MIOSHA Training Institute

MIOSHA Michigan Occupational Safety and Health Administration

Macomb Community College

Fundamentals of Industrial Hygiene

Student Materials
MTI Level Two Course
Consultation Education and Training Division
Michigan Occupational Safety and Health Administration
Michigan Department of Labor and Economic Opportunity
www.michigan.gov/miosha
517-284-7720

MICHIGAN DEPARTMENT OF LABOR & ECONOMIC OPPORTUNITY

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Fundamentals of Industrial Hygiene

Presented By:
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Course Overview

- Module 1: History of Hazards
- Module 2: Anticipation of Hazards
- Module 3: Recognition of Hazards
- Module 4: Evaluation of Hazards
- Module 5: Control of Hazards

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Module 1 – History of Hazards

- Objectives
  - Define Industrial Hygiene
  - Differentiate the Role of an Industrial Hygienist from other Safety and Health Professionals
  - Review the History and Development of Modern IH practice

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Death on the Job – Case Study

- Link to Article
- Restaurant Fatality – Employee assigned to clean occupied dining room floor using two cleaners:
  - Super 8
  - Scale Kleen
- Occupants reported difficulty breathing, employee relieved by manager who attempted to mop chemicals into a drain, then wipe up with a towel, manager died, 11 others hospitalized

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A Brief History of Workplace

- The workplace is continuously changing, so Industrial Hygiene is always needed
  - Hunter-Gatherer/Nomadic Societies
  - Agricultural Revolution/Sedentary Societies
  - Bronze/Iron Ages/Mining and Metallurgy
  - Middle/Dark Ages/Trade Guilds and Specialization
  - Industrial Revolution/Powered Machinery
  - 19th-20th Centuries/Petroleum and Chemicals
  - 21st Century/Information Age?

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Historical Figures in Industrial Hygiene

- Hippocrates – 4th Century BCE Greek – Lead Toxicity in Mining
- Pliny the Elder – 1st Century AD Roman – First Respirator – From a Pig Bladder!
- Galen – 2nd Century AD Greek – pathology of lead poisoning – Acid mists in copper mining
- Agricola – 16th Century German – Wrote *De Re Metallica* reviewing accidents, exposures and recommending controls (industrial ventilation!) in mines
- Bernardo Ramazzini – 17th-18th Century Italian – The Father of Industrial Hygiene – Wrote *De Morbis Artificum Diatriba* (The Diseases of Workmen) – Proposed study of the environment for causes of occupational disease
- Percival Pott – 18th Century Englishman – Identified effect of soot on Chimney Sweepers, resulting in first employee protection law – Chimney Sweepers Act of 1788

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Spotlight – Dr Alice Hamilton

- 20th Century American
- Observed Industrial/Occupational settings first-hand
- Identified correlations between exposure to various toxins and incidence and/or prevalence of worker illness
- Presented proposals for eliminating unhealthful working conditions
- The “Mother” of American Industrial Hygiene

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A Brief History of Industrial Hygiene Regulation in the United States

- Prior to 1900 – Assumption of Risk Doctrine in employment, few worker protections
  - 1908 – First U.S. Workers Compensation Laws
  - 1913 – First State Industrial Hygiene Programs
  - 1948 – All States had Industrial Hygiene Programs
    - Minimal Enforcement
    - Little Uniformity
    - Corporations with multistate operations faced widely varied civil and/or regulatory liability, and lobbied for a low, uniform regulatory standard of care

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Occupational Safety and Health Act of 1970

- Created the Occupational Safety and Health Administration (OSHA)
  - Given authority to set and enforce workplace health and safety standards (laws)
  - Established the National Institute for Occupational Safety and Health (NIOSH)
  - Section 5 of the Act – "General Duty Clause" allows enforcement of the act where
    - A Hazard is Present
    - The Hazard is Recognized
    - Likely to cause serious harm
    - The Hazard is correctable

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Occupational Safety and Health Act of 1970 State Plans

- Section 8 of the Act permits and encourages states to adopt their own plans
- Must be "at least as effective in providing safe and healthful employment" as Federal Act
- Allows for additional or higher standards to be issued (e.g., Part 505)
- 23 approved State Plans (including Michigan)
- MIOSHA is Michigan's state plan under Section 8 of the OSHAct
  - Act 154 of 1974

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MIOSHA Standards

- Laws or Regulations passed under Act 154 of 1974, e.g., Part 451 Respiratory Protection
- None existed prior to OSHAct, most published from federal standards issued in 1971
- Compiled from existing federal, state and consensus standards, can be better than OSHA
  - E.g., MIOSHA Part 301 Air Contaminants for General Industry
    - OSHA and MIOSHA initially adopted 1968 ACGIH TLVs
    - OSHA attempted to reduce limits in 1989, was stopped by legal action
    - MIOSHA adopted 1989 revisions into Part 301
    - Some MIOSHA air contaminant limits differ from Federal OSHA PELs

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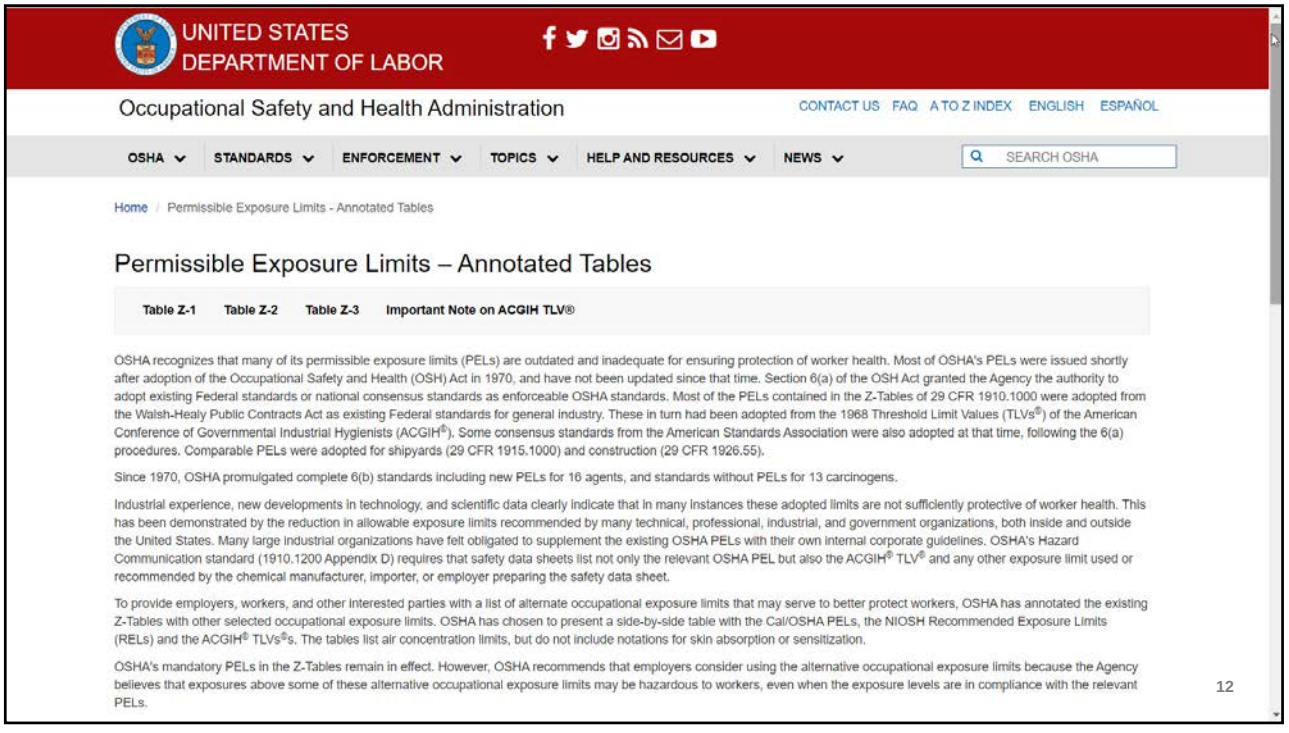

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NIOSH – "The Scientists"

- Principal Federal Agency engaged in occupational health and safety research
  - Identifies Hazards
  - Makes recommendations for regulations – NIOSH Recommended Exposure Limits (RELS)
  - Issues criteria documents and health hazard alerts
  - Tests and certifies respiratory protective equipment
  - Conducts health hazard evaluations

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What is Industrial Hygiene?

- . . . "that **science and art** devoted to the **anticipation, recognition, evaluation, and control** of those **environmental factors or stresses arising in or from the workplace**, which may cause sickness, impaired health and well-being, or significant discomfort among workers or among the citizens of the community."

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Who is an Industrial Hygienist?

- Has knowledge of natural sciences (physics, chemistry, biology, environmental science) - **Anticipate** exposures
- Conducts investigations to observe conditions - **Recognize** exposures
- Conducts monitoring and analysis to quantify extent of hazard - **Evaluate** exposures
- Eliminates or reduces hazards that arise during course of work – **Control** exposures

- An Industrial Hygienist is defined by the process above to provide an expert opinion on risk
- We answer the difficult question of “Am I safe?”

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Industrial Hygiene Professionals

- Certified Industrial Hygienist (CIH)
  - Professional Certification “CIH” Gold Standard in the field
    - Education
    - Experience
    - Examination
    - Continuing Education
  - Approximately 6600 worldwide, insufficient to meet demand

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How many CIHs are there?

- 2,490 current CIHs in the United States
- 158,000,000 employed persons of all ages in the U.S.
- 1 CIH for every 63,454 workers
- One CIH for every:
  - 84 primary care physicians
  - 546 active military personnel
  - 488 firefighters
  - 2 workers killed on the job in 2020

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Who Isn't an Industrial Hygienist?

- Safety Professionals – knowledgeable in factors of accident occurrence and implementation of methods and procedures to control safety hazards
- Occupational Health Nurse – delivers health care services to workers, links employee health to process and ability to do job
- Occupational Medicine Physician – knowledgeable of cause-and-effect relationship of occupational hazards and employee response, able to diagnose illness and state cause

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Be an Industrial Hygienist!

- Open Module 1 Activity Packet
- Anticipation – Review Safety Data Sheets (SDSs)
- Recognition – Discuss Death on the Job Case Study – What was the hazard?
- Evaluation – What are Occupational Exposure Limits? How could we measure risk?
- Control – How could this exposure have been eliminated or reduced?

