PROCESS SAFETY ENGINEERING (0905477)

07- INDUSTRIAL HYGIENE

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The superior man, when resting in safety, does not forget that danger may come…. When all is orderly, he does not forget that disorder may come. Confucius (551 BC – 479 BC)

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Outline

- Definition
- Environmental stressors
  - Air contaminants
  - Chemical
  - Biological
  - Physical
  - Ergonomic
- What Is an Industrial Hygienist?
- Industrial Hygiene Phases
  - Identification
  - Evaluation
  - Control

Definition

- **Industrial hygiene** is a science devoted to the **identification, evaluation, and control** of occupational conditions that cause sickness and injury.
- Industrial hygiene is concerned with **predicting, recognizing, assessing, controlling, and preventing** workplace environmental stressors that can cause sickness or serious discomfort to workers.

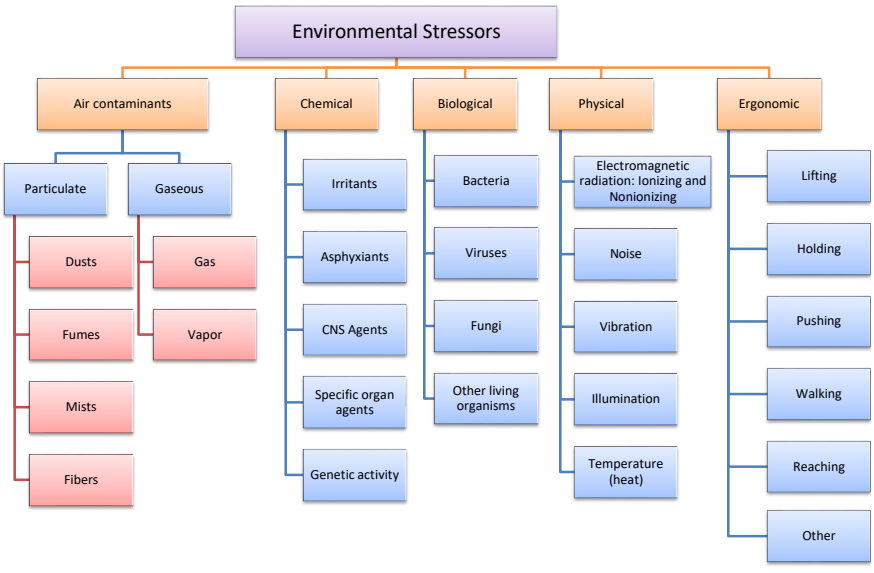
Worker safety and well-being

Health, Safety and Wellbeing
Work safe, live well

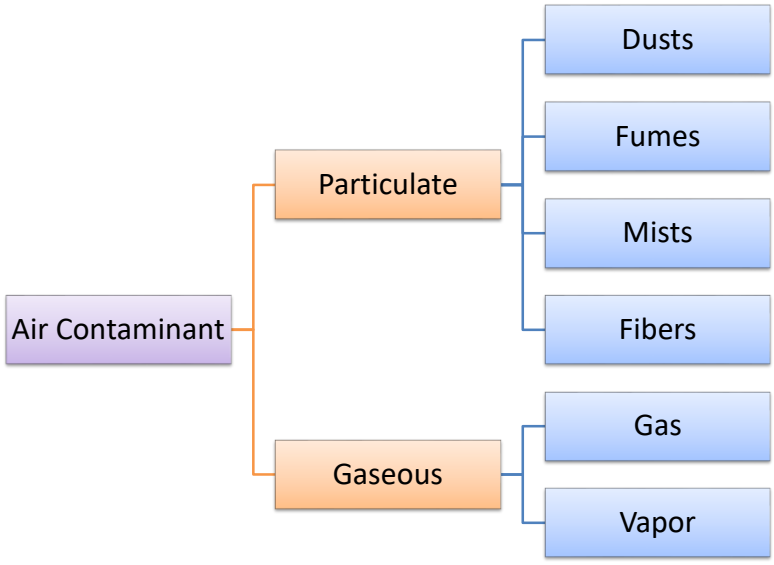
OSHA Information Booklet #3143 -- Industrial Hygiene
https://www.osha.gov/Publications/OSHA3143/OSHA3143.htm

Environmental Stressors

- Any factor that can cause enough discomfort to result in lost time or illness.

