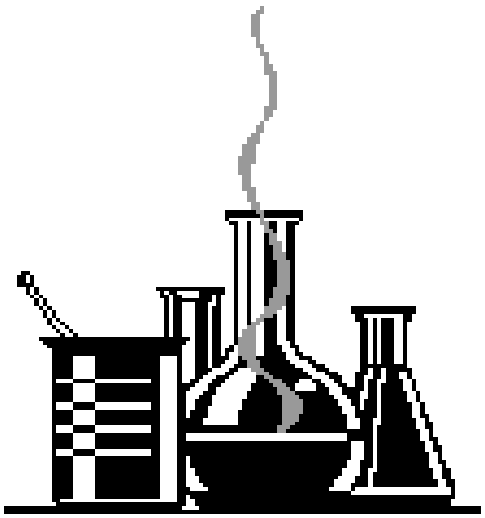
- ***Applied Industrial Toxicology***

Objectives

- Identify hazards associated with specific chemical exposures
- Identify where to find toxicological information
- Discuss Severity and Probability assessments when dealing with chemical exposures

Objectives

- Discuss the HCO's role when NC PEL's differ from Federal OSHA PEL's
- Identify situations where there may be combined effects from chemicals
- Discuss BEI's and their use in compliance



The HCO's Role

Recognize Hazards

Evaluate

Identify OSH Violations

Recommend Controls

Ensure Implementation

Hazard Recognition

- **Toxicity**
  - Capacity of a substance to produce harmful effects.

- **Toxicity + Exposure = Hazard**

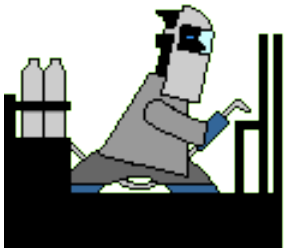
- OSH compliance activity is based on hazard, not toxicity.

Classes of Toxic Substances

- Asphyxiants
- Metals
- Organic solvents
- Pesticides
- Particulates: dusts/fibers
- Other chemicals

Asphyxiants

- **Simple**
  - The presence of a contaminant causes the displacement of oxygen
    - » Methane, carbon dioxide, inert gases
    - » OSHA minimum is 19.5% O_2



- **Chemical**
  - Cause hypoxia through some sort of a chemical reaction
    - » Carbon monoxide, cyanide, hydrogen sulfide

Metals

- Exposures found during welding, grinding, soldering, blasting, etc.
  - Absorption through the lung from exposure to dust and fumes
  - Absorption through GI tract based on solubility, oxidation state
  - Acute effects include metal fume fever
  - Chronic effects include cumulative systemic illness, cancers

Organic Solvents

- Found in a number of operations, including application of paint and adhesives, and chemical formulation.
- Exposure via the lungs (vapors) or the skin (liquid). Dermal exposure may lead to local or systemic effects.
- The greater the vapor pressure (volatility), the higher the vapor concentration in air.

Organic Solvents

- **Acute effects**
  - Include CNS depression, membrane irritation (primary – defatting)
- **Chronic effects**
  - Involve cumulative systemic illnesses (liver, kidney) and cancers.
- Toxicological properties are similar within groups
  - Liver toxicity from chlorinated HC's
  - Irritation from aldehydes
- Dermal absorption may contribute to overall exposure (shown as a **"Skin"** designation)

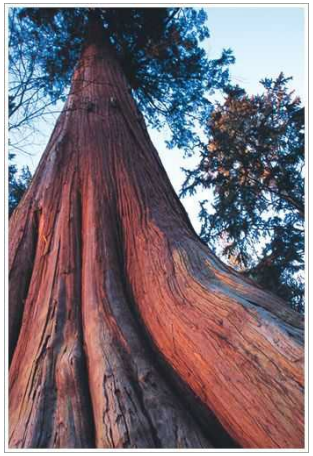
Pesticides

- Seen primarily in agricultural operations
  - Exposure via inhalation, ingestion, and skin

- Classes include:
  - Organophosphate
    - » Inactivation of acetylcholinesterase (AchE) enzyme
  - Carbamate
    - » AChE inactivation
      - Muddles/sludge
  - Organochlorine
    - » Such as DDT
      - CNS Effects

Particulates: Dusts/Fibers

- **Minerals**
  - Silica, asbestos, coal dust
- **Bio-organics**
  - Cotton dust, Western Red Cedar

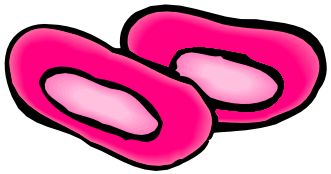


Other Chemicals

- **Acids/alkalies**
  - Low volatility, causes tissue damage
- **Ethylene oxide**
  - High odor threshold
  - Binds to DNA, may cause mutations
  - Toxic to reproductive function
- **Formaldehyde**
  - Causes direct irritation
- **Styrene**
  - High fire and health hazard