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Module 2 – Anticipation of Hazards

- Objectives:
  - Differentiate Toxicity from Hazard
  - Understand Routes of Exposure
  - Understand Anatomy of:
    - The Respiratory System
    - The Skin (Integumentary System)
    - The Ears (Auditory System)
    - The Eyes (Ocular System)

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Understanding Exposure – Toxicity vs Hazard

- **Toxicity** – The ability/capacity of a chemical to harm or injure a living organism.
- **Hazard** – The probability that a toxic concentration will occur.
- Two chemicals can have same toxicity but different hazards (e.g., one with poor warning properties)
  - Route of Entry
  - Dose (amount and duration)
  - Environmental variables
  - Physical characteristics of the substance
  - Combined exposures
- Industrial Hygienists assess hazards

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Classes of Hazards

- Chemical Hazards – Excessive concentrations of mists, vapors, gases, solids. Eye or Skin irritants. Absorption through the skin.
- Physical Hazards – Excessive Noise levels. Ionizing or non-ionizing radiation. Vibration, temperature extremes, pressure extremes.
- Ergonomic Hazards – Improperly designed tools, work areas, work procedures.
- Biological Hazards – Any organisms or infectious agents that can cause an adverse response in humans.

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Understanding Exposure – Exposure vs Dose

- Exposure – Contact with a chemical, biological, or physical hazard – measured through personal exposure monitoring
- Dose – Used to express amount of exposure to a chemical substance or physical hazard – measured through biological monitoring/medical surveillance
- Industrial Hygienists estimate dose through exposure measurements
  - This is a close estimation if all routes of entry are considered, inadequate if all exposure routes are not considered

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What are Main Routes of Entry?

- Inhalation – Airborne contaminants that are inhaled directly into the lungs then into the blood. Major route of entry for hazardous chemicals in the work environment.
- Skin Absorption – Chemical passage through the skin, either through non-intact or intact skin. Also includes harm caused by direct contact with the skin
- Ingestion – Toxic compounds absorbed through the gastrointestinal tract into the blood, usually through unintentional eating or drinking of harmful chemicals
- A single chemical can present multiple hazards – e.g., solvent degreasing: inhalation of vapors, skin absorption of liquid or vapor, metabolites, flammability etc.

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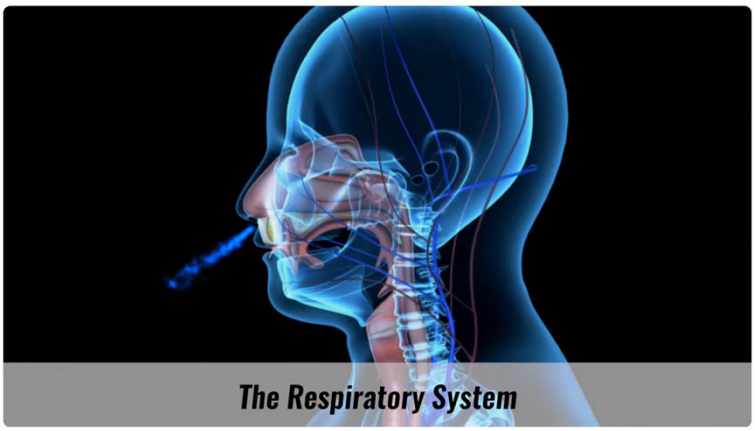
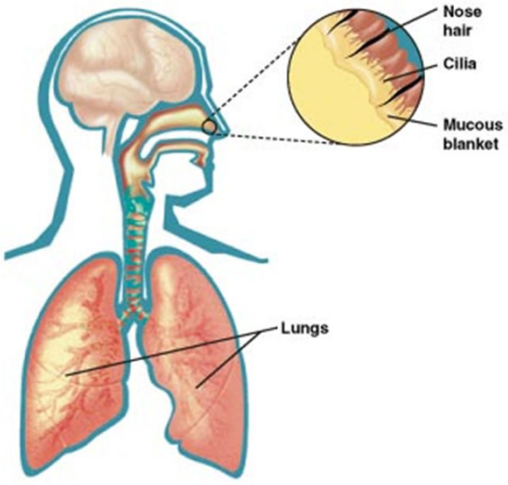
Inhalation – The Respiratory System

- Gas Exchange
- Mechanics of Breathing
- Air Contaminant Fate
  - Size
  - Chemical Reactivity
  - Solubility



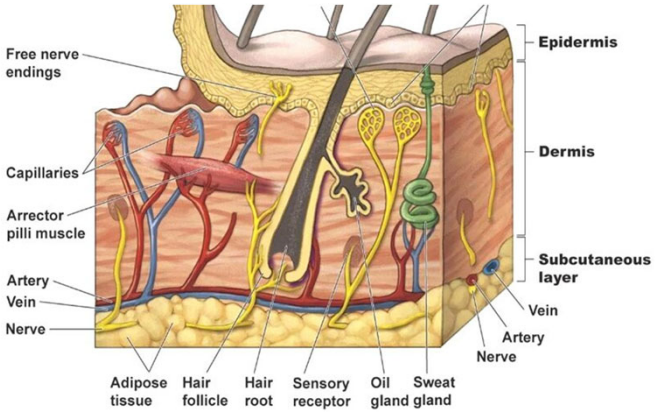
Inhalation – Natural Defenses

- Nose – Warms or cools, adds moisture helping it flow and making it less irritating. Nose Hairs trap large particles
- Cilia – Tiny hairs of respiratory tract which move particles out of airway
- Mucous blanket – Lines airways and traps particles for cilia to move out by coughing or swallowing
- Cough reflex – Triggered by unwanted particles near lungs
- Impaction – Large particles slam into walls of branches of respiratory system
- Macrophages – White blood cells ingest particles



Skin Absorption

- Epidermis – mostly dead flat cells
- Dermis – sweat, hair follicles, sebaceous
- Subcutaneous – Insulation
- Protective Barrier against:
  - Mechanical
  - Thermal
  - Physical injury
  - Hazardous Substances



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Skin Absorption – Natural Defenses

- Provides a protective barrier against mechanical, thermal and physical injury and hazardous substances
- Prevents loss of moisture
- Reduces harmful effects of UV radiation
- Acts as a sensory organ (touch, detects temperature)
- Helps regulate temperature
- An immune organ to detect infections etc.
- Production of vitamin D

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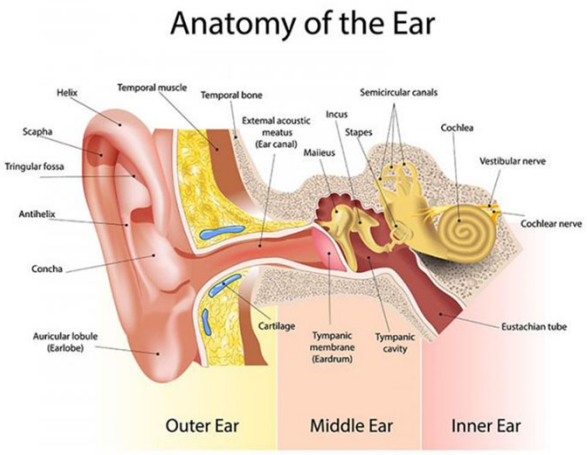
Anatomy and Physiology of the Ears

- External Ear
- Middle Ear
- Inner Ear

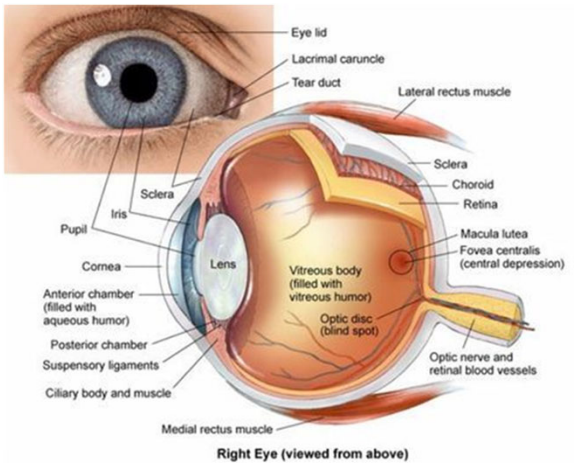


Effects of Excessive Noise

- Loss of hearing
- Increased heart rate and blood pressure
- Constriction of blood vessels leadir to tension and stress
- Nervousness, sleepiness, and fatig
- Impaired communication

Anatomy and Physiology of the Eyes

- Eyeball
- Retina
- Binocular Vision



Eye Hazards

- Blows from Objects
- Corneal Lacerations and Abrasions
- Foreign Bodies
- Thermal Burns
- Irradiation Burns
- Chemical Burns
- Excessive Brightness
- Eyestrain

Module 3 – Recognition of Hazards

- Objectives:
  - Differentiate between the states of matter and their behavior in the atmosphere and workplace
  - Evaluate the risks of solvents based on vapor hazards including cumulative effects of similar solvents
  - Assess physical factors impacting noise, radiation, and thermal stresses

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Review - Industrial Toxicity

- A toxic effect is any harmful effect on the body as a result of contact with a substance with a body tissue
- Toxicity is the capacity of a chemical to harm or injure a living organism

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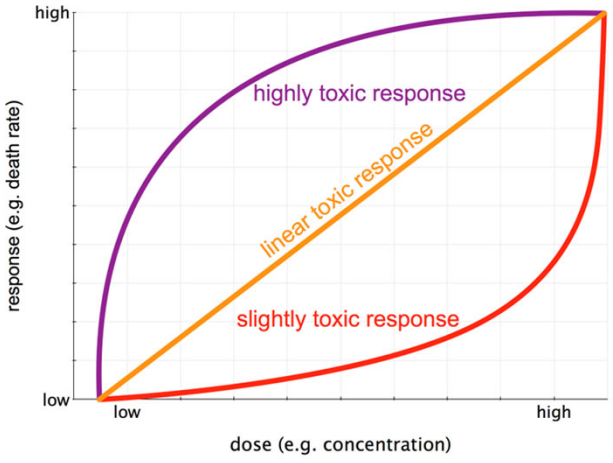
Review – Hazard Recognition

- Hazard is the probability that a toxic concentration will occur at a certain site in the body
- Hazard is estimated on a case-by-case basis
- Just because a toxic chemical is present, does not mean that a hazard exists
  - E.g., A closed, sealed, intact container of drain cleaner is toxic, but does not present a hazard until it is handled by an employee

Dose-Response Relationship

- A high concentration/amount of a toxic substance causes a severe reaction, and a low concentration/amount causes a less severe or no reaction
- A more toxic substance causes harm at lower concentrations compared to other substances
- Scientific studies are performed, and exposure limits are set below concentrations that cause severe reactions



Acute vs Chronic

- Acute – short-term, high concentrations, and immediate or prompt health effects (within minutes or hours)
- Chronic – symptoms or disease of long duration, exposures continued or repeated for a prolonged period (years)
- Exposure limits are set to control both acute and chronic exposures

Particulate Matter

- Particulate matter is typically a chronic hazard
- One exception is the 1935 drilling of a tunnel in West Virginia
- Massive exposure to quartz causing silicosis.
- Approximately 1500 became sick, many within a week
- This was an acute effect

Chemical Properties

- The properties of a compound are often one of the main factors in its hazard potential
  - For example, Compound A and B may be of equal toxicity, i.e., they require the same dose to cause the same effect. However, if Compound A is more easily released into the air, or is less detectable to the senses, it is more hazardous than Compound B. AS ITS CHEMICAL FEATURES MAKE A TOXIC DOSE MORE LIKELY TO OCCUR