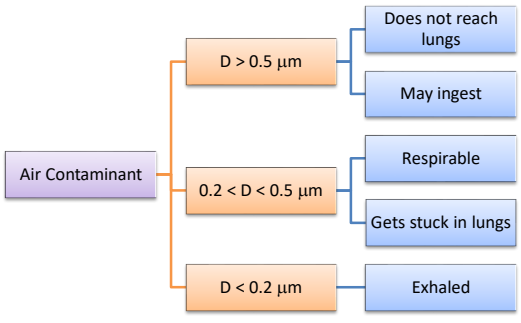


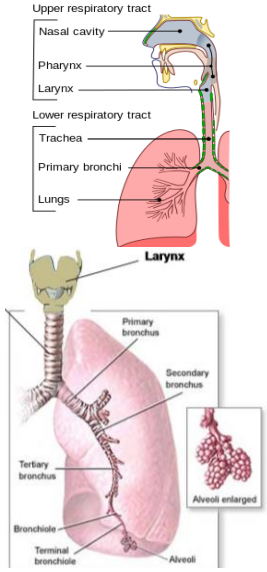
Air Contaminants



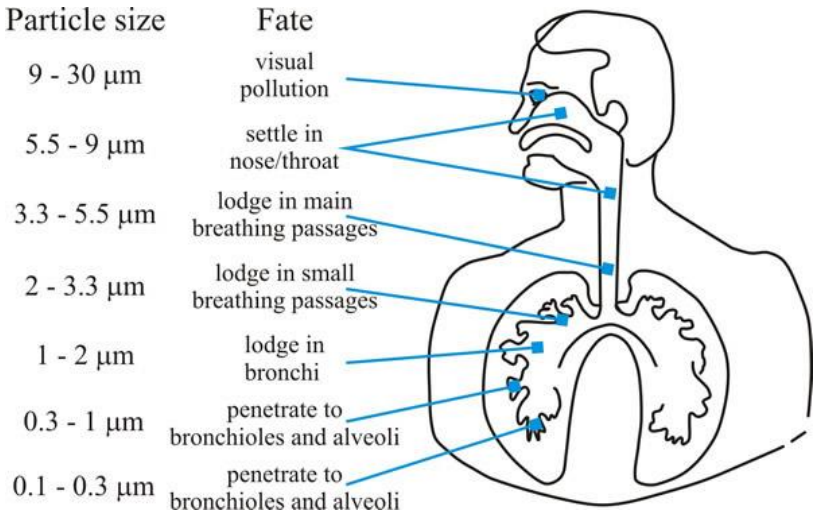
Air Contaminants

- Concerned about particle size and its penetration into the pulmonary track.



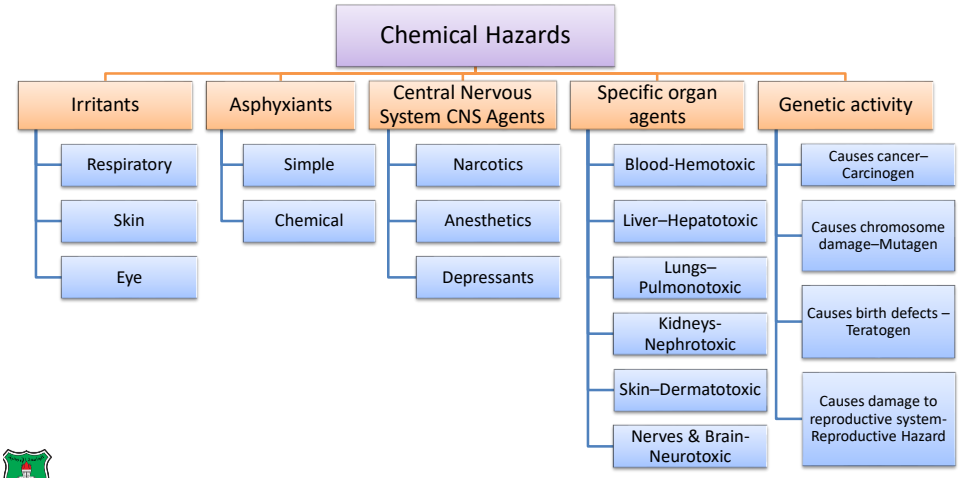


Fate of Air Contaminants

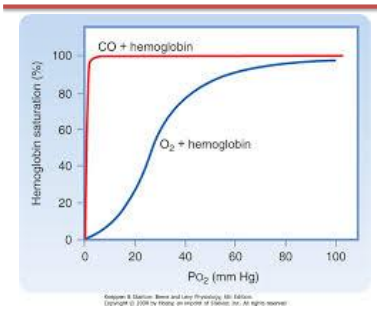


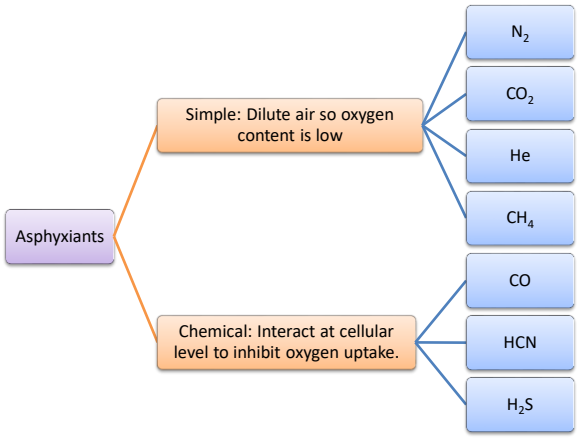
Chemical Hazards

- The degree of worker risk from exposure to any given substance depends on the **nature** and **potency** of the toxic effects and the **magnitude** and **duration** of exposure.



Asphyxiants





Chemical Hazards: MSDS

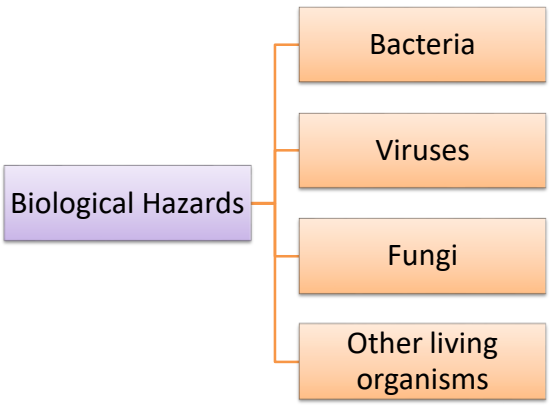
- Information on the risk to workers from chemical hazards can be obtained from the **Material Safety Data Sheet (MSDS)**
  - The **MSDS** is a summary of the important health, safety, and toxicological information on the chemical or the mixture's ingredients.
  - OSHA'S Hazard Communication Standard requires MSDS to be supplied by the manufacturer or importer to the purchaser of all hazardous materials.
  - Other provisions of the Hazard Communication Standard require that all containers of hazardous substances in the workplace have appropriate warning and identification labels.