Occupational Hematology

- May affect blood cell formation, survival, morphology and function, or coagulation
- Anilines, nitrobenzenes may cause Methemoglobinemia (Fe^{2+} to Fe^{3+})
- Heavy metals may cause hemolytic anemia
- Porphyrias (heme biosynthesis problems) seen with lead, Al, Vinyl Chloride, others
- Carboxyhemoglobin



Red Blood Cell

Occupational Infections

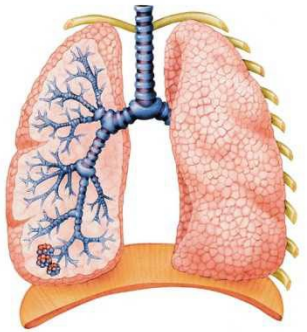
- These involve contact with a biologically active organism (e.g. bacteria, virus)
  - **Tuberculosis** – mycobacterial infection of the lungs
    - » Usually remains subclinical
  - **Brucellosis** – from contact with infected animal tissues
  - **Hepatitis B/C** – caused by viral agent
  - **Legionnaire's Disease** – can be fatal if not recognized early

Occupational Lung Diseases

- Lungs are the most common route of occupational exposure.
  - Chemicals have rapid access to the blood stream.
    - » Large surface area
    - » Nasal hair, cough reflex and mucocilliary ladder prevents large particles from reaching the deeper parts.

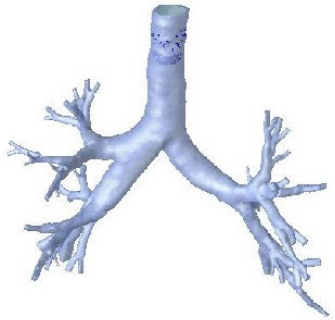
Occupational Lung Diseases

- Deposition in lungs is based on water solubility for gases and particle sizes for solids.
  - Ammonia and SO_2 are water soluble and are almost entirely removed by aqueous layer in the nose and upper airways
  - Nitrogen dioxide and phosgene are water insoluble and reach the distal airways and alveoli.



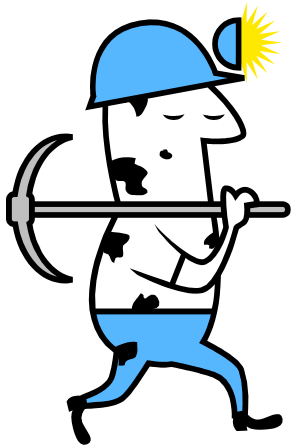
Occupational Lung Diseases

- **Particle deposition**
  - Aerodynamic diameter >10 um deposited in nasal mucosa
  - Particles between 3 and 10 um deposited throughout tracheobronchial tree
  - Particles 0.1 to 3 um are deposited in and around the alveoli.



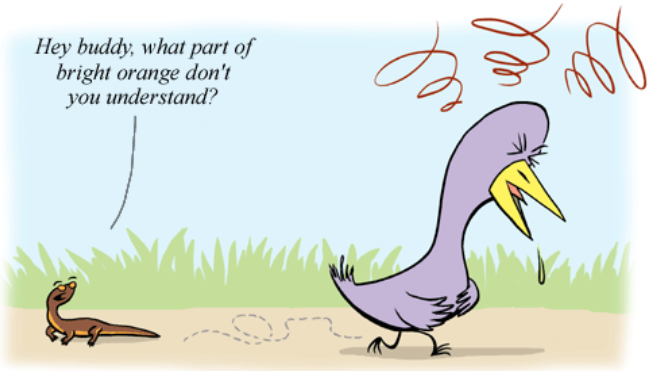
Occupational Lung Diseases

- Common problems include:
  - **Asthma**
    - » From wood dust or isocyanates
  - **Pneumoconiosis**
    - » Such as seen with asbestos, silica, coal dust
  - **Cancer**
    - » Includes both lung cancer and mesothelioma from exposure to asbestos, radon, chloromethyl ethers