Example – Ammonia vs. Carbon Monoxide

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States of Matter – Gases and Vapors

- The physical state of a chemical can also greatly affect its hazard potential
- Gas - Formless state of matter which at room temperature and pressure has low density/viscosity and readily and uniformly distributes itself throughout any container
- Examples: O_2, SO_2, O_3, NO_2, formaldehyde (HCOH), methane (CH_4)
- Vapor - Gaseous form of a substance which coexists as a solid or liquid at normal temperature and pressure
- Examples: Hg, H2O, benzene (C6H6), acetone (C3H6O), ethanol (C2H6O)

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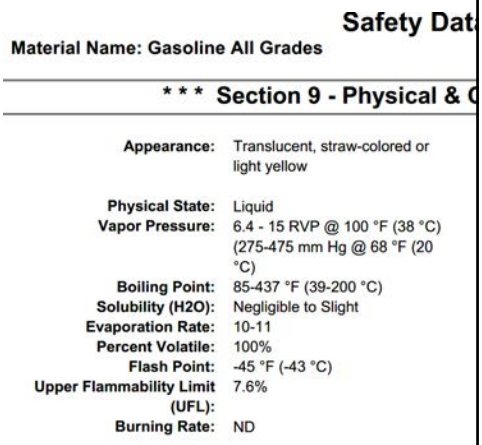
Vapor Pressure

- Vapor pressure - the pressure exerted when a solid or liquid is at equilibrium with its own vapor
- The higher the vapor pressure, the more volatile the chemical, and the more likely the chemical will evaporate and become an air contaminant
- It is temperature dependent, as temperature increases, so does the amount that evaporates
- Chemicals with lower vapor pressure are typically less hazardous despite having equal toxicity
- Vapor Pressure is provided in section 9 of SDSs



Safety Dat

Material Name: Gasoline All Grades

* * * Section 9 - Physical & C

Appearance:	Translucent, straw-colored or light yellow
Physical State:	Liquid
Vapor Pressure:	6.4 - 15 RVP @ 100 °F (38 °C) (275-475 mm Hg @ 68 °F (20 °C)
Boiling Point:	85-437 °F (39-200 °C)
Solubility (H2O):	Negligible to Slight
Evaporation Rate:	10-11
Percent Volatile:	100%
Flash Point:	-45 °F (-43 °C)
Upper Flammability Limit (UFL):	7.6%
Burning Rate:	ND

Solvent Exposure Scenario

- A 5 ml vial of benzene was spilled in a 400 m^3 laboratory, researcher sealed room and exited, wants to reenter to continue working safely.
- If this were reported to you, the industrial hygienist, how would you respond?
  - Anticipation
  - Recognition
  - Evaluation
  - Control

Solvent Exposure Scenario

- Anticipation
  - Benzene SDS shows inhalation hazard, high vapor pressure
  - Part 301 for Benzene (PEL = 1 ppm, STEL = 5 ppm)
- Recognition
  - Spill was uncontrolled, outside lab hood
  - Room is unventilated, but ventilation is available
- Evaluation
  - Closed box system results = 3 ppm

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Solvent Exposure Scenario

- Result of approximately 3 ppm exceeds the PEL by a factor of 3, but does not exceed the STEL
  - PEL is a standard designed to protect workers for an eight-hour workday, five times a week, for many years—so don't panic!
  - STEL would not be exceeded, so can advise reentry is permissible for up to 15 minutes, to activate ventilation and then leave the room.
  - Reenter after results indicate concentrations below the PEL.

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Solvent Usage

- Household Use (Painting, Cleaning, WD-40)
- Circuit board manufacturing
- Autobody Repair
- Ink formulation
- Metal finishing and plating
- Pharmaceutical manufacturing
- Dry cleaning
- Furniture manufacturing
- Printing
- Pulp and paper manufacturing
- Semiconductor manufacturing
- Film developing
- Agriculture
- Others?

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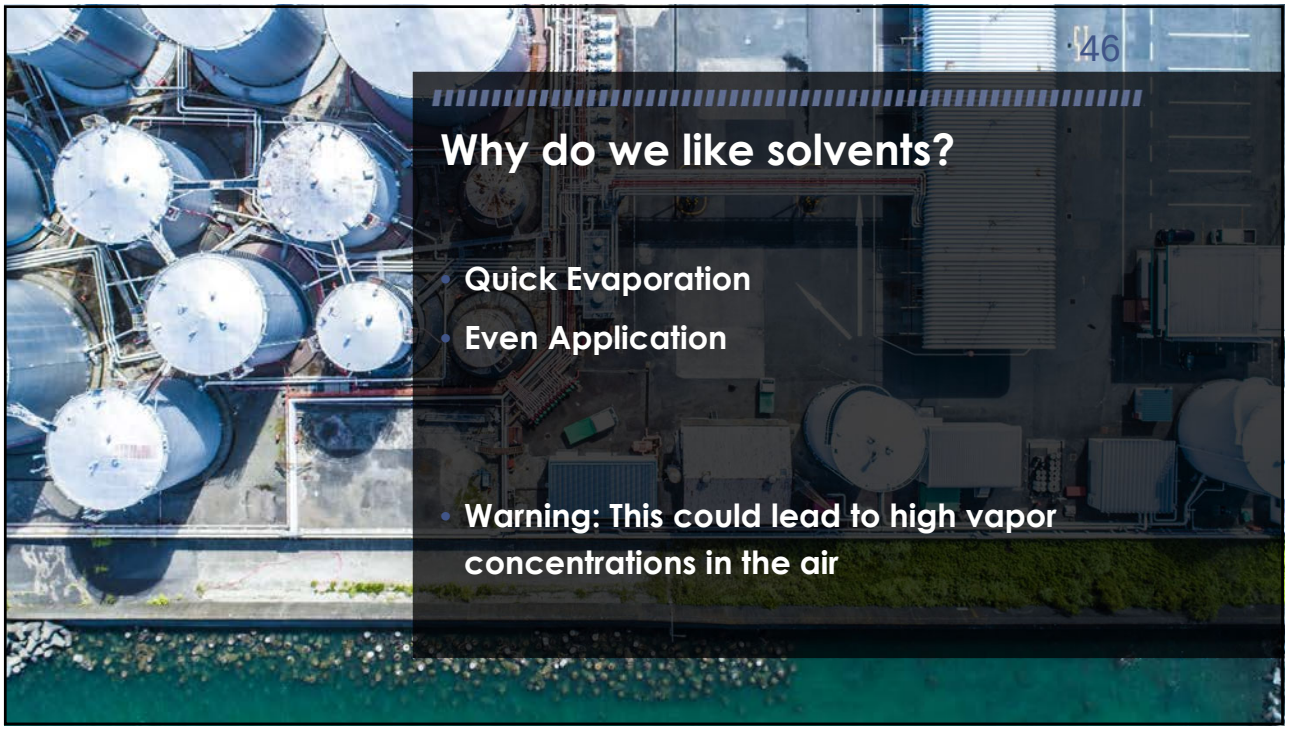

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Quantification of Gases/Vapors

- Remember: Industrial Hygienists use concentrations to estimate dose
  - Percentage
  - Parts per million (1% = 10,000 ppm)
  - Parts per billion
- Atmosphere is a gas, volumetric comparison
- Units of an occupational exposure limit (OEL) can give a rough idea of toxicity

Examples: MIOSHA TWA PELs

- Ethanol 1000 ppm (0.1%)
- Toluene 100 ppm
- Methylene bisphenyl isocyanate (MDI)
  0.02 ppm (20 ppb)

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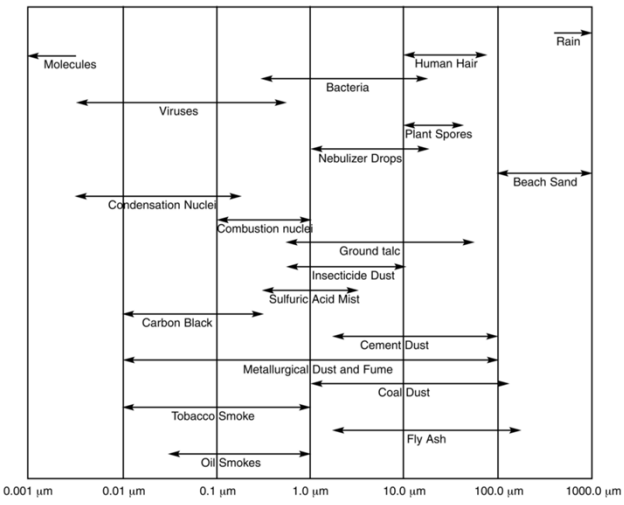
States of Matter – Particulate Matter

- Small discrete pieces of solid material or liquid droplets (e.g., welding fume)
- Suspends in air which can be inhaled
- Size Matters
  (range: 0.001 µm – 100 µm)
  - Particles >100 µm fall to the ground
  - Particles ~0.001 µm start acting like a gas
- Smaller particles inhaled are more hazardous than larger size particles



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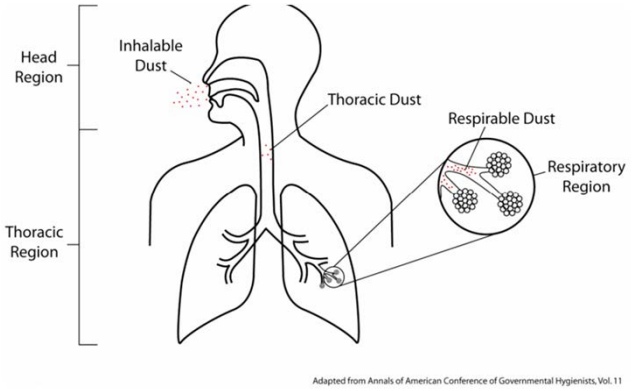
Natural Defenses - Review



- Inertial impactions
  - Function of particle velocity and mass
- Interception
  - Function of particle diameter

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Particulate Matter - Examples

- Pollen, dust, mold spores
- Wood dust
- Asbestos fibers
- Silica dust
- Paint/powder coat
- Lead dust
- Weld fume
- Metalworking fluid spray
- Engineered nanoparticles… and many more!

