Introduction to Exposure Assessment
New Recognition of Industrial Hygiene

• Definition of Industrial Hygiene
  – The science and art of *anticipating*, *recognizing*, *evaluating*, and *controlling* health hazards in the workplace.
Role of Industrial Hygienists

- To recognize, evaluate and control potential workplace hazards to ensure that all employees are under a safe and healthful occupational environment throughout their working lifetimes.

- To understand and manage health risks in the workplace.

- Industrial hygienists must ensure that exposure are characterized well enough --- and control well enough --- to keep present risks within acceptable limits and to put the organization in the position to manage future risks.
Purpose of Designing a Sound Exposure Assessment

• To assess potential health risks faced by all workers; to differentiate between acceptable and unacceptable exposures; and to control unacceptable exposures.

• To determine the needs and priority for health hazard controls.

• To ensure and demonstrate compliance with governmental and other exposure guidelines.

• To establish and document an historical record of exposure levels for all workers and to communicate exposure monitoring results to each worker.

• To focus on how to position their industrial hygiene programs with efficient and effective allocation of time and resources to manage changes and minimize any future risks.
  – working training program
  – personal protective equipment
  – medical surveillance programs
Two Important Things

• Compliance with current limits is not sufficient.
  – Most chemicals have no occupational exposure limits, and the information used to set existing limits is often incomplete.
  
  – Existing limits are not always designed to protect the most sensitive workers. These limits might even be out of date.

• Have a historical database for all exposure should allow identification of employees who were exposed above the lowered exposure limit and enable the extent of their past overexposures to be estimated.
Exposure Assessment versus Risk Assessment

• Health Risk = (Exposure) (Toxicity)

\[ risk = potency \times dose \]

• Good risk assessment is driven on the quality of exposure assessment.
Shifting State of the Art

• The state-of-art approach has changed from compliance monitoring to comprehensive exposure assessment.
  – Compliance monitoring focuses on the maximum-risk employee to determine whether exposures are acceptable.
  – Comprehensive exposure assessment emphasizes characterization of all exposures for all workers on all days.

• A comprehensive approach to assessing occupational exposures better positions an organization to understand the risks associated with the exposures and better positions the organization to manage those risks.
Figure 1.2 — A strategy for assessing and managing occupational exposures.
Major Steps
in Exposure Assessment Strategy
Step 1. Start

• Establish the exposure assessment strategy
  – role of the industrial hygienist
  – exposure assessment goals
  – written exposure assessment program
Step 2. Basic Characterization

• To collect and organize basic information needed to characterize the workplace, work force and environmental agents.

• To understand:
  – tasks being performed
  – materials being used
  – processes being run
  – controls in place
Characteristics of Occupational Exposure

• Workers are exposed to hazardous agents due to:
  – direct use of the agents in the tasks they performed,
  – nearby the tasks performed by other workers, and
  – incidental contact from background contamination in the workplace.

• Workers are exposed to multiple agents.

• Concentrations of environmental agents vary over both time and space.
Step 3. Exposure Assessment (1)

• Define similar exposure groups (SEGs)
  – SEGs are groups of workers having the same general exposure profile for the agent(s) being studied because of the similarity and frequency of the tasks they perform, the materials and processes with which they work, and the similarity of the way they perform the tasks.
  
  – Information on jobs, processes, tasks, control equipment and materials are needed to be gathered.
    • More detailed walkthrough survey is required.

  – Individual workers may be members of more than one SEG.
Step 3. Exposure Assessment (2)

• Define exposure profiles
  – An exposure profile is an estimate of the exposure intensity and how it varies over time for an SEG.
  
  – Information used for defining the exposure profile may include qualitative or quantitative data, or both.
  
  – When more information is gathered and assessed, SEGs may be redefined and their exposure profiles are modified.
Step 3. Exposure Assessment (3)

- Make judgments on acceptability of the exposure profile of each SEG
  - Exposures judged unacceptable are put on prioritized list for control.
  - Exposures not certain enough for a decision are put on a prioritized list for further information gathering.
  - Exposure judged acceptable are documented as such and may be put on a list for periodic routine reassessment to verify that exposures continue to be acceptable.
Step 4. Further Information Gathering

- Exposure monitoring
  - personal exposure measurements (how about area monitoring?)

- Exposure modeling
  - Mathematical modeling techniques

- Biological monitoring
  - dermal absorption significant

- Epidemiological data generation
  - One of the biggest weaknesses in current epidemiology practice is the lack of useful exposure data.
Step 5. Health Hazard Controls

• Engineer controls
  – ventilation
  – change processes

• Administration control

• Personal protection equipments
Step 6. Reassessment

• To update the exposure profiles of SEGs through entire exposure assessment process.

• Ensure that exposure continues to be well-understood and that the organization’s industrial hygiene program continue to respond to changing priorities.
Step 7. Communication and Documentation

• Exposure findings must be communicated to all affected workers and others who are involved in worker health protection.

• The entire exposure assessment process, including follow-up recommendations and closure on the recommendations, must be documented.
  – baseline and routine exposure monitoring data
  – hazard control plans
  – evidence of appropriate recommendations functioning
Definition of Exposure

- A person’s exposure to a contaminant in community and/or occupational environments is defined as “the contact at one or more boundaries between human and contaminant at a specific concentration for a period of time.”

- Mathematical expression of exposure is:

\[ E = \int_{t_1}^{t_2} C(t) \, dt \]

where \( E \): exposure, 
\( C(t) \): a concentration which varies as a function of time, and 
\( dt \): an increment of time from \( t_1 \) to \( t_2 \).
A Conceptual Framework of the Relationship between Dose and Risk of a Disease

\[ h(r) = \int_0^\infty g(r \mid D) f(D) dD \]
Tasks of Exposure Assessment

• To determine exposure metrics which are fairly simple, yet mechanistically defensible functions of practically attainable measurements.

• To characterize exposure profiles or distributions to achieve better exposure estimation.

• To evaluate the magnitude of errors of exposure metrics and estimation.
Exposure Metric

• Definition

A direct exposure measurement refers to the mass of an agent or an amount of energy delivered to the body barrier, for example, acoustical energy into the ear canal or benzene to the skin and/or into the respiratory system. This function linking direct exposure to health risk will be called an **exposure metric**.
Example 1: Noise Induced Hearing Loss

Damage accumulated according to equal energy principle

\[ E_a = L_A + 10 \log\left(\frac{T}{T_0}\right) \]

Exposure metric
Example 2: Benzene-induced Leukemia

Problem: It is not clear about the identity of the metabolite(s) of benzene responsible for producing damage at the receptor site.