Occupational Hygiene Principles

Assoc. Prof. Dr. İlker BÜYÜK

Learning Objectives

By the end of this lesson, you should be able to:

- Classify the types of hazards workers face
- Define "exposure" and related terms
- List the routes by which workers can be exposed to hazardous agents
- Describe the occupational hygiene framework of anticipating, recognizing, evaluating, and controlling workplace hazards

Occupational Hygiene Framework

Occupational Hygiene = Industrial Hygiene

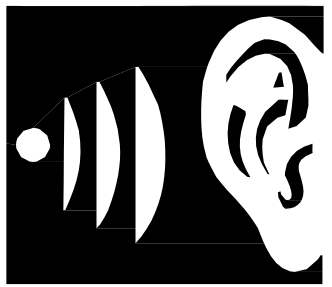
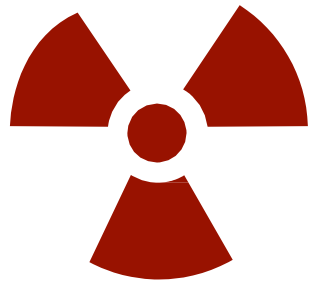
- "Industrial hygiene is the science of protecting and enhancing the health and safety of people at work and in their communities."
  (American Board of Industrial Hygiene, http://www.abih.org/content/ih-defined)
- "Occupational hygiene is the science of the anticipation, recognition, evaluation and control of hazards arising in or from the workplace, and which could impair the health and well-being of workers, also taking into account the possible impact on the surrounding communities and the general environment."
  (Goelzer, B.I.F., in *30. Occupational Hygiene*, Herrick, R.F., Ed., *Encyclopedia of Occupational Health and Safety*, J.M. Stellman, Editor-in-Chief. International Labor Organization, Geneva, 2011)

With whom do OHs/IHs interact?

- Workers
- Owners/Managers/Supervisors
- Regulators
- Members of the public
- Occupational physicians
- Occupational health nurses
- Safety specialists
- Environmental specialists
- Occupational epidemiologists
- Occupational hygiene technicians
- Engineers
- Facilities and maintenance personnel

Types and Examples of Workplace Hazards

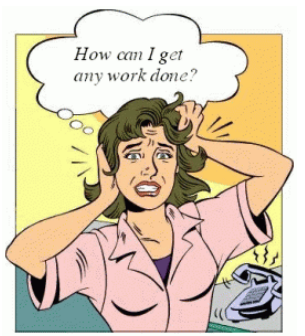
- Chemical hazards
  - Particles, including nanoparticles
  - Gases and vapors, especially solvents
  - Heavy metals
  - Skin irritants
- Physical hazards
  - Noise
  - Radiation
  - Temperature extremes
- Biological hazards
  - Infectious disease agents
  - Mold
- Injury hazards
  - Unintentional traumatic injuries, including vehicle crashes
  - Violence
  - Musculoskeletal disorders
- Social/behavioral hazards
  - Stress
  - Sleep deprivation
  - Substance abuse







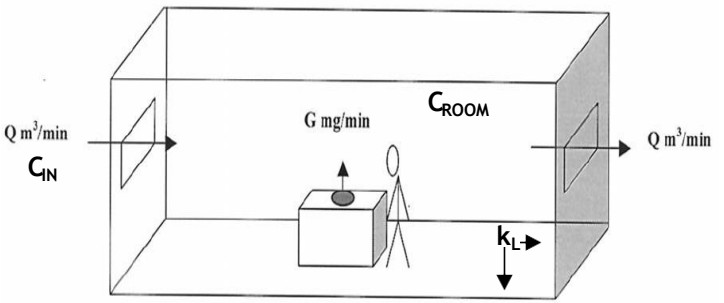


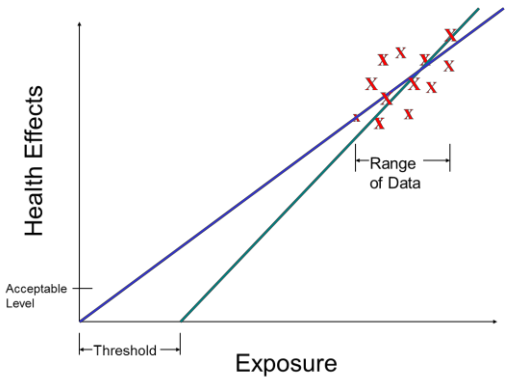

Why evaluate hazards?