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Particulate Matter in the Environment

- Airborne behavior, such as settling velocity, is a function of:
  - Size
  - Specific gravity
  - Shape

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Particulate Matter - Dusts

- Solid dust (a.k.a. aerosols) generated by the handling, grinding, abrasion, or cutting of a bulk material
- Dust particle size is related to the amount of energy involved in creation;
  - The higher the energy = smaller particle created;
  - The lower the energy = larger particle created
  - Examples: Saw dust, coal dust, asbestos dust (prohibition on power tools)

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Particulate Matter - Mists

- Liquid aerosols generated by condensation from a gaseous state or by the breaking up of a bulk liquid into a dispersed state
- Droplet size related to energy input as in dusts and fibers
- Examples: Metal working fluids from lathe, paint spray, liquid mixing operations

Particulate Matter - Smoke

- Solid aerosols resulting from the incomplete combustion of carbonaceous materials
- Wide range of particle sizes
- Size related to combustion efficiency
  - High efficiency = smaller particles
  - Low efficiency = larger particles
- Examples: Wood smoke, diesel exhaust

Particulate Matter - Fumes

- Solid aerosols generated by the condensation of vapors or gases from combustion or other high temperature processes
- Usually very small and spherical
- Sources: Welding, foundry and smelting operations, hot cutting or burning operations

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Particulate Matter - Bioaerosols

- Solid or liquid aerosols from biological sources
- May be infectious, allergenic, and/or irritating
- Wide range of particle sizes
  - Virus (0.002–0.03 um)
  - Tree pollen (10 – 100um)
- Examples: Mold spores, animal allergens, anthrax

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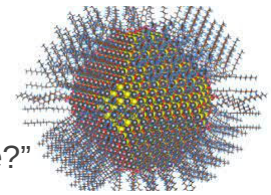
Particulate Matter - Fibers

- A special (based on toxicological properties) kind of dust that is fibrous in nature (i.e., longer than it is wide)
- Aspect ratio (L:W) defined as 3:1 or 5:1
- Toxicity a function of composition, size, and number of fibers
- Examples: Asbestos, fiberglass, refractory ceramic fibers

Looking Ahead – Engineered Nanoparticles

Engineered Nanoparticles typically include four specific characteristics:

- Very small, generally less than 100 nm in at least two dimensions
- Either free independent particles with no strong bonds to a larger substrate, ***or*** if they are attached to a substrate, they are readily displaced
- Novel, that is, only recently used or studied
- Made intentionally as a product



Industrial Hygienists will need to answer the question “Am I Safe?”

Particulate Matter – Activity

A:

B:

C:

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Quantification of Airborne Particulate Matter

Aerosols typically use mass to volume ratio for concentration

- Typical Units
  - mg/m^3
  - $\mu g/m^3$
- Importance of Units?
  - Exposure Limits

Example MIOSHA TWA PELs

- Lead Inorganic (as Pb) 50 $\mu g/m^3$
- Total Dust 15 mg/m^3
- Welding Fumes (Total Particulate) 5 mg/m^3

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Pneumoconiosis – Case Study

Pneumoconiosis is the scarring of deep lung tissues

It results from long term exposure to cytotoxic dusts, and is often not detected until it is too late

In 2013, this occupational health category resulted in 230,000 deaths globally.

- 46,000 attributed to silicosis
- 24,000 attributed to asbestosis
- 25,000 categorized as coal workers pneumoconiosis

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Hazard Recognition – Health Outcomes

Identification of hazards for further evaluation is not limited to “proactive” SDS and OEL reviews etc.

Health outcomes can also trigger a need for industrial hygiene assessment:

e.g., symptom surveys of departments for adverse effects of overexposures, employee complaints, trained senses (odor, dizziness etc.), medical diagnosis (metal fume fever, fibrosis, dermatitis, etc.)

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Hazard Recognition – Other Routes of Exposure

- Particulate matter is typically an occupational hazard when suspended in air
- Exceptions to this are skin exposure or ingestion:
  - Dermal exposure can cause direct injury (cement, Caustic soda, hex chrome burns) or allergic response (grain dust, wood dust, other bioaerosols) or systemic effects (mercury)
  - Ingestion can cause direct (beryllium) or systemic injury (Inorganic lead)
- These routes of exposure should be considered where present, and added to evaluation

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Physical Hazards - Recognition

Includes:

- Ionizing Radiation
- Non-Ionizing Radiation
- Noise
- Vibration
- Pressure Extremes
- Temperature Extremes

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Noise

- Prior to the Industrial Revolution, few people were exposed to high noise levels
- Today, workers are employed in a wide range of industries
  - Agriculture, mining, construction, manufacturing, transportation, military. etc.
- NIOSH estimates that > 4 million production workers are exposed to hazardous noise
  - This represents approximately 17% of all production workers

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Physics of Noise

- A vibrating object has acoustic energy, but this is difficult to directly measure
- Instead, we measure the pressure changes in the air caused by the vibrating object
- Perceived noise is the result of numerous pressure waves of varying characteristics hitting the ear

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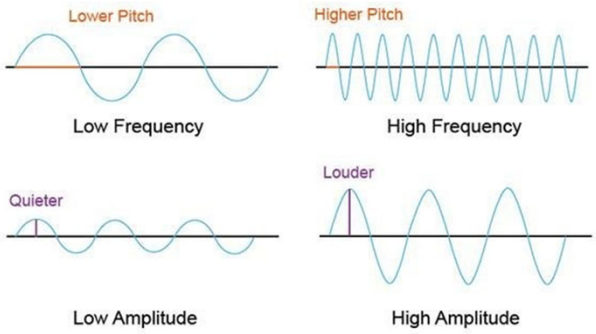
Physics of Noise

- Not all vibration is audible noise, we only hear certain amplitudes and frequencies
  - Amplitude – The amount of sound pressure measured in decibels (dB)
  - Frequency – The rate of vibration per unit time measured in cycles per second, commonly known as hertz (Hz)



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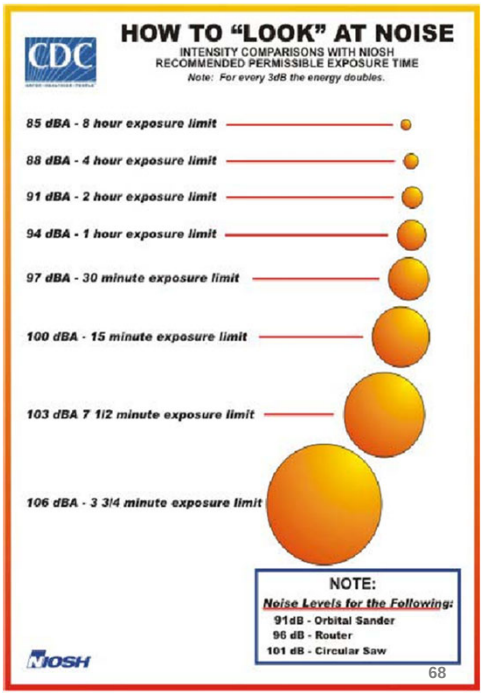
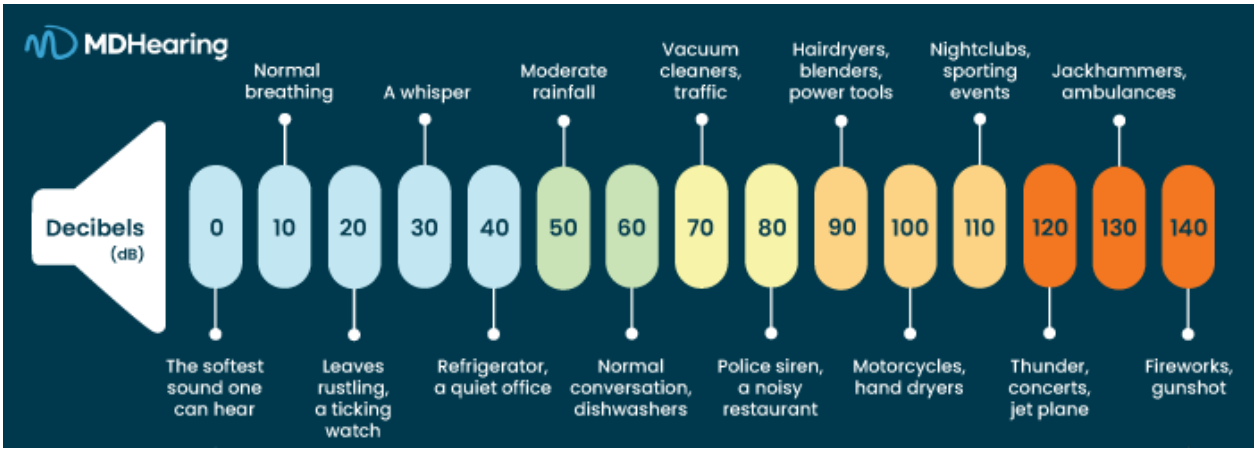
Quantification of Noise

- Sound Pressure is converted to decibels (dB) to quantify sound
- Range of 0-140 dB
  (0 is average threshold of human hearing, 140 dB is the peak for allowed exposures)
- Different Regulatory and Consensus Limits (PNEL vs REL)
  - PNEL of 90 dBA, AL of 85 dBA, Peak 140 dBA, 5 dB doubling
  - NIOSH REL of 85 dBA, 3 dB doubling



68

Quantification of Noise



69

Temperature Extremes - Heat Stress

Human Body thermoregulates to keep a normal 98.6°F core temperature

Heat stress is the amount of pressure put on that system as it works to keep body cool (98.6°F)

Environmental Factors

- Temperature
- Humidity
- Air movement
- Radiant heat sources (sun, furnace, dishwashing machine)

Personal Factors

- Metabolic heat factor (work level)
- Age, weight, degree of physical fitness
- Degree of acclimatization
- Use of alcohol or drugs, and medical conditions
- Clothing factor

70

Heat Related Illnesses

- Heat Rash
- Heat Cramps
- Heat Syncope
  (light headedness – near fainting)
- Heat Exhaustion
- Heat Stroke (Medical Emergency)