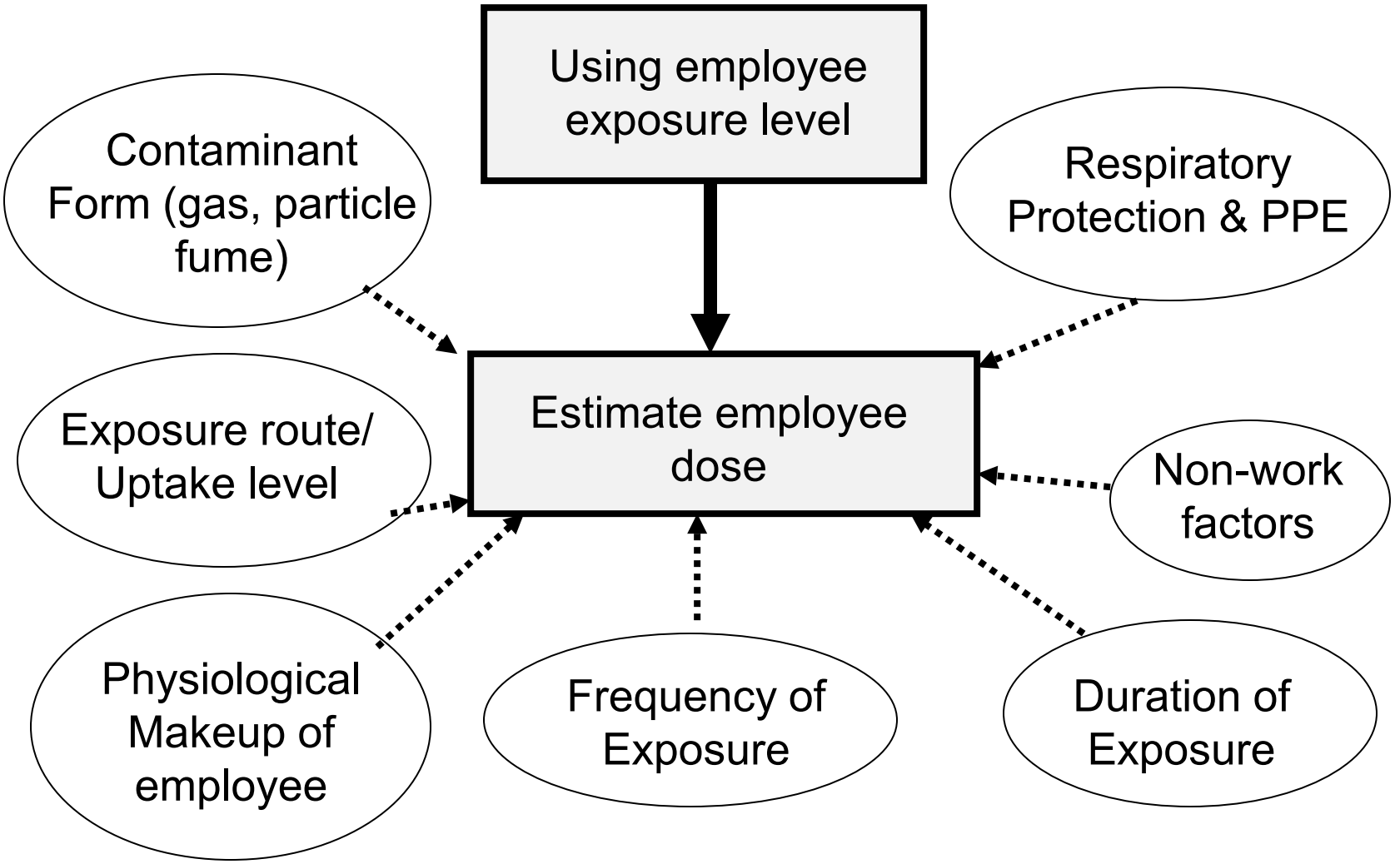
Other Toxic Effects

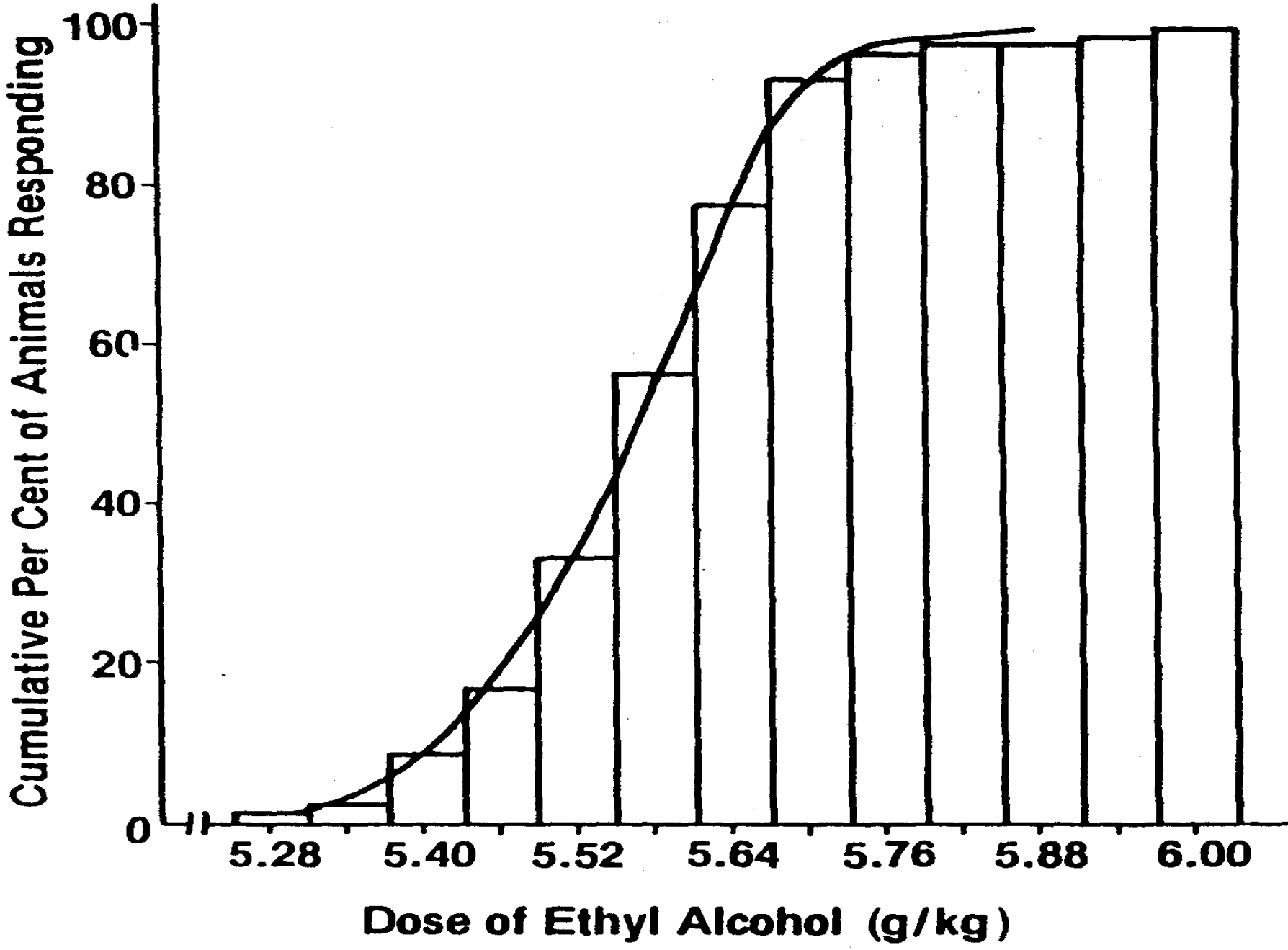
- **Hepatoxins**