MSDS or SDS

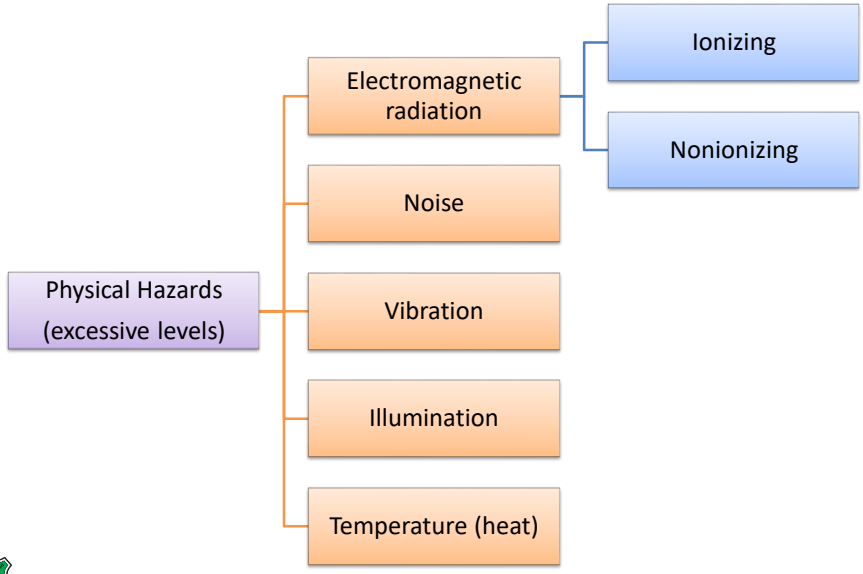
Check out the H_2S MSDS in this link

Biological Hazards

- Can cause acute and chronic infections by entering the body either directly or through breaks in the skin.



Physical Hazards



Noise Hazard Recognition

The DeciBel (dB)

Sound level in dB

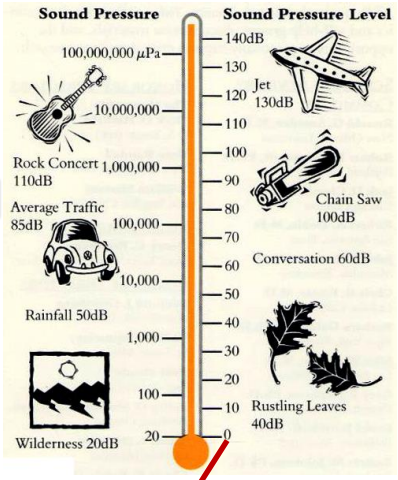
Sound intensity

Threshhold of hearing

$$L\,(\mathrm{dB}) = 10\log_{10}\left[\frac{I}{I_0}\right]$$

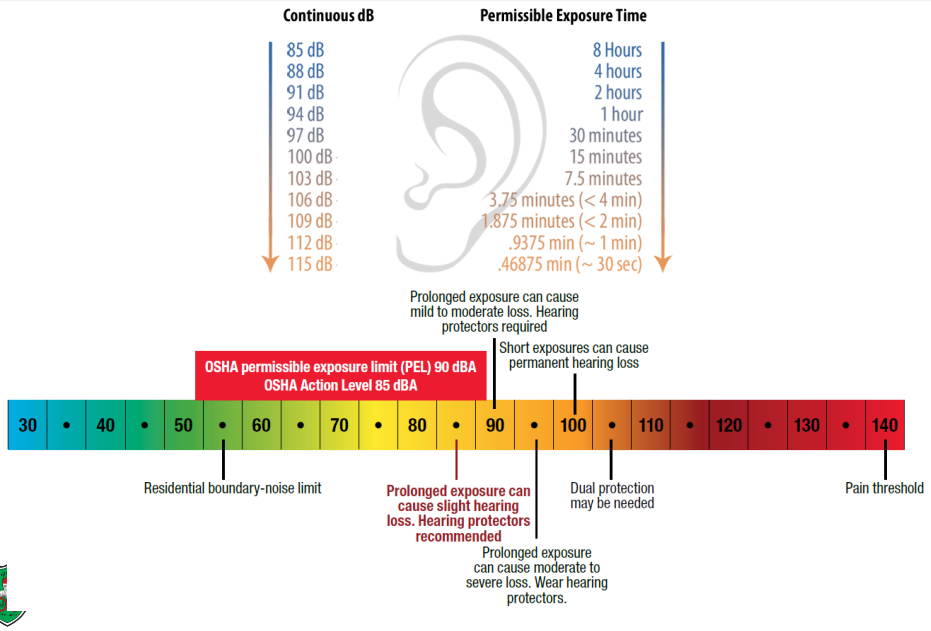
$$= 10\log_{10}\left[\frac{P^2}{P_0^2}\right] = 20\log_{10}\left[\frac{P}{P_0}\right],$$

$$P_0 = 2\times10^{-5}\ \mathrm{Pa}$$

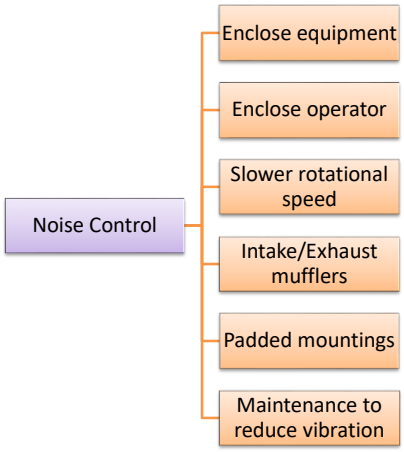


Limit of hearing (silence)