- For compliance: goal is to compare exposure to a limit or standard (Example: compare sound levels in metal stamping operation to OSHA permissible exposure limit)
- For source characterization: goal is to identify process generating hazard (Example: create a concentration map to identify emission sources for oil mist)
- For emergency situations: goal is to detect hazards at levels immediately dangerous to life and health (Example: monitor hydrogen sulfide levels when entering manure pits)
- For control measures: goal is to ensure that interventions are reducing exposure to the hazard (Example: ensure particles containing mouse urine protein are contained by enclosures during research animal cage change-outs)
- For research: goal will depend on hypothesis being investigated, often as part of occupational epidemiology study (Example: measure silica dust concentration to determine its influence on miner lung health in epidemiological study)
- For risk assessment: goal is to calculate exposure and/or dose (Example: measure radon concentrations in building sub-basement to estimate cumulative doses that workers receive)

Evaluating Hazards

- Measurements
  - Detection
  - Concentrations in air and other media
  - Biomarkers
- Modeling
  - Nothing can be measured everywhere at all times
  - Use mathematical equations
  - Predict concentrations as function of time and location
- Compare to occupational exposure limit (OEL)
  - Developed from risk assessment, relating risk of adverse health outcome to exposure
  - Health risk information from toxicological and epidemiological studies
  - What is an acceptable risk?





Controlling Hazards

From: http://www.merriam-webster.com

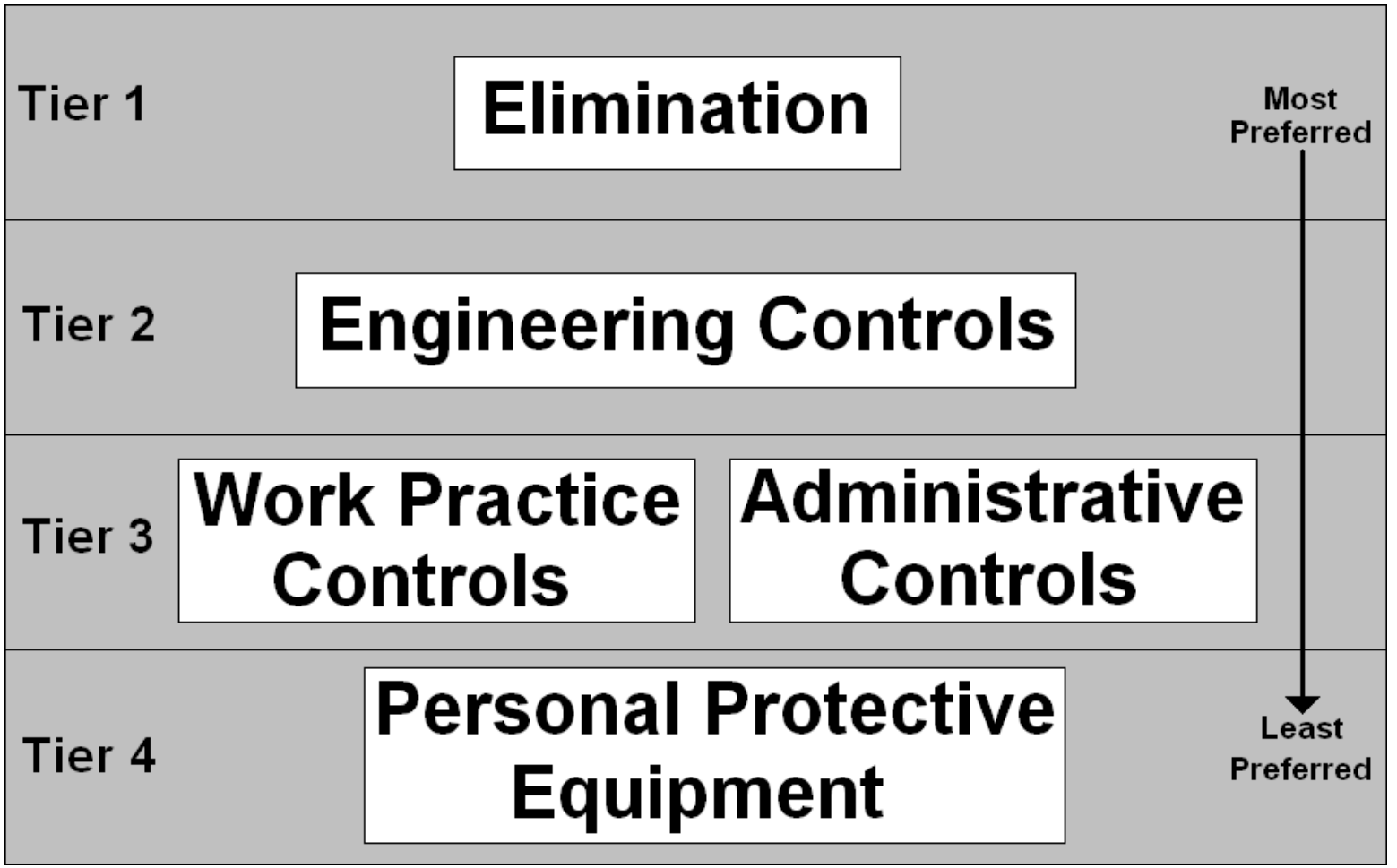
manage, *v.* to work upon or try to alter for a purpose