  - Liver damage



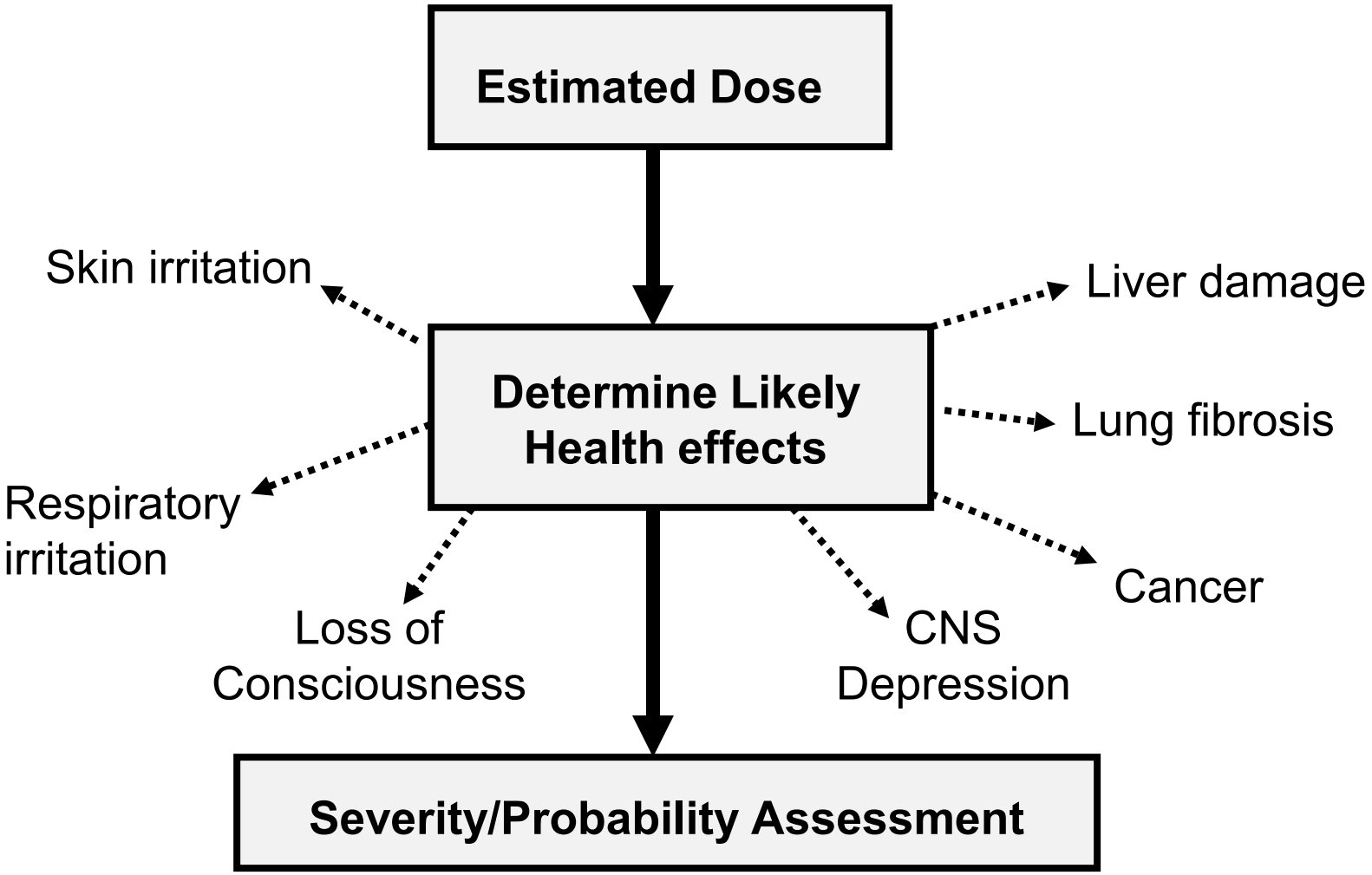
- **Nephrotoxins**
  - Renal (kidney) damage