OSHA PEL for Noise



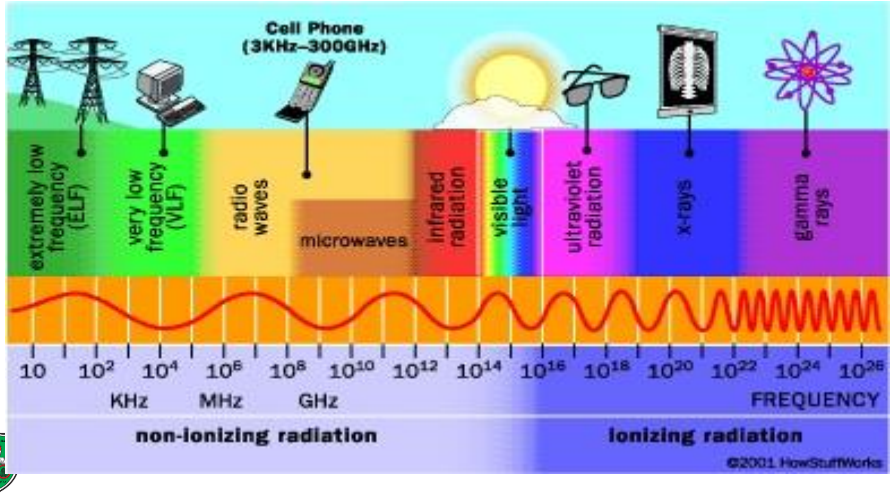
Noise Control



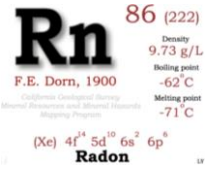
HW: Search for noise control technologies for FCC in petroleum refineries.

Radiation

The complete process in which energy is emitted (transmitted) by one body (source), transmitted through an intervening medium or space, and absorbed by another body.



Sources of Exposure to Radiation



- Exposure to radiation
  - Due to Human Activities
    - Medical/Dental X-ray (39 mrem ~ 11%)
    - Nuclear medicine (14 mrem ~ 4%)
    - Consumer products (10 mrem ~ 3%
    - Other (<1%)
  - Due to Natural Sources
    - Radon (200 mrem ~ 55%)
    - Inside human body (40 mrem ~ 11%)
    - Soil and rocks (28 mrem ~ 8%)
    - Cosmic rays (27 mrem ~ 8%)

Data from NCRP report no. 93.
Other may include: occupation, nuclear fuel cycle, fallout, etc.

Types of Radiation

- Radiation
  - Ionizing
    - Alpha
    - Beta
    - Gamma
  - Nonionizing
    - Gamma

Alpha Radiation

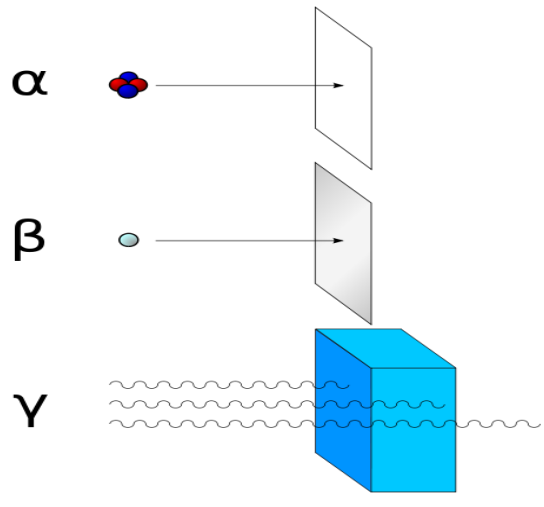
- A heavy, very short-range particle and is actually an ejected helium nucleus.
- Some characteristics are:
  - Most alpha radiation is not able to penetrate human skin.
  - Alpha-emitting materials can be harmful to humans if the materials are inhaled, swallowed, or absorbed through open wounds.
  - A variety of instruments has been designed to measure alpha radiation. Special training in the use of these instruments is essential for making accurate measurements.
  - A thin-window Geiger-Mueller (GM) probe can detect the presence of alpha radiation.
  - Instruments cannot detect alpha radiation through even a thin layer of water, dust, paper, or other material, because alpha radiation is not penetrating.
  - Alpha radiation travels only a short distance (a few inches) in air, but is not an external hazard.
  - Alpha radiation is not able to penetrate clothing.
- Examples of some alpha emitters: radium, radon, uranium, thorium.

Beta Radiation

- A light, short-range particle and is actually an ejected electron.
- Some characteristics of beta radiation are:
  - May travel several feet in air and is moderately penetrating.
  - Can penetrate human skin to the "germinal layer," where new skin cells are produced. If high levels of beta-emitting contaminants are allowed to remain on the skin for a prolonged period of time, they may cause skin injury.
  - Beta-emitting contaminants may be harmful if deposited internally.
  - Most beta emitters can be detected with a survey instrument and a thin-window GM probe (e.g., "pancake" type). Some beta emitters, however, produce very low-energy, poorly penetrating radiation that may be difficult or impossible to detect. Examples of these difficult-to-detect beta emitters are hydrogen-3 (tritium), carbon-14, and sulfur-35.
- Clothing provides some protection against beta radiation.
- Examples of some pure beta emitters: strontium-90, carbon-14, tritium, and sulfur-35.

