Fundamentals of Industrial Hygiene

Lori Seiler, CIH
What is Industrial Hygiene?

“… the science of anticipating, recognizing, evaluating, and controlling workplace conditions that may cause workers' injury or illness.

Industrial hygienists use environmental monitoring and analytical methods to detect the extent of worker exposure and employ engineering, work practice controls, and other methods to control potential health hazards.”

Source: https://www.osha.gov/Publications/OSHA3143/OSHA3143.htm
Typical Roles of an Industrial Hygienist

- Investigating and examining the workplace for hazards and potential dangers
- Making recommendations on improving the safety of workers and the surrounding community
- Conducting scientific research to provide data on possible harmful conditions in the workplace
- Developing techniques to anticipate and control potentially dangerous situations in the workplace and the community
- Training and educating the community about job-related risks
- Advising government officials and participating in the development of regulations to ensure the health and safety of workers and their families
- Ensuring that workers are properly following health and safety procedures

Source: www.aiha.org
# Industrial Hygiene Practice Technical Competency

<table>
<thead>
<tr>
<th>Risk Assessment, Risk Management, and Risk Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Work Environments, Occupations, and Industrial Processes</strong></td>
</tr>
<tr>
<td><strong>Basic Controls</strong></td>
</tr>
<tr>
<td>Engineering Controls/Ventilation</td>
</tr>
<tr>
<td><strong>Workplace Hazards, Advanced Science, and Evaluation Techniques</strong></td>
</tr>
<tr>
<td>Air Sampling and Instrumental Analysis</td>
</tr>
<tr>
<td>Chemical Hazards</td>
</tr>
<tr>
<td>Ergonomics</td>
</tr>
<tr>
<td>Indoor Air Quality</td>
</tr>
<tr>
<td>Radiation (Ionizing and Non-Ionizing)</td>
</tr>
</tbody>
</table>

| **Basic Science and Math** |
| Algebra, Anatomy, Biochemistry, Biology, Calculus, Chemistry, Geometry, Physics, Physiology |

What Are Different Types of Industrial Hygiene Hazards?

Let’s look at an example.
You have just been assigned a new facility to support…..

Before your first site visit, your local contact sends you the following description:

Our facility is a wood furniture manufacturer with approximately 50 employees. The operation includes six primary process steps:

• Drying
• Machining
• Assembly
• Pre-finishing
• Coating applications
• Finishing

What hazards do you expect?
Example Industrial Hygiene Hazards

- **Drying**
  - Heat, carbon monoxide, particulates
- **Machining**
  - Noise, dust,
- **Assembly**
  - Noise, adhesives, heat, solvents
- **Pre-finishing**
  - Dust, resins, glues, acetone, ammonia, bleaching agents
- **Coating & Finishing Applications**
  - Mineral spirits, alcohols, solvents, pigments, lacquers, stains, paints, dust

Any other examples?
General Industrial Hygiene Hazard Types

<table>
<thead>
<tr>
<th>Chemical Hazards</th>
<th>Physical Hazards</th>
<th>Biological Hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>Heat Stress</td>
<td>Bacteria</td>
</tr>
<tr>
<td>Vapor</td>
<td>Cold Stress</td>
<td>Fungi</td>
</tr>
<tr>
<td>Dust</td>
<td>Ionizing Radiation</td>
<td>Viruses</td>
</tr>
<tr>
<td>Mist</td>
<td>Non-Ionizing Radiation</td>
<td>Plants</td>
</tr>
<tr>
<td>Fume</td>
<td>Noise</td>
<td>Animals</td>
</tr>
<tr>
<td>Fiber</td>
<td>Vibration</td>
<td>Insects</td>
</tr>
<tr>
<td>Smoke</td>
<td>Ergonomics</td>
<td></td>
</tr>
<tr>
<td>Solid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
When evaluating chemical hazards, what information should you know?

Physical form
Toxicity and Health Hazard
Concentration
How the chemical is used
Types of Chemical Hazards

- Airborne
  - Gas
  - Vapor
  - Dust
  - Mist
  - Fume
  - Fiber
  - Smoke

- Physical State
  - Solid
  - Gas
  - Liquid
  - Vapor

- Properties & Appearance
  - Vapor pressure
  - Color
  - Odor
Why is it important to know the physical state or form of a chemical in the workplace?