- **Neurotoxins**
  - Affects the central and/or peripheral nervous system


Using employee exposure level
Contaminant Form (gas, particle fume)
Respiratory Protection & PPE
Estimate employee dose
Exposure route/ Uptake level
Non-work factors
Physiological Makeup of employee
Frequency of Exposure
Duration of Exposure



NOTE: Reprinted, by permission from, Pharmacology Drug Actions and Reactions, Ruth R. Levine. Boston: Little Brown and Company, 1973, p. 186.


Estimated Dose
Skin irritation
Liver damage
Determine Likely Health effects
Lung fibrosis
Respiratory irritation
Cancer
Loss of Consciousness
CNS Depression
Severity/Probability Assessment

Severity Assessment

- What is the definition of **serious**?
  - Likely to cause death or serious physical harm

- **Examples:**
  - High
    - » Death/permanent disability
  - Medium
    - » Hospitalization, partial disability, lost worktime
  - Low
    - » Requires minor supportive treatment (such as an emergency room visit)

Probability Assessment

- CSHO must determine the **probability** that an accident or health hazard exposure will result from the hazard.
  - Comes into play only for penalty calculation

- Factors affecting probability include:
  - # of workers exposed, frequency/duration
  - Proximity to the hazard, use of PPE

- All classifications begin at medium

Overexposures

- What is the definition of an **overexposure**?

- How does the injury/illness differ based on the specific PEL exceeded?
  - TWA?
  - STEL?
  - Ceiling?

Overexposures

- Are all overexposures serious?
- Are all non-overexposures non-serious (if violations are found)?
- Can you have a hazard when airborne levels of a specific chemical are non-detectable?

"Our scientists say it would be a public health hazard, but market research shows it would sell like hot cakes - what do you think?"

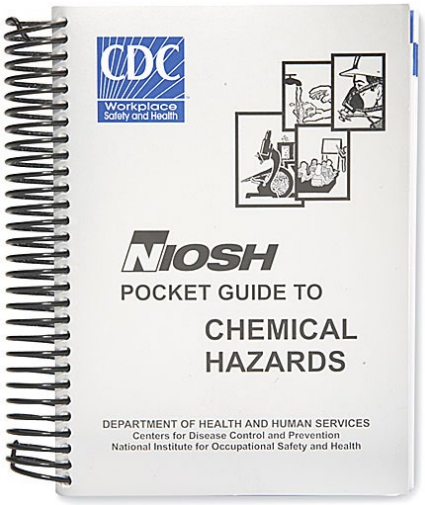
Additive Effects

- Chemicals with identical or very similar mechanisms and target organs can be treated as one when evaluating employee exposures
  - (Exposure 1/PEL 1) + (Exposure 2/PEL 2)
    - » If result exceeds unity (1.0), then the employee is overexposed

Hazard Information

- **NIOSH Databases** (www.cdc.gov/niosh/database.html)
  - Pocket Guide to Chemical Hazards
  - IDLH Viewer
  - OSH Guidelines for Chemical Hazards
  - Chemical Safety Cards

- **Federal OSHA web site** (www.osha.gov)



Silica

- Found in rockdrilling, sandblasting, cutting brick, cement or concrete industries or any application dealing with earthen materials.
  - Crystalline vs. amorphous
  - How do we evaluate exposure?
    - » Total vs. Respirable dust
    - » Use of mini-ram?
    - » Bulk samples?