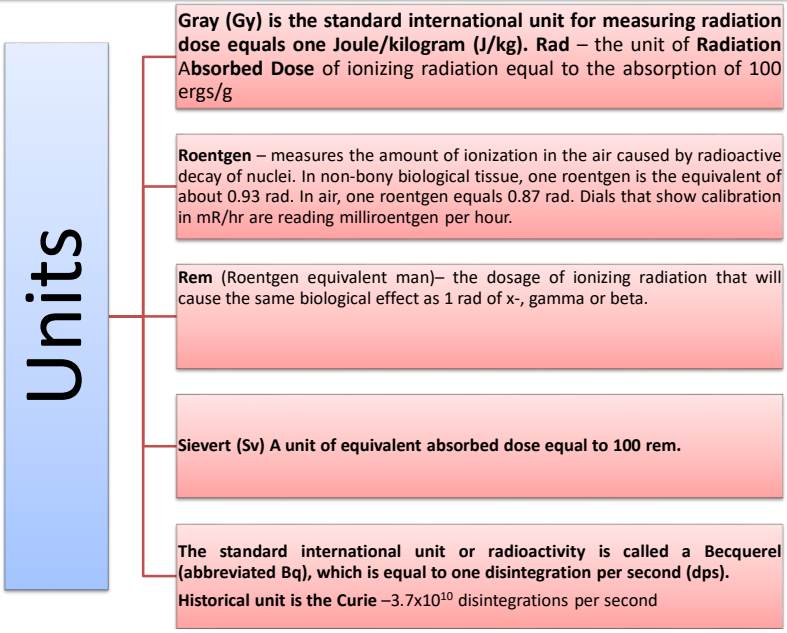
Gamma Radiation and x-Rays

- Highly penetrating electromagnetic radiation.
- Some characteristics of these radiations are:
  - Gamma radiation or x rays are able to travel many feet in air and many inches in human tissue. They readily penetrate most materials and are sometimes called "penetrating" radiation.
  - X rays are like gamma rays. X rays, too, are penetrating radiation. Sealed radioactive sources and machines that emit gamma radiation and x rays respectively constitute mainly an external hazard to humans.
  - Gamma radiation and x rays are electromagnetic radiation like visible light, radiowaves, and ultraviolet light. These electromagnetic radiations differ only in the amount of energy they have. Gamma rays and x rays are the most energetic of these.
  - Dense materials are needed for shielding from gamma radiation. Clothing provides little shielding from penetrating radiation, but will prevent contamination of the skin by gamma-emitting radioactive materials.
  - Gamma radiation is easily detected by survey meters with a sodium iodide detector probe.
  - Gamma radiation and/or characteristic x rays frequently accompany the emission of alpha and beta radiation during radioactive decay.
- Examples of some gamma emitters: iodine-131, cesium-137, cobalt-60, radium-226, and technetium-99m.



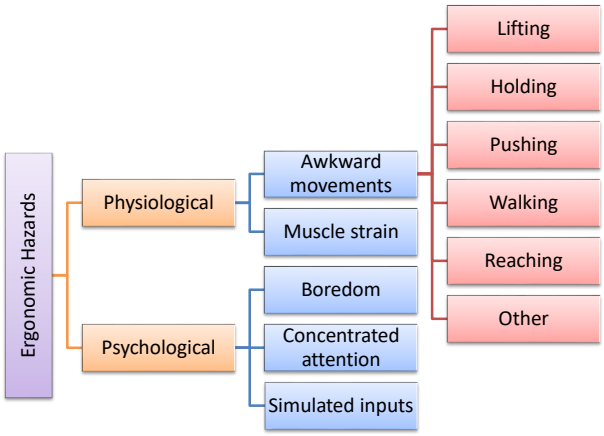
Alpha radiation consists of helium-4 nucleus and is readily **stopped by a sheet of paper**.
Beta radiation, consisting of electrons, is halted by an **aluminium plate**.
Gamma radiation is eventually absorbed as it **penetrates a dense material**. Lead is good at absorbing gamma radiation, due to its density.

Common Units to Measure Radiation



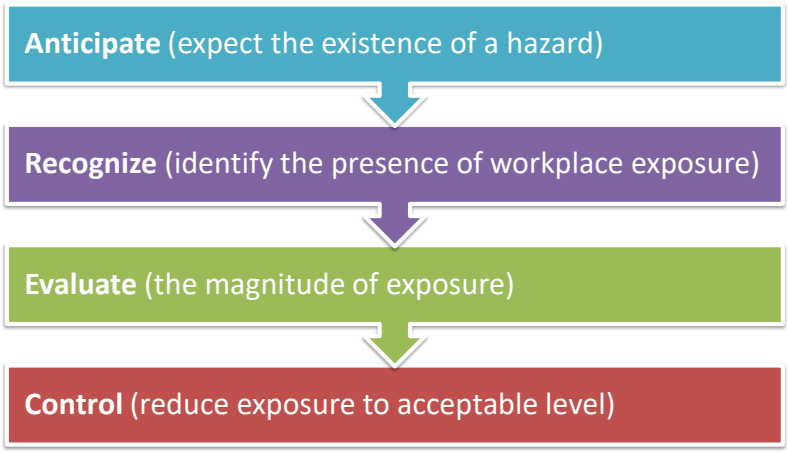
Ergonomic Hazards

- Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system.
  - Mostly encountered in manufacturing industries other than CPI.