This helps determine the route of exposure
Routes of Exposure

Source: https://riskmanagement.unt.edu/hcs-ghs-module2
Chemical Health Hazards

- Acute Toxicity
- Skin Corrosion or Irritation
- Eye Damage or Eye Irritation
- Respiratory or Skin Sensitization
- Mutagenicity
- Carcinogenicity
- Reproductive Toxicity
- Specific Target Organ Toxicity (e.g. Liver, Kidney, Nerves)
- Aspiration Hazard

Source: OSHA 3491 Hazard Communication Standard Pictogram Quick Card
Toxicity vs Hazard

What’s the difference?
Toxicity vs. Hazard

Toxicity – ability to cause harm

Hazard – probability that toxic effect will occur

Risk = Hazard x Exposure
Evaluating Exposures

Exposure Profile

Concentration (ppm) vs. Time (Hours)

0 1 2 3 4 5 6 7 8 9
0 1 2 3 4 5 6 7 8

4/16/2019
Evaluating Exposures, cont....

Exposure Profile

8-hr TWA

TWA = Time Weighted Average

Concentration (ppm)

Time (Hours)
Calculating an 8-hr TWA

\[
\frac{(C_1 \times T_1) + (C_2 \times T_2) + (C_3 \times T_3) + \ldots + (C_n \times T_n)}{T_t}
\]

- \(C_n\) = measured concentration
- \(T_n\) = length of time sampled
- \(T_t\) = Total length of shift (e.g. 8-hrs)
Air sampling results for a worker’s exposure to gasoline found that he was exposed the following:

- 108 ppm for 2 hours
- 50 ppm for 3 hours
- 200 ppm for 3 hours

\[
\frac{108 \text{ ppm} \times 2 \text{ hrs}}{8 \text{ hrs}} + \frac{50 \text{ ppm} \times 3 \text{ hrs}}{8 \text{ hrs}} + \frac{200 \text{ ppm} \times 3 \text{ hrs}}{8 \text{ hrs}}
\]

\[
8\text{-hr TWA} = 121 \text{ ppm}
\]
What about these peak levels?

8-hr TWA

TWA = Time Weighted Average
Evaluating Exposures, cont....

Exposure Profile

Exposure Limit

8-hr TWA

TWA = Time Weighted Average
Exposure Limits

“Airborne concentrations of a substance under which it is believed nearly all workers may be repeatedly exposed, day after day, without experiencing adverse health effects.”

Does this present any complications?

• Some workers can experience discomfort at or below the levels
• Some workers can be more seriously affected because of a pre-existing condition
Exposure Limit Setting Groups

OSHA
Occupational Safety & Health Administration

ACGIH®
American Conference of Governmental Industrial Hygienists

AIHA
American Industrial Hygiene Association

NIOSH
National Institute of Occupational Safety & Health

PEL — Permissible Exposure Limit

TLV — Threshold Limit Value

WEEL — Workplace Environmental Exposure Limit

REL — Recommended Exposure Limit

Are there others?
Types of Exposure Limits

- 8-hour Time Weighted Average (TWA)
- Short-term Exposure Limit (STEL)
- Ceiling Limit (C)
- Excursion Limit
- Biological Monitoring Levels
Exposure Limit Durations

- 8-hour Time Weighted Average (TWA)
  - Set for a routine 8-hr workday and a 40-hr work week
  - Level is set so that nearly all workers may be repeatedly exposed without adverse health effects
Exposure Limit Durations cont…

- Short-Term Exposure Limit (STEL)
  - 15-min TWA, 60 minutes between peaks, maximum 4 times per day
  - Set to prevent irritation, chronic, or irreversible tissue damage, narcosis
  - Set for chemicals where there are acute toxic effects in addition to chronic effects
  - STEL is in addition to 8-hr TWA
Types of Exposure Limits

- 8-hour Time Weighted Average (TWA)
- Short-term Exposure Limit (STEL)
- Ceiling Limit (C)
  - Concentration that should not be exceeded during any part of the workday

For some substances, more than one type of limit may be relevant.
What If?