Silica

- Silicosis is the resultant illness
  - Toxic interaction between silica crystals and alveolar macrophages
  - **Three forms – chronic, accelerated, and acute**
    - » Acute silicosis is usually fatal.
    - » Chronic silicosis may be stable with little reduction in lung function.
    - » Accelerated silicosis occurs after exposure to larger amounts of silica over a shorter period of time
  - Progressive massive fibrosis may be characterized by lung restriction or by restriction/obstruction
  - At risk for tuberculosis infection

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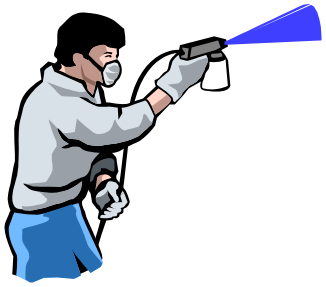
Terex S-60


USA

Lead

- Serves no biological function in humans
- Uses include:
  - Manufacture of storage batteries
  - Solder
  - Paints and plastics
  - Glazes



- Absorbed via respiratory system (40%) and GI tract (10%). GI absorption is greater is children.

Lead

- In bloodstream, **Lead** is bound to RBC's.
  - Distributed to soft tissue (liver, kidney, brain, muscle) where it is readily exchangeable.
  - Eventually deposits in the bone
  - Half-life of 5-10 years

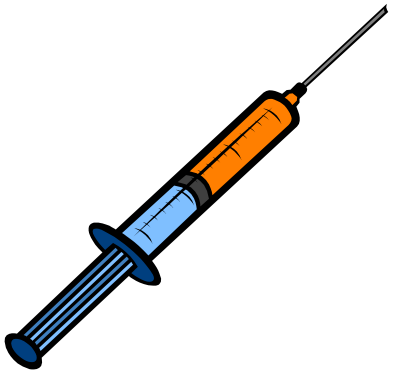
Lead – Health Effects

- **Acute**
  - Abdominal pains, encephalopathy, hemolysis, and acute renal failure
- **Chronic**
  - Altered heme synthesis at BLL > 40 ug/dL
  - Central and peripheral nervous system damage and effects at BLL's between 40 and 80 ug/dL.
  - Reproductive effects at levels >30 ug/dL.

Lead - Treatment

- First step is always to remove the individual from exposure (standard requires this at >50 ug/dL)

- Chelation therapy may be used as well
  - Toxic
  - Bounce-back effects – why?

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Carbon Monoxide

- Product of incomplete combustion, from the burning of a variety of fuels.
  - Gasoline – vehicles
  - Propane – forklifts, portable heater
  - Natural gas – heating systems

Carbon Monoxide

- **Chemical asphyxiant**
  - CO binds to hemoglobin forming carboxyhemoglobin (COHb).
  - Hemoglobin has affinity for CO 240X greater than that for oxygen.
  - COHb decreases oxygen saturation and shifts the O_2 hemoglobin dissociation curve to the left.
  - COHb levels of 6% may cause impairment
  - At 40-60%, alterations in mental status and death may be seen.


3 25 '98


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8 12:36

Methylene Chloride

- Organic solvent often used in furniture stripping and spray adhesives.
- Metabolized to carbon monoxide in the body.
  - Therefore, concerned about hypoxia in addition to normal CNS solvent effects
  - Possible carcinogen


2'23"99


CAUTION
WET
FLOOR

Isocyanates

- Intermediaries in the production of polyurethane
  - Seen in paints and coatings, foams, and other “two-part” chemicals mixes
  - TDI, MDI, HDI
- Primary effect is eye, nose, and throat irritation
- 5-10% of employees may become sensitized and experience asthma at **very low** levels.