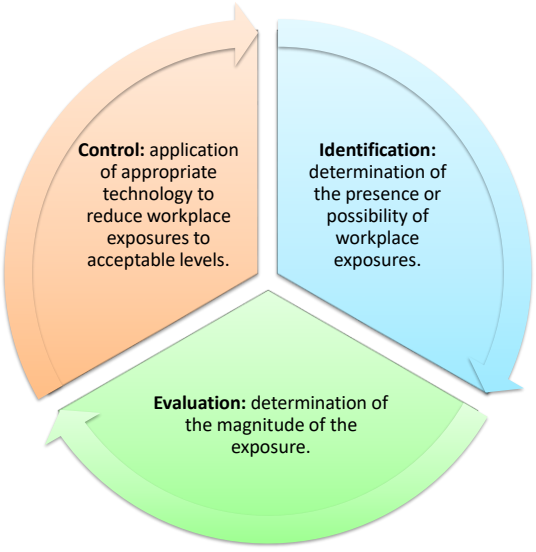


What Is an Industrial Hygienist?

- A person who by study, training, and experience can (**AREC**):



Industrial Hygiene Phases

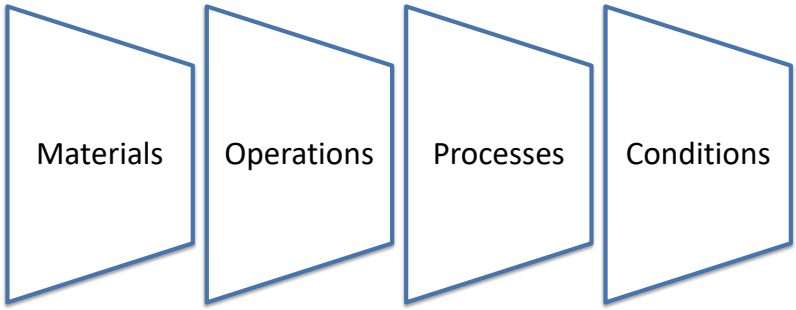


Identification

- In order to safely handle many hazardous chemicals on a daily basis within chemical plants, all potential hazards must be identified and controlled.
- Requires a thorough study of the chemical **process**, **operating conditions**, and **operating procedures**.
- Sources of information may include: process design descriptions, operating instructions, safety reviews, equipment vendor descriptions, information from chemical suppliers, and information from operating personnel.
- The quality of this identification step is often a function of the number of **resources** used and the quality of the **questions asked**.

Anticipation/Recognition

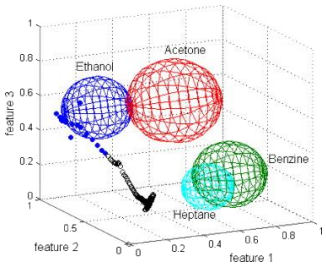
- Anticipation/recognition of potential or actual hazards through knowledge of:



M^4 = Man + Materials + Methods + Machines

Hints for the Recognition of Chemical Hazards

- Odors (الروائح)
  - Not all agents have detectable odor
- Frequent headaches (صداع متكرر)
- Dermatitis (اعراض او امراض على الجلد)
- Drowsiness (عدم التوازن وبطء الاستجابة)
- Personality changes (تغيرات في الشخصية)
- Clusters of problems (مجموعة مشاكل)



Potential Hazards

CHEMICAL PROCESS
OPERATING CONDITIONS
OPERATING PROCEDURES

- Process design
- Operating instructions
- Safety reviews
- Equipment description
- Chemical properties MSDS's

Data Useful for Health identification
Threshold limit values (TLVs)
Odor threshold for vapors
Physical state
Vapor pressure of liquids
Sensitivity of chemical to temperature or impact
Rates and heats of reaction
Hazardous by-products
Reactivity with other chemicals
Explosive concentrations of chemicals, dusts, and vapors
Noise levels of equipment
Types and degree of radiation

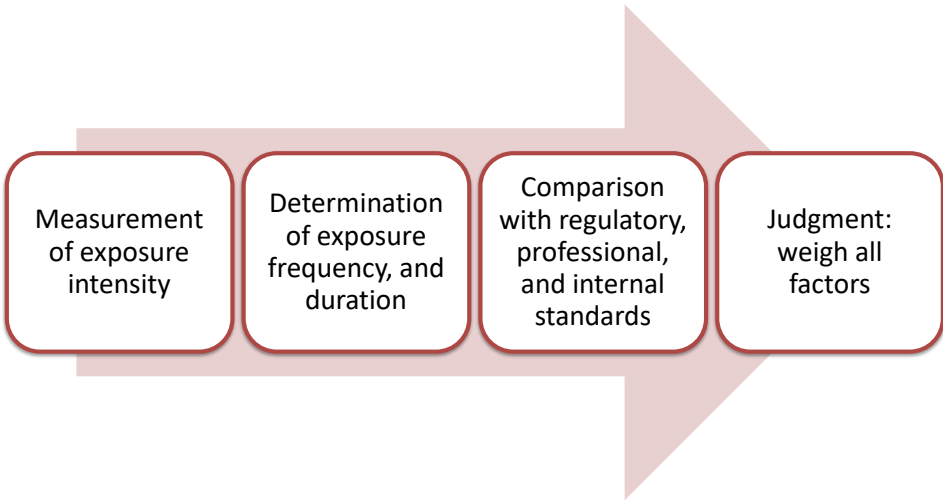
Potential hazards	
Liquids	Noise
Vapors	Radiation
Dusts	Temperature
Fumes	Mechanical
Entry mode of toxicants	
Inhalation	Ingestion
Body absorption (skin or eyes)	Injection
Potential damage	
Lungs	Skin
Ears	Eyes
Nervous system	Liver
Kidneys	Reproductive organs
Circulatory system	Other organs

[1]Olishifski, *Fundamentals of Industrial Hygiene*, pp. 24–26.

