Principles of Occupational Hygiene

Shelley Kirychuk, PhD
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Outline

- What is OH
- What is the importance to OM
- Definitions/Acronyms
- OH Process
  - OELs and TLVs
  - Assessing Exposure
  - Exposure Control

CASE STUDIES
Industrial/Occupational Hygiene

“that science and art devoted to anticipation, recognition, evaluation and control of environmental factors or stresses arising from the workplace...”

Plog 2002
OH

- Anticipate
- Recognize
- Evaluate
- Control
OH and OM Integration

- Learn of the hazards by personal visits to the workplace.
- Ask of your patient, “What is your trade?”
Definitions

- NIOSH
- ACGIH
NIOSH

- National Institute of Occupational Safety and Health
- A division of the US Center for Disease Control (CDC)
- Develops sampling methods for many chemicals and physical hazards
- Certifies respirators
ACGIH

- American Conference of Governmental Industrial Hygienist
- A non-profit organization that develops and publishes scientific information for the field of industrial hygiene.
Occupational Exposure Limits (OEL)

- Go by various names, depending on jurisdiction (US, Canada, Europe, etc.)

- Most jurisdictions base their OELs on the Threshold Limit Values published by the ACGIH (American Conference of Governmental Industrial Hygienists).

- The ACGIH publishes an annual list of TLV's based on the best available animal and human epidemiological evidence.
“Threshold limit values (TLVs) refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day, over a working lifetime, without adverse health effects.”

“TLVs are developed to protect workers who are normal, healthy adults.”

Page 3, TLV Handbook, ACGIH
How are TLVs Determined

- Committees review existing published and peer reviewed literature in various disciplines:
  - Industrial hygiene
  - Toxicology
  - Occupational medicine
  - Epidemiology

- Based on available literature, formulates a conclusion on appropriate level of exposure

- This is an ongoing process; updates and changes occur every year
2004

TLVs® and BEIs®
Based on the Documentation of the

Threshold Limit Values
for Chemical Substances
and Physical Agents

&

Biological Exposure Indices

ACGIH®
WORLDWIDE

Signature Publications
TLV Definition – the legalese...

- "TLVs are guidelines"

- "...are intended for use only as guidelines or recommendations to assist in hazard evaluation and control..."

- **not** for other use such as community air pollution, extended work periods, or proving / disproving disease in an individual.
TLV Definition – more legalese...

“... these values are not fine lines between safe and dangerous...”
Types of TLVs

- TLV – TWA (Time weighted Average)
- TLV – STEL (short term exposure limit)
- TLV – C (ceiling)

Usually just referred to as **TWA, STEL, and Ceiling**
Time Weighted Average (TWA)

- The TLV – TWA
  - the average concentration for a conventional 8 hour workday and 40 hour work week, to which it is believed nearly all workers may be repeatedly exposed, day after day, for a working lifetime without adverse effect
- Often referred to as the “8 hr – TWA”
Short Term Exposure Limit (STEL)

- The STEL is a 15 minute average exposure that should not be exceeded at any time during a work day, even if the 8-hr TWA is within limits.

- The STEL is the concentration to which it is believed that workers can be exposed continuously for a short period of time without suffering from:
  1. Irritation
  2. Chronic or irreversible tissue damage
  3. Dose-rate-dependent toxic effects
  4. Narcosis
Ceiling

- The ceiling is the concentration that should not be exceeded during any part of working exposure.
Question

- The 8 hr TWA is an average – how far “around” the average are you allowed to deviate?
Excursions

- “excursions in worker exposure levels may exceed 3 times the TWA for no more than 30 minutes total during a workday, and under no circumstances should then exceed 5 times the TWA.”
- This rule applies to those substances with a TWA that have no STEL.
Regulatory Aspects

- Many jurisdictions have adopted the ACGIH TLVs as legal exposure limits.
- Enforced by occupational health and safety legislation.
- Names vary: in Saskatchewan they’re called “contamination limits”, in Alberta “occupational exposure limits” and in the US “permissible exposure limits”... all mean the same thing.
### TABLE 21

[Sections 307 and 309, clause 346(f)]