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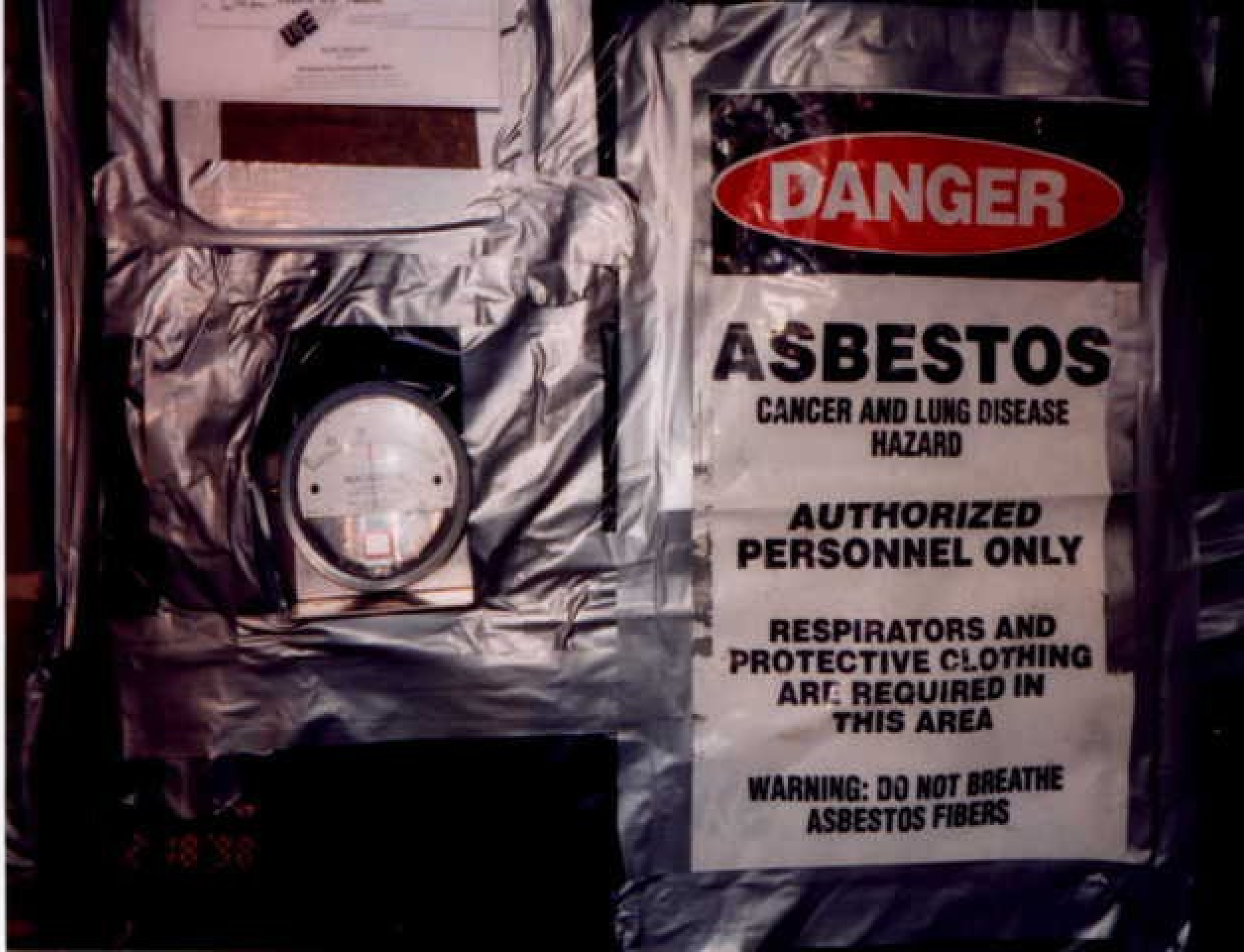
Asbestos

- Mineral silicates that are fibrous in nature and can be woven
- Fibers are very aerodynamic and tend to deposit in the lower respiratory tract

- Health effects:
  - Asbestosis (progressive restrictive lung disease)
  - Cancer (lung cancer and mesothelioma)
  - Synergistic effects between asbestos exposure and cigarette smoke


DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED IN THIS AREA
WARNING: DO NOT BREATHE ASBESTOS FIBERS


12 1'98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Cotton Dust

- Employees exposed to excessive cotton dust or other natural dusts (flax, hemp) may develop Byssinosis.
  - Causes chest tightness, cough, and difficulty breathing among the textile workers.
  - Dust causes the release of histamine and contains endotoxins that activates the complement system, causing broncho-constriction.
  - Symptoms are worse on the first day back at work following the weekend "Monday fever."

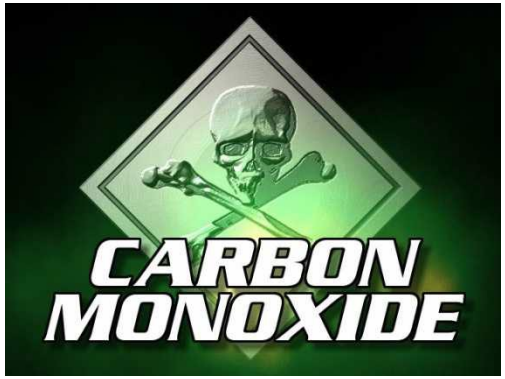
Biological Exposure Indices (BEI)

- Published by ACGIH, they are guidance values for assessing biological monitoring results.

- Some commonly used BEI's:
  - Pesticides – Acetylcholinesterase activity in RBC's.
  - CO – COHb in blood
  - Lead – lead in blood/ZPP in blood
  - Mercury – inorganic mercury in blood or urine

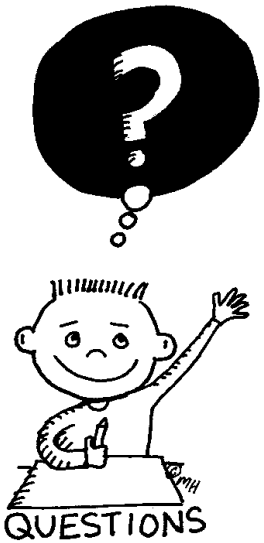
BEI for Carbon Monoxide

- Can use formulas for estimating the CO exposure given a particular COHb measurement.
  - Must know the following parameters:
    - » COHb concentration in blood
    - » Time delay between last exposure and biological sample
    - » Number of hours worked (exposed)



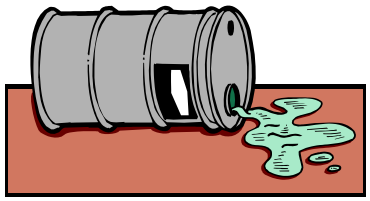
Case Studies

- Evaluate each case study and answer the following questions:
  - What's the hazard?
  - What the mechanism of action and the resulting injuries or illnesses?
  - Which OSH standards have likely been violated?