Evaluation

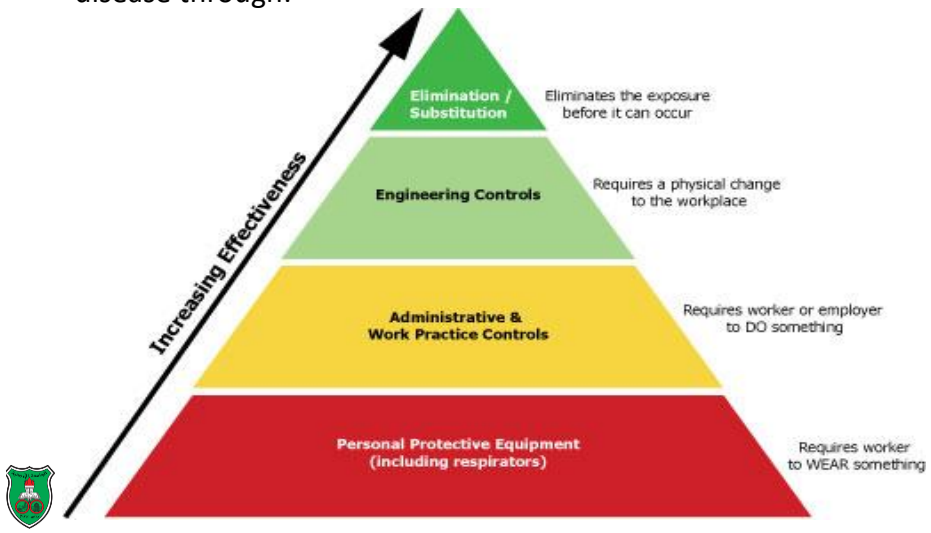
- The evaluation phase determines the extent and degree of employee exposure to toxicants and physical hazards in the workplace environment.
- The various types of existing control measures and their effectiveness are also studied in the evaluation phase.
  - Sudden exposures to high concentrations: ready access to a clean environment is important.
  - Chronic effects arise from repeated exposures to low concentrations: preventing and controlling through continuous or frequent and periodic sampling and analysis.
- After the exposure data are obtained, it is necessary to compare actual exposure levels to acceptable occupational health standards to identify the potential hazards requiring better or more control measures.

Evaluation



Control

- Employing of methods to eliminate or reduce exposure resulting in elimination or reduction of the occurrence of occupational disease through:



OSHA and Process Safety Management (PSM)

- PSM was developed after the Bhopal accident (1985), to prevent similar accidents from happening.
- Activities undertaken in Emergency management:

Before the emergency situation. → During the emergency situation. → Immediately After the emergency situation.

- Emergency management is a part of PSM in CPI.

Purpose Of PSM

- Proactive and systematic Preventing or minimizing the consequences of catastrophic release of **toxic, flammable, reactive or explosive chemicals**.

Toxic	Flammable	Explosive	Reactive

Major Sections of PSM

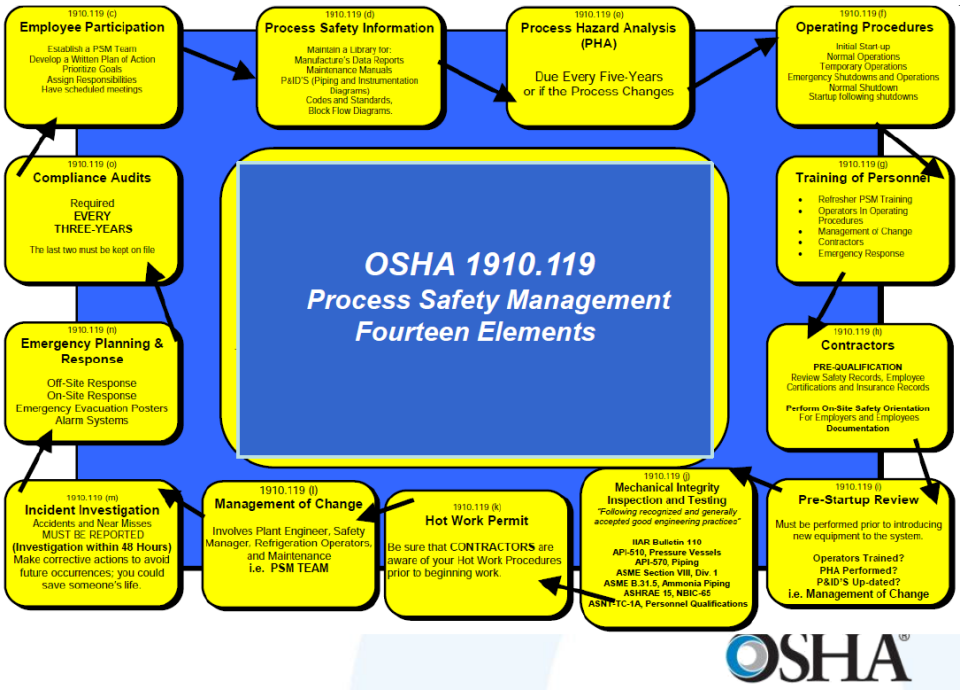
PSM

Evaluation of progress towards goals

- Process Hazard Analysis (PHA)
- Pre-Start-up Safety Review (PSSR)
- Management of Change
- Incident Investigation
- Compliance Audit
- Trade secrets

Achieving safety goals

- Process safety Information (PSI)
- Employee participation
- Operating procedure(s)
- Training
- Contractors safety
- Mechanical Integrity
- Nonroutine work authorization (**Hot Work Permits**)
- Emergency Planning and Response



EPA: Risk Management Plan (RMP)

- The RMP is aimed at decreasing the number and magnitude of accidental releases of toxic and flammable substances.
- Although the RMP is similar to the PSM regulation in many respects, the RMP is designed to protect off-site people and the environment, whereas PSM is designed to protect on-site people.