71

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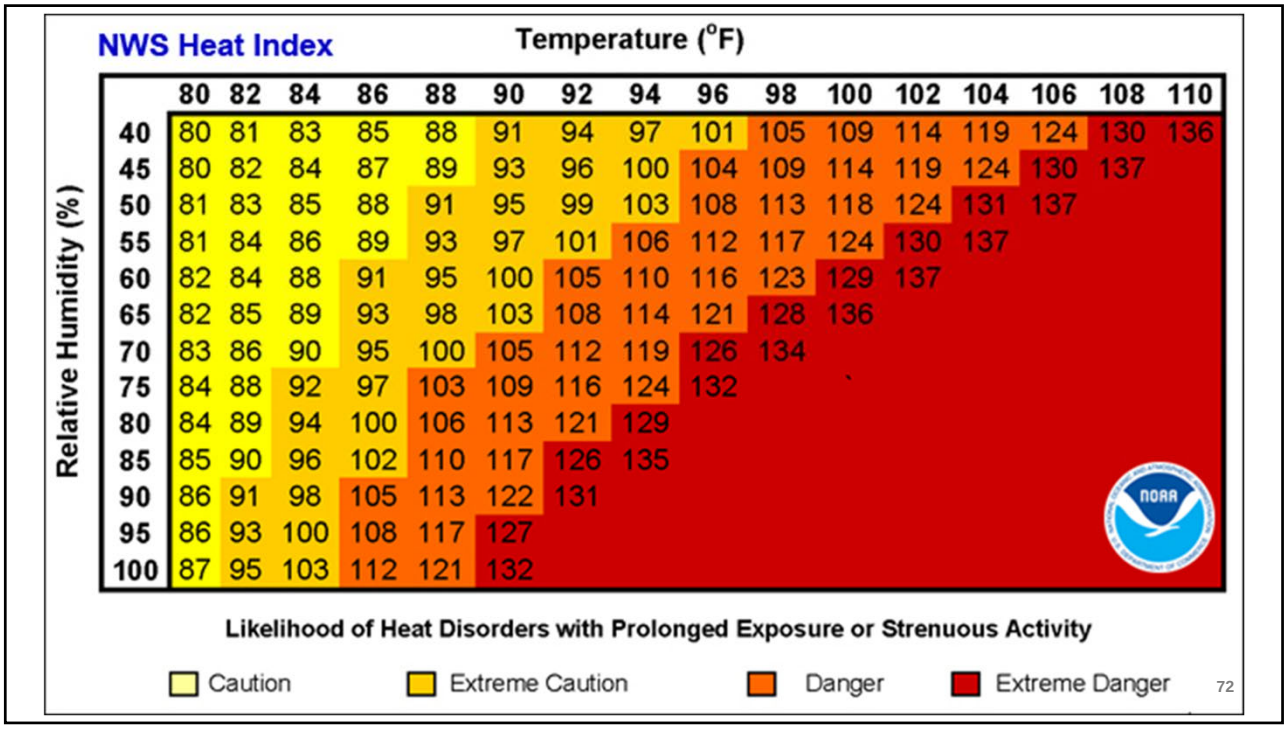

72

Ergonomics

- Physical Stressors
  - Repetitive motion
  - Heavy lifting (force)
  - Awkward or static postures
  - Contact stresses
  - Duration
- Nature of the work:
  - Manual material handling
  - Work area design
  - Tools/equipment design
- Psychological stressors
- Ergonomic solutions from NIOSH

Biological Hazards

- Encompasses all living organisms and their natural products
  - Rattlesnakes
  - Bird droppings
  - Insect infestations
  - Mold
  - Viruses
  - Bacteria

Biological Hazards – Infectious Diseases

- Can be caused by bacteria, fungi, protozoa, viruses etc.
  - 1991 OSHA promulgated the Bloodborne Pathogens Standard
    - HIV/Aids, Hepatitis B (HBV)
  - Airborne Infectious Diseases
    - Tuberculosis
    - Covid-19

75

Hazard Recognition Questions

- What is the final product?
- What are the raw materials?
- Are there any by-products?
- What equipment is involved?
- Where is the employee workstation located/ where is the work performed?
- What are routine cleaning or maintenance procedures?
- How is the waste disposed?

76

Module 4 – Evaluation of Hazards

- Objectives:
  - State the factors to be considered in an air contaminant occupational exposure evaluation
  - Differentiate between direct reading instruments and air sampling trains
  - Use an air contaminant standard to assess whether air monitoring data indicates an overexposure

77

Evaluation

- The decision-making process to determine the extent of hazards and exposures present in an environment
  - Assessment of the nature and severity of hazards
- Uses observations, employee interviews, measurement of air contaminants, and other available data

78

Hazard Evaluation Factors

- Toxicity
- Exposure Levels / Dose
- Duration of Exposure
- Process or Operation Analysis
- Irregular Tasks, Spills, Accidents
- Epidemiology Studies
- Employee Interviews
- Variability of Response
  - Age
  - Size
  - Respiratory Rate
  - General Health

79

Evaluation Prioritization

- Limited time and resources for industrial hygiene assessments often require setting of priorities
- Typically, look at one hazard “type” at a time – e.g., all departments ergonomics, noise, air contaminant, etc.
- Risk = impact x probability
  - Number of employees affected
  - Process duration
  - Toxicity of hazard
  - Amount of existing data

80

Sample Evaluation Process (Chemical)

- Identify chemical(s) in use
- Identify exposure limits for each contaminant – ACGIH TLV and MIOSHA PEL
- Identify process duration – exposure duration
- Identify number of employees exposed
- Identify current controls
- Assess exposure of air contaminants through air monitoring
- Compare to exposure limit

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Monitoring

- A continuous process to assess the extent of exposure
- Combination of Record Review, Observation, Interview, and Measurement
  - Personal
  - Area/Environmental
  - Medical Surveillance/Medical Screening
- More data points reduce uncertainty, amass good data

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Biological Monitoring / Medical Screening

- Best measure of an individual worker's total dose
- Includes multiple routes of exposure
- Includes individual risk factors (medical interaction)
- Typically blood or urine contaminant measurement
- Not well incorporated into MIOSHA standards, very extensive consensus guidance (e.g., ACGIH BEIs in TLV booklet)
- Excellent measure of effectiveness of controls/non-inhalation contribution
- Can assess acute as well as chronic exposures

83

Medical Surveillance

- Screening of entire populations (e.g., audiometric screening, lung x-rays)
- Used for early detection of disease / preliminary symptoms
- Identifies hazards for preventative control, often triggered by "Action Levels"
- Can be used to show ineffectiveness of PELs / need to use consensus standards
- 30+ MIOSHA standards have requirements for medical exams or tests
- Sometimes focus on only a single chronic health outcome, not always good for acute exposures

84

Off-site Evaluation

- Prep by review of Chemical Inventory
- Review safety data sheets (SDSs)
  - Use RELs, TLVs, in addition to PELs
- Review Process Flow Sheets or SOPs
- Any open systems or leaks/releases from closed systems
- Include non-routine tasks (maintenance, cleaning, refill, transport, disposal)
- Review past monitoring results, if available
- Of limited value, industrial hygiene is a field applied science

85

Initial Field Survey

- Conducted in advance of exposure monitoring, for design of sampling plan
  - Follow flow of materials through facility (receiving to shipping)
  - Track unwanted byproducts as well as product
  - Conducted with someone familiar with design and operation
  - Use trained senses (vision, hearing, smell)
  - Observe control measures in use (e.g., local exhaust ventilation)
  - Observation and Interview

86

Sampling

- Sampling is an estimation of actual exposure, should include reporting of uncertainty with results
- Factors to Consider
  - How to sample
  - Sampling location(s) and who to sample
  - Sampling time
  - Number of samples to collect
  - Conditions & Interferences

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Sampling Equipment

- Direct Reading
  - Immediate measurement of concentration
  - Can also show degree of variation in concentration across the day
- Sample Collection
  - Draws air through media (filter or tube)
  - Subsequently analyzed or weighed at a laboratory

88

Direct Reading – Gases and Vapors

- State of the Art – provide real time results and datalogging, software provides results from download
  - Compound-specific monitors (e.g., CO dosimeter)
  - Multi Gas Monitor
    (e.g., 4 gas confined space, IAQ Monitor)
  - Nonspecific Monitors (e.g., PID monitor)
  - Broad-Range monitors (e.g., GC/mass spec)
- Removes burden of sample handling, calculation of TWA, sampling train faults

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Direct Read - Particulates

- Measures dust, smoke, fumes and mists
- Battery operated
- Data-logging
- Uses light scattering laser photometers
- Can monitor total dust, PM10, PM 2.5, PM1 simultaneously
- Easy to program, easy to operate
- Real-time concentration readings

90

Calibration – Direct Read Instruments

- All active samplers require calibration prior to use:
  - All direct reading instruments (DRIs) must be calibrated before use
    - Full Calibration with zero and span gas
    - Bump test with known concentration
- Also, may require annual calibration depending on manufacturer's instructions (shipment back to manufacturer or third-party vendor)

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Video Exposure Monitoring

- Worker exposures are monitored with direct-reading instruments while workplace activities are simultaneously recorded.
- Low-cost system, easily donned by employee
- Benefits:
  - Recorded sampling conditions (production, interferences, controls used etc.)
  - Can show peak exposure events for control
  - Used to retrain monitored employee

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Sample Collection - Grab vs Integrated

- Grab samples are typically collected in less than five minutes and compared to peak or ceiling concentrations
- Due to sampling accuracy issues (+/- 33%), some cannot be used to demonstrate over or underexposures
- Used for screening
- Integrated Samples are used for 15-minute (STEL) to 8-hour (TWA) exposures

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Area Monitoring

- Measures concentration in ambient air
- Can be continuous (sensor installation) or periodic (portable instruments)
- May not be representative of personal TWA employee exposure
- Typically used to determine need to develop, implement, or improve controls
- Extended datalogs and video monitoring can show sources and timing of exposures
- Can be used for reentry to areas (abatement, spills)

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Personal Exposure Monitoring

- Usually, representative employees for a Similar Exposure Group (SEG)
- Usually done for specific time period (8 hours, 15 minutes)
- Must be observed due to variability of exposure, pump failure
- Monitoring device placed as close as possible to route of entry
- Active Sampling – relies on portable, battery powered pump
- Passive Sampling – relies on diffusion of contaminant onto badge

95

Sampling Train

- Basic Components:
  - Air Inlet / Size selective device
  - Collection Media
  - Flexible tubing
  - Suction pump

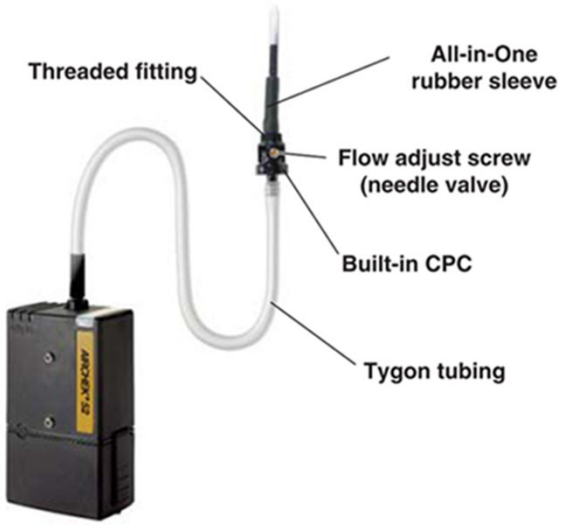

Figure 2. *All-in-One Low Flow Holder Connected to AirChek 52*

96

96

Suction Pumps

- Responsible for movement of air through sampling train
- Personal pumps should be lightweight, quiet, use rechargeable batteries, and be easily attached to the worker
- Must be listed by Underwriters Laboratory (UL) for use in flammable or explosive atmospheres, consider RF shielding
- Low Flow – 5-500 ml/min – typically for gas and vapor sampling
- High flow – 0.5-15 L/min – typically for particulate sampling
- Contain a flow rate meter which can be adjusted through calibration, which maintains a constant flow rate as the media becomes loaded

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Air Contaminant Monitoring

- Breathing zone is a 6-9 inch hemisphere in front of shoulders
  - Sample placed on shoulder of dominant hand
  - Inside of welding hood (Not attached to hood)
  - Outside of respiratory protection