limit, *v.* to curtail or reduce in quantity or extent

intervene, *v.* to come in or between by way of hindrance or modification

control, *v.* to reduce the incidence or severity of, especially to innocuous levels

Hierarchy of Control



Hierarchy of Control

1) Elimination
   - Complete removal of the hazard or the process that produces it from the workplace
   - Responsibility for change not placed on exposed person
2) Engineering Controls
   - Physical, chemical, or biological changes made to a process or a product that reduce exposure to hazards
   - Responsibility for change not placed on exposed person
   - Concepts: substitution, automation, isolation, ventilation, control equipment
3) Work Practice and Administrative Controls
   - Changes in how, when, or by whom tasks are performed in order to reduce exposure to hazards
   - Management and exposed person responsible for change
4) Personal Protective Equipment (PPE)
   - Equipment or clothing used by individual to reduce exposure
   - Exposed individual responsible for change

Ventilation

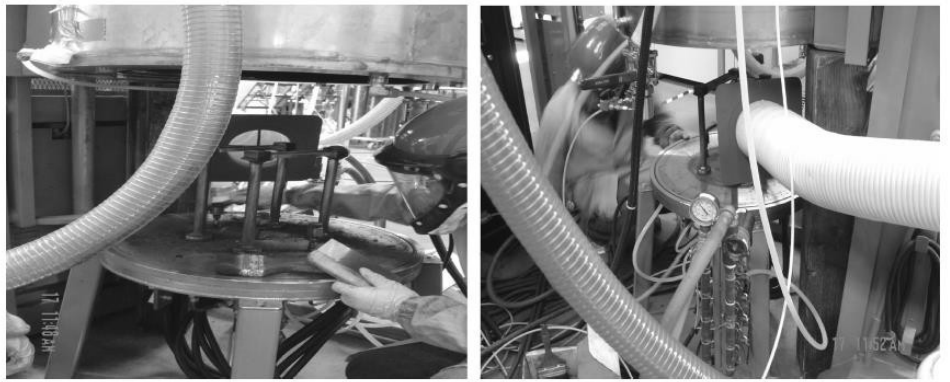


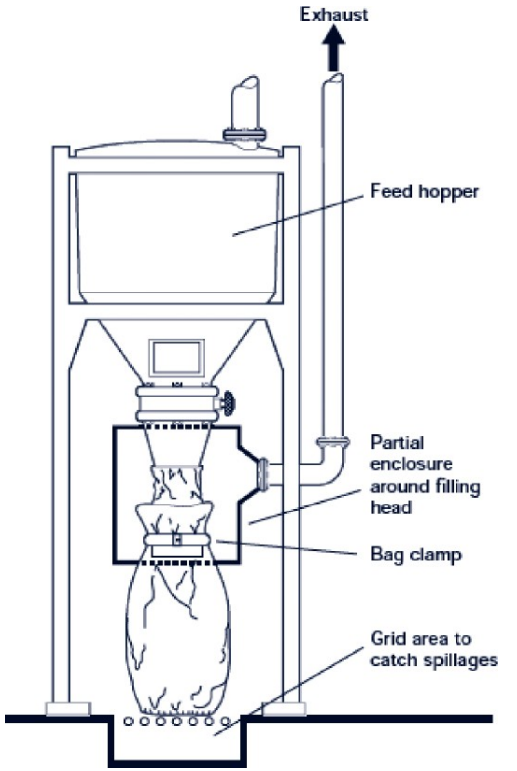
FIGURE 3. Typical location of fume extractor and production operator during reactor cleanout activities (filter-based air sampling devices located in upper left corner of photo on left)

Methner, *J. Occup. Environ. Hyg.*, 5:D63-D69 (2008)

DHHS (NIOSH) Pub. No. 2012–147 (2012)

http://www.nist.gov/ncnr/glovebox-coy-laboratory-products-basic-glove-box.cfm

DHHS (NIOSH) Pub. No. 2012–147 (2012)