RMP			
Hazard assessment,	Prevention program,	Emergency response program,	Documentation that is maintained on the site and submitted to authorities. This information is also shared with the local community.

Industrial Hygiene: Control

- Requires the application of appropriate technology for reducing workplace exposure.
- During the design phase, the designer must pay particular attention to ensure that the newly designed control technique provides the desired control:
  - Environmental controls → Ventilation.
  - Personal protection → Respirators.

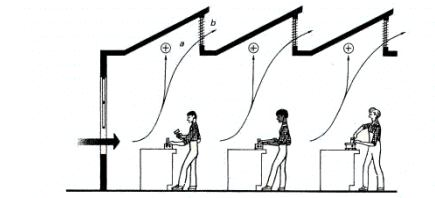


Figure 24. The design of a building may increase airflow and dilute the concentration of substances with low toxicity

Type and explanation	Typical techniques
Enclosures Enclose room or equipment and place under negative pressure.	Enclose hazardous operations such as sample points. Seal rooms, sewers, ventilation, and the like. Use analyzers and instruments to observe inside equipment. Shield high-temperature surfaces. Pneumatically convey dusty material.
Local ventilation Contain and exhaust hazardous substances.	Use properly designed hoods. Use hoods for charging and discharging. Use ventilation at drumming station. Use local exhaust at sample points. Keep exhaust systems under negative pressure.
Dilution ventilation Design ventilation systems to control low-level toxics.	Design locker rooms with good ventilation and special areas or enclosures for contaminated clothing. Design ventilation to isolate operations from rooms and offices. Design filter press rooms with directional ventilation.
Wet methods Use wet methods to minimize contamination with dusts.	Clean vessels chemically vs. sandblasting. Use water sprays for cleaning. Clean areas frequently. Use water sprays to shield trenches or pump seals.
Good housekeeping Keep toxicants and dusts contained.	Use dikes around tanks and pumps. Provide water and steam connections for area washing. Provide lines for flushing and cleaning. Provide well-designed sewer system with emergency containment.
Personal protection As last line of defense.	Use safety glasses and face shields. Use aprons, arm shields, and space suits. Wear appropriate respirators; airline respirators are required when oxygen concentration is less than 19.5%.

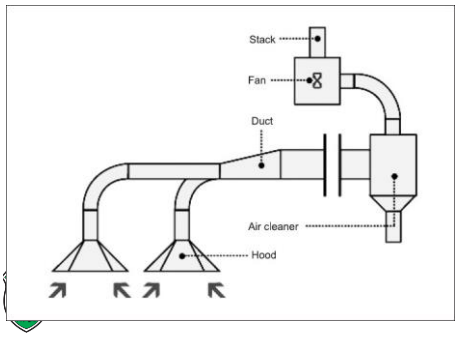
Ventilation

- Ventilation can quickly remove dangerous concentrations of flammable and toxic materials.
- Ventilation can be highly localized, reducing the quantity of air moved and the equipment size.
- Ventilation equipment is readily available and can be easily installed.
- Ventilation equipment can be added to an existing facility.
- Ventilation is based on two principles: (1) dilute the contaminant below the target concentration, and (2) remove the contaminant before workers are exposed.

The major drawback of ventilation is the operating cost

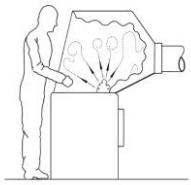
Ventilation Systems

- Ventilation systems are composed of fans and ducts.
  - The fans produce a small pressure drop (less than 0.1 psi) that moves the air.
- The best system is a negative pressure system, with the fans located at the exhaust end of the system, pulling air out.

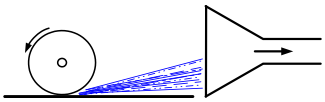


Local Ventilation

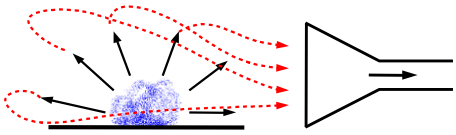
Enclosing (Contain and separate)



Receiving (Receive, contain & empty)



Capturing (Capture)

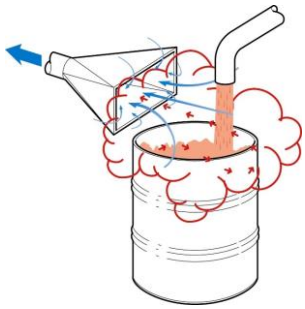


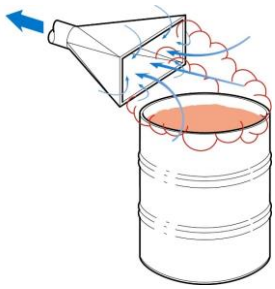
Source: HSE

Main Reasons Why Systems Fail to Protect

- Incorrect type of hood is chosen (and could never provide sufficient protection).
- Airborne contaminant isn't contained or captured.
- LEV hood design doesn't match the process and source(s).
- Insufficient airflow (various reasons).

Capturing Hoods





Air Cleaners - Filters

HW

- 3.15
- 3.21
- 3.22
- 3.25