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How to Sample

- Sampling method is determined by contaminant
- Methods are reviewed and approved by NIOSH, OSHA, ANSI, ASTM etc. based on precision/accuracy/repeatability
- MIOSHA/OSHA Standard may specify analytical method (e.g., asbestos or silica)
- Method lists requirements to properly collect, handle, and analyze a sample
- Typically, one sample per contaminant, some methods allow for multiple contaminant analysis

How to Sample – NIOSH Methods

[NIOSH Manual of Analytical Methods]

NMAM

LEAD by Flame AAS **7082**

Pb MW: 207.19 (Pb) CAS: 7439-92-1 (Pb) RTECS: OF7525000 (Pb)
MW: 223.19 (PbO) CAS: 1317-36-8 (PbO) RTECS: OG1750000 (PbO)

METHOD: 7082, Issue 3 **EVALUATION:** FULL **Issue 1:** 15 February 1984 **Issue 3:** 12 July 2017

OSHA: 0.050mg/m³
NIOSH: 0.050 mg/m³
OTHER OELs: [1-3]

PROPERTIES: soft metal; d 11.3 g/cm³; MP 327.5 °C valences +2, +4 in salts

SYNONYMS: elemental lead and lead compounds, except alkyl lead

SAMPLING

SAMPLER:	FILTER (0.8-µm cellulose ester membrane) or INTERNAL CAPSULE, cellulose acetate dome with inlet opening attached to filter
FLOW RATE:	1 to 4 L/min
VOL-MIN:	200 L @ 0.05 mg/m³
-MAX:	1500 L
SHIPMENT:	routine
SAMPLE STABILITY:	stable at least 7 weeks [4]
BLANKS:	2 to 10 field blanks per set

ACCURACY

RANGE STUDIED:	0.13 to 1.7 mg/m³ [8]
BIAS:	-3.1%
OVERALL PRECISION ($\hat{S}_{rT}$):	0.07 [5,6]
ACCURACY:	±17.6%

MEASUREMENT

TECHNIQUE:	ATOMIC ABSORPTION SPECTROPHOTOMETER, FLAME
ANALYTE:	lead
ASHING:	conc. HNO_3, 6 mL + 30% H_2O_2, 1 mL; 140°C
FINAL SOLUTION:	10% HNO_3, 10 mL
FLAME:	air-acetylene, oxidizing
WAVELENGTH:	283.3 nm
BACKGROUND CORRECTION:	D_2 or H_2 lamp, or Zeeman
CALIBRATION:	Pb^{2+} in 10% HNO_3
RANGE:	10 to 200 µg/sample [6,7]
ESTIMATED LOD:	2.6 µg/sample [8]
PRECISION ($\bar{S}_r$):	0.03 [5]

Selecting Sampling Methods

- Type of sampling needed (e.g., area, personal, grab)
- Sampling objective (exposures, compliance, source ID)
- Physical and Chemical properties of contaminant
- Interferences
- Technical feasibility (portability, travel time, etc.)
- Cost
- Duration of sampling

101

The Industrial Hygiene Laboratory

- Your best source of support!
- Most have a sampling guide available
- Most have client services staff/ internal CIH
- Pay attention to minimum/maximum air volumes (number of samples)
- Submit blanks (field or media)
  - Field – to determine if handling caused contamination, briefly opened
  - Media – to determine if media was received contaminated from lab, not opened

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Collection Media

- Direct read instruments often do not require use of collection media
- Time integrated instruments do require use of media
- Type of media used depends on instrumentation and contaminant state
  - Sorbent tubes (gases, vapors)
  - Filter cassettes (particulates)
  - Passive monitors (gases, vapors)

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Sorbent Tubes

- Charcoal Tubes
  - High adsorptive capacity for wide range of organic gases and vapors
  - Can be used to sample for several kinds of vapors at once
  - Limit is on number which can be extracted from one tube (talk to lab)
- Silica Gel Tubes
  - Used for contaminant not able to be collected or extracted from charcoal
  - Silica gel is electrically polar and attracts interfering compounds (water vapor)
- Other tubes (XAD-2, Tenax-GC, Ambersorb, Chromosorb)

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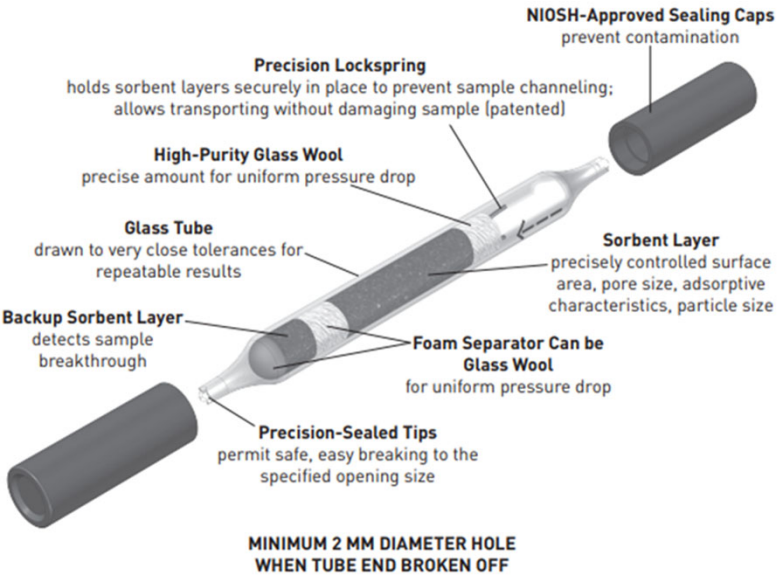

105

Breakthrough

- Overloading a sorbent tube
- Tube has two or more sections of sorbent material
- If flow rate or concentration are too high, some contaminants pass through first section and are collected on the second (back up section)
- If more than 10% of the mass collected on front section is found in second section, a significant quantity of the contaminant in the atmosphere has not been collected, and analytical results will underestimate actual concentration

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Passive Diffusion Samplers

- Do not require use of a pump, calibrator etc.
- Inexpensive and easy to use
- Highly accurate
- Requires some air movement and moderate temperatures
- Cannot be used in applications where semi-permeable barrier becomes obstructed (painting)

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Particulate Media - Filters

- Most common particulate collection media
  - Mixed Cellulose Ester (MCE)
  - Polyvinyl Chloride (PVC)
  - Glass Fiber (GF)
- Selected based on their ability to collect material and suitability to lab analysis
- Examples
  - Total dust - PVC filters used because they are easily weighed
  - Metals - MCE filters used because they have low metal background levels

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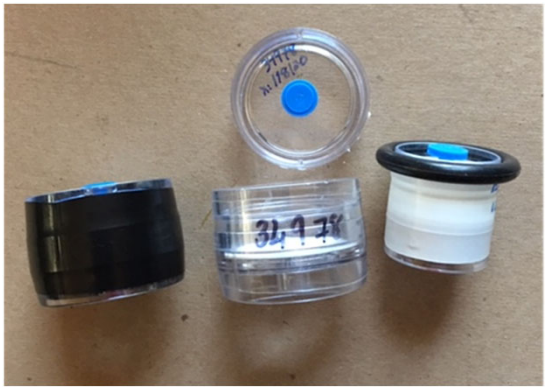
Cassettes

- Protects filter and prevents air bypass
- Closed face – top of cassette is not removed during sampling, only caps removed (e.g., metals)
- Open face
  - Top of cassette is removed during sampling (e.g., asbestos, silica)
  - Some contain chemically treated filters (e.g., isocyanates)
  - These have special handling requirements



109

Size Selective Samplers - Cyclones

- Some particulate air contaminants have limits for respirable dust (e.g., silica)
- Where respirable dust exposures need to be evaluated, an additional component needs to be added to the sampling train at the air inlet
- Cyclones or Parallel Particle Impactors (PPI) are used to separate larger dust particles from the smaller respirable dust collected on the filter
- Different size selective samplers have different flow rates they must be used at

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Filter Overloading

- Collecting too much particulate on a single filter
- Indicated by loose or excessive material on the filter or cassette walls (dust cake)
  - Must check filter periodically during sampling, change out when visible accumulation
- Typically occurs at approx. 1 mg of sample on 37 mm open face cassette
- Leads to underestimation of contaminant concentration in atmosphere
  - Dust falls off filter instead of being retained for analysis

111

Sampling Strategy

- Samples should represent, as closely as possible, workers' exposures
- When quantifying exposures, consider purpose of monitoring (Routine / Nonroutine) when selecting employees monitored
- Use the employee closest to hazard source (with the highest potential exposure) for monitoring
- Consider work habits observed, experience, output
- Sample for each occupational exposure limit (OEL)

112

Number of Samples

- The Art of Industrial Hygiene
- No predetermined number, depends on:
  - OELs (Ceiling, STEL, TWA, extended shift)
  - Sampling method
  - Number of different tasks performed
  - Variability of exposure
  - Contaminant concentrations
  - Cost

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Recordkeeping

Complete and detailed as to:

- Sampling procedures
- Sampling conditions
- Sample results
- Identity of equipment
- Identity of collection devices
- Calibration procedures and results
- Identity of analytical laboratory
- Air sampling calculations

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Sampling Notes

Use a worksheet which prompts notes:

- Total time sampled
- Pump flow rate
- Location
- Identity of person monitored
- Process being evaluated
- Engineering controls in use (e.g., local exhaust ventilation in place)
- Personal Protective Equipment (PPE) worn (e.g., was hearing protection or a respirator worn)
- Work practices (e.g., was compressed air used to blow off parts)
- Anything else that would be required to replicate sampling? (e.g., number of parts produced, employee shift duration)

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Example: Welding Sampling Notes

- Name and Location of welder
- Material being welded (mild steel)
- Types of welding (MIG, TIG, etc.) rod/wire used (and amount if possible)
- Number of pieces welded
- Use of PPE
- Location/use of Local Exhaust Ventilation (LEV)
- LEV performance check results (e.g., using smoke tube testing to see if exhaust is drawing)
- Time of year/dilution ventilation present (general wall exhaust fans, overhead bay doors open)
- Anything that helps interpret the result or repeat monitoring conditions

116

Calibration – Integrated Samplers

- Pumps must be calibrated to the flow specified in the selected analytical method.
- Sample volume depends on flow rate and elapsed time
  - Primary – direct measurement of airflow
    - Soap Bubble Burette (outdated)
    - Electronic Instruments (modern)
  - Secondary indirect measurement of airflow which must be periodically calibrated with a primary calibrator
    - Rotameter

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Calibration Procedure

- Assemble sampling train
- Select one collection media, mark it as calibration media “CAL”
- Connect calibration media between sampling train and calibrator
- Start pump and use calibrator to determine flow rate (average of 10 readings)
- Record as this value as the pre calibration flow rate
- Remove calibration media, insert field sample media, and collect samples through day
- At end of sampling event, reconnect calibration media and repeat procedure to determine and record post calibration flow rate

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Personal Exposure Sample Collection

- Place sampling train on representative employee at start of work shift
  - Communicate purpose of sampling and pump function
  - Gather information needed for sampling worksheet
  - Turn on and place air sampling suction pump on worker
  - Place and secure flexible tubing to the worker
  - Place sampling media near breathing zone and outside PPE
  - Review sampling train for kinks, disconnected elements, and comfort/mobility of worker

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Sample Handling

- Based on sampling plan, samples may need to be periodically swapped out
- To swap media, take fresh media and media plugs out to worker
- Remove media from sampling train and immediately insert media plugs and place sample seals
- Remove plugs from fresh media and place onto sampling train
- Record start and stop times and any additional recordkeeping notes
- Follow any special handling requirements from analytical method (keep cool, protect from light)

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Sample Shipment

- Follow any and all special handling requirements
  - Sample retention time (e.g., Hexavalent Chromium must ship within 24 hours)
  - Temperature (e.g., isocyanates ship on ice)
  - Protect from vibration
  - Protect from light
- Bulk samples may also be requested by lab, ship separate from air samples
- Place sealed samples into gallon ziplock bag with chain of custody, requested analysis, and volume of air collected for each sample, hand deliver or FedEx to analytical lab

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Chain of Custody

- Like police evidence, samples collected have a specific document to track who has had control of the sample from its time of collection until its ultimate analysis at a lab, a chain of custody.
- Typically, this lists the name of the IH collecting the sample, the name of the transporting entity, and the name of the lab technician who received the sample for analysis.
- Multiple samples may share a common chain of custody.
- A copy of the chain of custody is transferred with the sample results back to the industrial hygienist, often noting any issues with the condition of the samples when received.