Case Study #1

- Employees of a synthetic fiber manufacturing plant use toluene during the extrusion process.
- The toluene is reclaimed in a room twenty feet below ground.
- One of the reclaim tanks overflows, spilling approximately 100 gallons on to the floor.
- Two workers go down to clean-up the spill and lose consciousness.
- They are rescued by the local Fire Department and released following treatment at the local hospital.



Case Study #2

- Two employees at a mobile home manufacturing plant spend most of their day arc welding on steel support beams.

- The facility has general exhaust ventilation. Air monitoring shows one employee exposed to total welding fumes at 17.4 mg/m^3 (8 hour TWA) and the other exposed at 15.25 mg/m^3.

- No respiratory protection is used.

Case Study #3

- A subcontractor is hired to pressure wash the inside of a newly constructed public storage facility.
- They use gasoline-powered washers.
- After six hours of work, three employees begin to feel sick.
- After one loses consciousness, they call 911 and all three are transported to the hospital.
- Blood tests show the three to have carboxyhemoglobin levels of 27.2%, 24.1% and 18.0%.
- Two employees are transported for hyperbaric O_2 treatments and released the next day.

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Case Study #4

- Employees at a cement plant routinely (once each week) climb into the back of transport trucks to remove cement that has hardened.
- This is done using pneumatic hammers and chippers.
- A double strapped dust mask is used, but the company has no respirator program.
- Air sampling for one worker shows the following results:
  - 1200 liters collected, 2.54 mg total dust
  - 0.42 mg quartz, other forms of SiO_2 were ND

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Case Study #5

- Employees at a small furniture plant are responsible for stripping the stain from old church pews.
- The pew is placed in a large tub, coated with methylene chloride, and hand stripped.
- Air sampling showed employee exposure to be 1223 ppm.
- Employees use gloves, an apron, and a half-mask respirator with organic vapor cartridges.
- The company has not developed a respirator program.

Case Study #1 - Answers

- **Hazard** – Exposure to excessive concentrations of toluene vapors due to not ……(doing what the standard requires).
- **Mechanism** – As with other solvents, aromatic hydrocarbons will primarily cause CNS depression.
- **Injury/Illness** – headache, nausea, dizziness, light-headedness, slurred speech, vertigo, disorientation, loss of consciousness, death.
- **Standards Violated** – 1910.1000, 1910.134, 1910.120, 1910.119, 1910.1200, others?

Case Study #2 - Answers

- **Hazard** – Exposure to excessive concentrations of metal fumes due to not … ……(doing what the standard requires).
- **Mechanism** – Deposition of small metal particles in the alveoli and lower portion of bronchiole tree.
- **Injury/Illness** – Metal fume fever, respiratory irritation
- **Standards Violated** – 1910.1000, 1910.134, 1910.132, others?

Case Study #3 - Answers

- **Hazard** – Exposure to excessive concentrations of carbon monoxide due to not ……(doing what the standard requires).

- **Mechanism** – Chemical asphyxiation. CO combines with hemoglobin to reduce the oxygen-carrying capacity of the blood. Organs with greatest need for oxygen (heart, brain) are affected first.

- **Injury/Illness** – Hypoxia, loss of consciousness

- **Standards Violated** – 1910.1000, 1910.134, 1910.1200, others?

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Case Study #4 - Answers

- **16.5% Silica. PEL = 0.54 mg/m^3. Exposure = 2.12 mg/m^3**
- **Hazard** – Exposure to excessive concentrations of respirable dust containing crystalline silica due to not ……(doing what the standard requires).
- **Mechanism** – Deposition of silica crystals in the lung. Interaction between crystals and alveolar macrophages may eventually lead to fibrosis and other pathophysiology of the lung.
- **Injury/Illness** – Silicosis – characterized by coughing, difficulty breathing, scarring of the lungs, and a limited disability.
- **Standards Violated** – 1910.1000, 1910.134, others?

Case Study #5 - Answers

- **Hazard** – Exposure to excessive concentrations of methylene chloride vapors due to not ……(doing what the standard requires).
- **Mechanism** – CNS depression, chemical asphyxiation (MC metabolized to CO).
- **Injury/Illness** – Hypoxia, nausea, dizziness, loss of consciousness.
- **Standards Violated** – 1910.1052, 1910.134, others?

Thank You For Attending!

Final Questions?

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