DHHS (NIOSH) Pub. No. 2014–102 (2013)

Work Practice & Administrative Controls

- Work practice (how) control examples
  - Scooping powders rather pouring from containers
  - Regular maintenance of equipment
  - Regular cleaning of work surfaces
  - Wet cleaning instead of dry methods to reduce dust levels
  - Proper hand washing
  - Continuing education and training
  - Emergency drills
- Administrative (when, by whom) control examples
  - Restricting access to areas with potentially hazards
  - Use of hot, warm, and cold zones in response to spills
  - Security procedures
  - Limit work time to reduce mistakes
  - Schedule potentially hazardous operations during shifts when fewer workers are present

Personal Protective Equipment

"When exposure to hazards cannot be engineered completely out of normal operations or maintenance work, and when safe work practices and other forms of administrative controls cannot provide sufficient additional protection, a supplementary method of control is the use of protective clothing or equipment. This is collectively called personal protective equipment, or PPE." (https://www.osha.gov/SLTC/etools/safetyhealth/comp3.html)

Generic Definition of "Exposure"

The intensity of the agent in question, time-averaged in some way relevant to the adverse health outcome, at an appropriate interface between the environment and the population or individual at risk

Generic Definition of "Dose"

The cumulative amount of a property derived from an exposure that drives a biological response within the exposed organism

More Formal Definitions

K. Sexton, M.A. Callahan, and E.F. Bryan (1995). *Environmental Health Perspectives*, 103(Suppl 3):13-29.

Exposure: "contact of a biologic, chemical, or physical agent with the outer part of the human body, such as the skin, mouth or nostrils"

Exposure concentration: "the concentration of an environmental agent in the carrier medium at the point of contact with the body"

Potential dose: "the amount of the agent that is actually ingested, inhaled, or applied to the skin"

Internal dose: "the amount of the agent absorbed, and therefore available to undergo metabolism, transport, storage, or elimination"

Exposure "Intensity"

Metrics of exposure relevant to the health outcome associated with the agent in question:

- Mass concentration (e.g., mg of substance/m^3 of air) for gases, vapors, and aerosol particles
- Number concentration (e.g., number of organisms per unit volume or mass of air, water or food) inhaled or ingested
- Sound pressure level (in decibels) for noise

Concentration Units

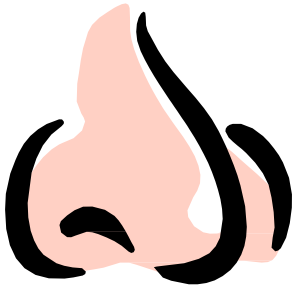
- Water
  - Parts per million (ppm) on mass/mass basis = mg/L ($1 mg = 10^{-3}$ g)
  - Parts per billion (ppb) = µg/L ($1 \mu g = 10^{-6}$ g)
  - Parts per trillion (ppt) = ng/L ($1 ng = 10^{-9}$ g)
- Air
  - For gases and vapors, we usually use ppm or ppb on a mole/mole basis, which is preferred for gases
  - For particles, mass/volume such as mg/m^3 or $\mu g/m^3$ is preferred

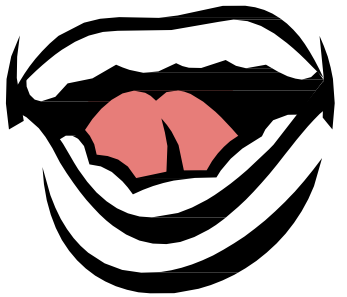
Dose Units

- Dose: mass over a certain amount of time, e.g., mg
- Dose rate: mass per unit time, e.g., mg/day
- Both dose and dose rate may be normalized to body weight, e.g., mg/kg or mg/kg-day

Routes of Exposure

- Inhalation
- Ingestion
- Dermal
- Ocular
- Auditory
- Whole body





Acute vs. Chronic Exposures

- Exposure to a hazard is influenced by both quantity and duration
- Acute exposures to hazards typically have large quantity and short duration
- Chronic exposures to hazards typically have relatively small quantity and long duration

Summary

- Occupational hygiene is the science of anticipating, recognizing, evaluating and controlling workplace hazards
- Workers face a variety of chemical, physical, biological, injury, and social/behavioral hazards
- Many hazards are evaluated using measurements or modeling and comparison to occupational exposure limits
- Control options are selected based on a hierarchy in which options that place the least burden on individual workers are preferred
- Exposure is the amount or intensity of an agent at the interface between a person and the environment
- Dose is the amount of the agent brought into a person