122

Analytical Results

- Use only an AIHA accredited lab to determine the mass of contaminant collected on each sample.
- In addition to reporting the mass of contaminant, the lab may also report the concentration based on the reported volume of air collected on each sample
  - Ensure correct units are used for comparison to the OEL (e.g., mg or µg)
- To compare a worker's sampling results to an OEL, either the time monitored for a sample must match the OEL (e.g., a 15-minute sample's result compared to the STEL) or multiple samples may need to be combined for comparison.

123

Time Weighted Average (TWA) Exposures

- Most air contaminants have an 8-hour TWA limit
- Most sampling strategies require collection of multiple samples across an 8-hour period
- In order to calculate the worker's TWA exposure, it is necessary to combine multiple sample analytical results
- Results are not simply averaged, but are time weighted:

$$TWA = \frac{C1T1 + C2T2 + \cdots + CnTn}{8\ hours}$$

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Analytical Results Example

28. Pump Model: SKC Airchek		Pump #: 01763	
29. Sample Submission Number		WD-1	WD-2
30. Sample Type/Media		LAPVC	LAPVC
31. Filter/Tube Number		31408	31365
32. Time On		7:00 am	12:93 pm
Time Off		11:52 am	3:13 pm
33. Total Time (in minutes)		292	154
34. Flow Rate ☒ l/min ☐ ml/min		2.006	2.006
35. Volume (in liters)		586	309
36. Lab Sample Number		172231	172232
37. Analyze For:	38. RL*		
1. 2587 Welding Fume	40µg	1.4	0.82
2. Metal Scan			

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Standard Error / Uncertainty

- All samples are estimates of exposures, and all have inherent error
  - Airflow – calibration error by the IH
  - Time – time period measurement error by IH
  - Analytical – inherent error in lab method
- The analytical lab report issued will contain a statement of the Sampling and Analytical Error (SAE)
- Each calculated exposure needs to reflect this potential error, and therefore upper and lower confidence limits are calculated:
  - UCL = severity plus SAE
  - LCL = severity minus SAE

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Interpretation of Results / Unit Conversion

- Evaluation ends with a decision, are exposures acceptable or unacceptable?
- Analytical results are compared to exposure limit(s)
  - MIOSHA PELs for legal compliance (< 500 Air Contaminants in Part 301)
  - NIOSH RELs or ACGIH TLVs for employee safety and health (< 1200 combined)
  - Exposure Banding or other literature where no published OEL
- Results may need to be adjusted based on error or sampling conditions
  - Gas and vapor samples are often corrected for temperature and altitude by the lab

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IH Reporting

- Ultimately, the IH report provides the employer with the results of your evaluation, including:
  - Description of scope and purpose of assessment
  - Sampling Information
  - Analytical Report
  - Chain of Custody
  - Reporting of Sampling Results
  - Indicate if OELs exceeded and recommended controls

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Module 5 – Control of Hazards

- Objectives
  - Describe examples of the different methods of control
  - Differentiate local exhaust ventilation (LEV) and dilution ventilation in industrial settings
  - State the limitations of respiratory protection

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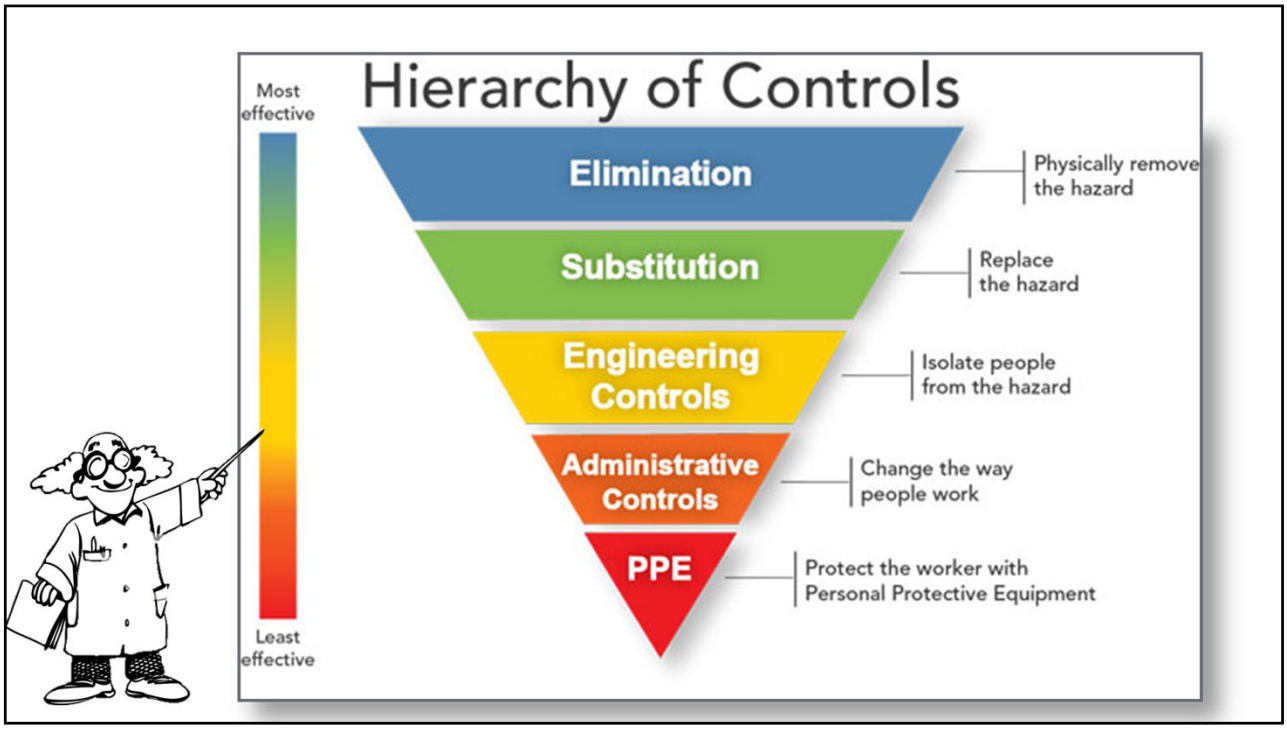
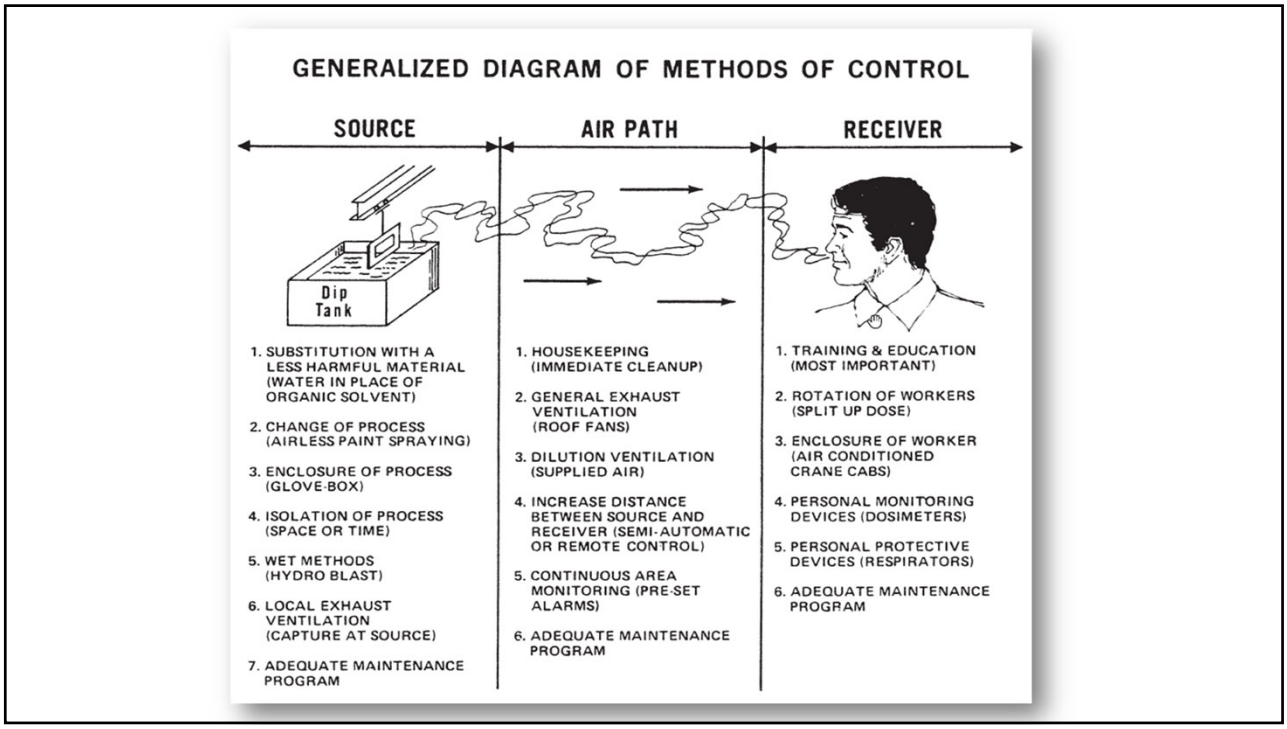
Hazard Control