You are evaluating chemical exposures during a short-term task but there is no published STEL or Ceiling limit for the chemical being used.

What can you do?

Consider an excursion limit.
Excursion Limits — How to Apply

- Short-term exposures where there is no STEL or Ceiling Limit available
  - Up to 3 times the 8-hour TLV-TWA for no more than a total of 30 minutes during a workday
  - Not to exceed up to 5 times the 8 hr-TLV-TWA
- Apply in addition to the 8-hour TLV-TWA cannot be exceeded
Exposure Limit Units

- Expressed as concentrations
  - Mass per unit volume of air
  - Volume of material per volume of air
- Exposure limits are listed by several different types of units
  - mg/m$^3$ — milligrams per cubic meter of air
  - ppm — parts per million
  - f/cc — fibers per cubic centimeter of air
Biological Monitoring Limits

- Represent warning levels of biological response to either the chemical or a metabolite
- Levels are measured in tissues, fluids, or exhaled air

Blood lead levels - 40 µg/100 g
Exposure Limits, so far we’ve discussed…

- Exposure limit setting groups
- Different types of limits
  - 8-hr TWA
  - STEL
  - Ceiling
  - Excursion
  - Biological
- Concentration units and how to use them

There is one more thing!

Skin Notation
Skin Notation

- Refers only to the potential contribution to the overall exposure through the skin, mucous membranes, and eyes
  - Exposure can be either airborne or through direct contact with substance
  - Designed to raise awareness that skin exposures need to be prevented
## Exposure Limit Examples

<table>
<thead>
<tr>
<th>Gasoline</th>
<th>OSHA</th>
<th>ACGIH TLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEL-TWA</td>
<td>TLV-TWA</td>
<td>300 ppm</td>
</tr>
<tr>
<td>PEL- STEL</td>
<td>TLV-STELE</td>
<td>500 ppm</td>
</tr>
<tr>
<td>PEL-C</td>
<td>TLV-C</td>
<td></td>
</tr>
<tr>
<td>Skin Notation</td>
<td>N</td>
<td>Skin Notation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acrylic Acid</th>
<th>OSHA</th>
<th>ACGIH TLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEL-TWA</td>
<td>1 ppm</td>
<td>TLV-TWA</td>
</tr>
<tr>
<td>PEL- STEL</td>
<td>5 ppm</td>
<td>TLV-STELE</td>
</tr>
<tr>
<td>PEL-C</td>
<td></td>
<td>TLV-C</td>
</tr>
<tr>
<td>Skin Notation</td>
<td>N</td>
<td>Skin Notation</td>
</tr>
</tbody>
</table>
Industrial Hygiene Functions

- Recognition
- Evaluation
- Control

Workplace Health Hazards

Anticipation

4/16/2019
Hierarchy of Controls

Source: https://www.cdc.gov/niosh/topics/hierarchy/default.html
Case Study Exercise

A maintenance crew has been assigned a job that involves refurbishing an old, out of service, 120 ft. diameter chemical storage tank.

The tank previously contained leaded gasoline in the 1990’s. It now needs to be cleaned out, inspected, and repaired so that it go back into service.

Their job is to cut open the tank, clean out any residual material, and prepare the tank for inspection. The inspection results will determine the type of repair work needed.

The tank contents were pumped off by the tank farm operators. The crew plans to burn off the paint and then use a torch to cut out a large door opening.

During the job, several of the workers report symptoms of fatigue, headache, and muscle soreness. One reports having a “metallic taste” in his mouth.

The workers go to the medical department and two are found to have a dark line on their gums.
Industrial Hygiene Functions

Control
Eliminate/Reduce Hazards
Engineering Controls
Administrative Controls
Personal Protective Equipment

Anticipation
Process knowledge
Experience
Continuing education

Evaluation
Sampling

Recognition
Observations
Interviews
Inspections, audits

Workplace Health Hazards
Fundamentals of Industrial Hygiene

- Know types of hazards to expect
- Understand toxicology and how chemicals affect the body
- Recognize routes of exposure
- Evaluate/measure exposure levels
- Compare exposure levels to appropriate exposure limit
- Devise control strategies to eliminate/reduce worker exposures

**Bottom Line:** Keep workers, their families and the community healthy and safe