- Controls reduce or eliminate employee exposure to hazards
- Where overexposures are identified, they must be controlled:
  - PELs exceeded must be controlled as a matter of law, Part 301 for General Industry
  - RELs/TLVs exceeded should be controlled to prevent employee injury and illness
- Effectiveness of implemented controls is then determined by reassessment

130


Hierarchy of Controls
Most effective
Least effective
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment

131


GENERALIZED DIAGRAM OF METHODS OF CONTROL
SOURCE
AIR PATH
RECEIVER
Dip Tank
1. SUBSTITUTION WITH A LESS HARMFUL MATERIAL (WATER IN PLACE OF ORGANIC SOLVENT)
2. CHANGE OF PROCESS (AIRLESS PAINT SPRAYING)
3. ENCLOSURE OF PROCESS (GLOVE-BOX)
4. ISOLATION OF PROCESS (SPACE OR TIME)
5. WET METHODS (HYDRO BLAST)
6. LOCAL EXHAUST VENTILATION (CAPTURE AT SOURCE)
7. ADEQUATE MAINTENANCE PROGRAM
1. HOUSEKEEPING (IMMEDIATE CLEANUP)
2. GENERAL EXHAUST VENTILATION (ROOF FANS)
3. DILUTION VENTILATION (SUPPLIED AIR)
4. INCREASE DISTANCE BETWEEN SOURCE AND RECEIVER (SEMI-AUTOMATIC OR REMOTE CONTROL)
5. CONTINUOUS AREA MONITORING (PRE-SET ALARMS)
6. ADEQUATE MAINTENANCE PROGRAM
1. TRAINING & EDUCATION (MOST IMPORTANT)
2. ROTATION OF WORKERS (SPLIT UP DOSE)
3. ENCLOSURE OF WORKER (AIR CONDITIONED CRANE CABS)
4. PERSONAL MONITORING DEVICES (DOSIMETERS)
5. PERSONAL PROTECTIVE DEVICES (RESPIRATORS)
6. ADEQUATE MAINTENANCE PROGRAM

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Industrial Hygiene Control Methods

- Design Phase Engineering
- Substitution
- Change the Process
- Isolation
- Ventilation
  - General Ventilation
  - Local Exhaust Ventilation (LEV)
- Wet Methods
- Personal Hygiene
- Maintenance & Housekeeping
- Waste Disposal
- Medical Controls
- Personal Protective Equipment
- Education & Training

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Design Phase Engineering

- The best time to introduce engineering controls is early, during planning.
- A process or plant should be designed with contaminant control and ventilation as a forethought, not an afterthought.
- Questions to consider:
  - To what degree can we remove/reduce the hazardous substance(s)?
  - Can the system be designed to operate maintenance free?
  - Can the operation be conducted as a closed system?
  - Can the process be automated to minimize worker involvement?

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Substitution: Changing the Material

- Substitute nontoxic or less toxic materials for highly toxic materials:
  - e.g., use walnut shells for abrasive blasting instead of silica
- Often inexpensive and easiest method of control, once hazards are recognized
- Must be used cautiously to ensure new hazards are not introduced (e.g., flammability)

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Substitution: Changing the Process

- Most production process changes are done to improve quality or reduce cost
- Processes can also be changed to reduce exposures
  - Brush painting or dipping instead of spray painting
  - Vapor degreasing with ventilation to replace manual degreasing with shop rags
  - Electrostatic coating instead of spray painting

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Engineering Controls

- Removing employee from the hazard
  - Physical barriers
  - Isolation in time or space from bulk of employees
  - Control room/booth for operator
  - Enclosure of process
  - Automation

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Ventilation

- Strategically supplying or exhausting air to:
  - Dilute air contaminants levels
  - Remove contaminants at their source
  - Heat or cool work environment
  - Control humidity, odor, other environmental conditions for employee comfort

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General Exhaust Ventilation

- Uses natural convection or air movement provided by blowers to exchange facility air
  - Requires large volumes of clean makeup air
  - Does not control exposure of employee close to the contaminant
  - Equipment for moving, filtering and tempering air is expensive
- Limited to use where:
  - Slow generation
  - Low toxicity contaminants
  - No treatment of exhaust air is required (EGLE/MIOSHA)

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Local Exhaust Ventilation (LEV)

- Ventilation which captures or contains contaminant at the source (e.g., welding fume exhaust hood, lab hood)
  - Requires less airflow than dilution ventilation, lower cost for tempering makeup air
  - Systems must be properly designed and balanced
  - Must be properly positioned and maintained to work properly
  - Can be installed or portable

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Local Exhaust Ventilation System

- Hoods – point where air is drawn into the system, fits around contaminant source
- Ducts – network of piping that connects air system components and carries contaminant laden air stream
- Fan – air moving device that provides energy to draw air into system
- Air Cleaner – device which removes airborne materials before exhaust air is discharged to the environment

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Local Exhaust Ventilation Evaluation

- Smoke Tube – illustrates capture range and system effectiveness, used to assess relative pressurization of a room, used for worker training (e.g., importance of welding close to the LEV hood)
- Velocity Measurements (fpm) – hot wire anemometer used to assess capture velocity, average face velocity across a booth (e.g., paint booth or lab hood)
- Static Pressure Measurements – done using a pitot tube and manometer to evaluate performance and diagnose ventilation system problems

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Administrative Controls

- Work Period Reduction (e.g., heat stress)
- Job rotation (e.g., ergonomics)
- Appropriate work practices
- Proper maintenance
- Personal hygiene
- Employee Training
- Supervision and management
- Maintenance and housekeeping

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Wet Control Methods

- Alternatively classified as engineering or administrative depending on degree of employee involvement
- Applying a water spray before sweeping is an administrative control
- Water curtains used for pickling lines would be an engineering control

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Personal Hygiene

- Providing employees with adequate facilities to wash and remove contaminants
  - Required under OSHA/MIOSHA standards for certain exposures (e.g., asbestos, lead, coke ovens, etc.)
- Primarily hand washing to quickly wash exposed skin
- Easy access is key
- Eating, storage of food, drinking forbidden for certain exposures (e.g., lead)
- Change rooms and showers may be required

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Housekeeping

- Always important for workplace safety, but when toxic materials present in the workplace, is of greater significance in protecting worker health
- Re-entrainment increases number of employees exposed as well as dose
- Remove settled dusts before they can become resuspended in air
  - Traffic
  - Vibration
  - Air currents
- Immediately clean up spills and leaks, dispose of rags in airtight metal containers
- Use of HEPA vacuums, never use compressed air

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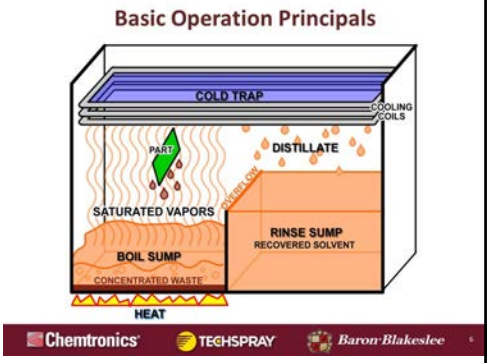
Maintenance

- Vapor Degreaser Example
  - If thermostat breaks, seal fails, or ventilation is insufficient, solvent concentrations quickly accumulate
- Sensors useful to detect leaks
- Periodic shutdowns for PM (clean and repair) require SOPs
  - Flushing, Lockout, Confined Space, Use of LEV, PPE
- Air Monitoring is essential during non-routine tasks to develop database of effective controls



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Personal Protective Equipment

- Last resort when engineering and administrative controls are implemented and insufficient to reduce exposures to safe levels
  - Short exposures
  - Nonroutine tasks
  - Emergency response
- Hazard still exists, any failure of PPE results in exposure without worker knowledge
- PPE assessment is required by MIOSHA, written certification required

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Respiratory Protection Devices

- PPE for inhalation route of exposure
- Selected based on:
  - Type of air contaminant
  - Expected maximum concentration
  - Possibility of oxygen deficiency
  - Useful life of the respirator
  - Escape routes available

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Types of Respirators

- Air Purifying Respirators (APRs) - remove contaminant from breathing air by filtering or chemical absorption
  - Half-mask – cover the mouth and nose
  - Full-facepiece – Also protect the eyes
  - Powered air may be preferred as cooler and offer no resistance to breathing
- Air Supplied Respirators – Provide clean air from an outside source
  - Supplied-Air respirator (SAR) – an airline respirator that must have source of Grade D breathing air (compressor or cylinders), source of breathing air is not designed to be carried by the user.
  - Self-contained breathing apparatus (SCBA) – face masks attached by hoses to compressed air cylinder, breathing air source is designed to be carried by the user.

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Protective Clothing

- Barrier to hazards that cause injury when in contact with the skin
  - Gloves, gauntlets, boots, aprons, coveralls
- Determine hazards present and tasks to be performed
  - Physical limitations
  - Material chemical resistance
  - Ease of decontamination/disposal
  - Cost, physical strength, fire resistance
- No material protects against all chemicals, discuss with manufacturer

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Eye and Face Protection

- Safety Glasses, Chemical Goggles, Face Shields
- Glasses for particulates
- Goggles for splashes and vapors
  - Direct, indirect, and non-vented available, do not use direct vent where vapors present
- Faceshield for direct splash to face, does not protect eyes
- UV filters for glasses, welding face shields

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Hearing Protection

- Earplugs or Earmuffs
  - Must be properly selected, fitted, and worn
  - Provide when noise level above 85 dBA and require use if noise level above 90 dBA (or STS and 85 dBA)
  - Plugs - insert to fit to ear canal
  - Muffs – seal to head around ear

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Education and Training

- Needed for ALL employees exposed to hazards
  - Supervisors must know hazards of operations
  - Employees must know proper procedures and how to operate controls
    - If hazardous chemicals present, Hazard Communication training required
  - Establish for internal health hazard evaluations (e.g., peer observations/audits)
  - Establish for emergency response procedures (e.g., small vs. large spill clean up)
  - OSHA/MIOSHA standards set specific training requirements (e.g., asbestos awareness)

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Any Questions?

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Assessment

- The purpose of this assessment is to validate the knowledge learned in class.
- Passing score of 70% correct is required.
- Class reference materials/books are not allowed to be used during the test.
- Collaboration/discussion with others is not allowed during the test.
- Answers will be reviewed after everyone completes and submits their test.

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Thank you.
Don’t Forget to Take the Survey
MIOSHA
Michigan Occupational Safety and Health Administration

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Fundamentals of Industrial Hygiene

Student Resources

MIOSHA Standard:

Part 301. Air Contaminants for General Industry

Other Resources:

OSHA Technical Manual (OTM) Section II: Chapter 1

MIOSHA Training Institute (MTI) Resources:

www.michigan.gov/mti

MIOSHA Training Calendar:

www.michigan.gov/mioshatraining

MIOSHA Homepage:

www.michigan.gov/miosha

Michigan Department of Labor and Economic Opportunity
Michigan Occupational Safety and Health Administration
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