**Contamination Limits**

<table>
<thead>
<tr>
<th>CAS Number</th>
<th>Substance</th>
<th>8-hour average Contamination Limit mg/m³*</th>
<th>15-minute average Contamination Limit mg/m³*</th>
</tr>
</thead>
<tbody>
<tr>
<td>75-07-0</td>
<td>Acetaldehyde</td>
<td><strong>C45</strong></td>
<td>—</td>
</tr>
<tr>
<td>64-19-7</td>
<td>Acetic acid</td>
<td>25</td>
<td>37</td>
</tr>
<tr>
<td>108-24-7</td>
<td>Acetic anhydride</td>
<td>20</td>
<td>30</td>
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<tr>
<td>67-64-1</td>
<td>Acetone</td>
<td><strong>C5</strong></td>
<td>—</td>
</tr>
<tr>
<td>75-86-5</td>
<td>Acetone cyanohydrin, (asCN)</td>
<td>1780</td>
<td>2380</td>
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<tr>
<td>75-05-8</td>
<td>Acetonitrile</td>
<td>67</td>
<td>101</td>
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<tr>
<td>98-86-2</td>
<td>Acetophenone</td>
<td>49</td>
<td>74</td>
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<tr>
<td>79-27-6</td>
<td>Acetylene tetrabromide</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>50-78-2</td>
<td>Acetylsalicylic acid</td>
<td>5</td>
<td>10</td>
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<tr>
<td>107-02-8</td>
<td>Acrolein</td>
<td>0.23</td>
<td>0.7</td>
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<tr>
<td>79-06-1</td>
<td>Acrylamide</td>
<td>0.03</td>
<td>0.09</td>
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<tr>
<td>79-10-7</td>
<td>Acrylic acid</td>
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<td>12</td>
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<tr>
<td>107-13-1</td>
<td>Acrylonitrile</td>
<td>4.3</td>
<td>8.6</td>
</tr>
<tr>
<td>124-04-9</td>
<td>Adipic acid</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>111-69-3</td>
<td>Adiponitrile</td>
<td>8.8</td>
<td>17.6</td>
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<tr>
<td>309-00-2</td>
<td>Aldrin</td>
<td>0.25</td>
<td>0.75</td>
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<tr>
<td>107-18-6</td>
<td>Allyl alcohol</td>
<td>4.8</td>
<td>9.5</td>
</tr>
<tr>
<td>107-05-1</td>
<td>Allyl chloride</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>106-92-3</td>
<td>Allyl glycidyl ether (AGE)</td>
<td>23</td>
<td>47</td>
</tr>
<tr>
<td>2179-59-1</td>
<td>Allyl propyl disulfide</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>—</td>
<td>Aluminum metal and oxide, (as Al)</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>
mg/m³ to ppm

$$ppm = \frac{mg / m^3 \times 24.45}{M.W.}$$

- ppm = parts per million
- mg/m³ = milligrams per cubic metre
- M.W. = molecular weight
mg/m³ to ppm Example

Lab results for air monitoring results were reported as 1057.5 mg/m³ acetone.

What is the concentration in ppm?

Is this acceptable?
(TLV-TWA = 500 ppm)
mg/m³ to ppm Example

\[
ppm = \frac{mg / m^3 \times 24.45}{M.W.}
\]

\[
ppm = \frac{1057.5 mg / m^3 \times 24.45}{58.05}
\]

\[
ppm = 445.4 \text{ ppm}
\]
Assessing exposure

- Ask
- Observe
- Measure (quantify if possible)
Applied Occupational Hygiene

Question:

Is air sampling data an accurate representation of the actual level of exposure and absorbed dose?
Applied Occupational Hygiene

Answers:

Measured values are estimates of exposure.

- Errors, human, sampling, etc.
- Accuracy of equipment and sampling process
- Representativeness

Absorption may depend on:

- Age, gender
- Health status, breathing rate
- Pre-existing conditions
Exposure Evaluation

1. By Matrix
   a) Air (most common)
   b) Surface (dermal, source)
   c) Bulk (source)
   d) Biological (BEI’s)
Bulk Sample

A sample of the physical material for identification and quantification. Requires laboratory analysis.

Example: spray insulation is sampled to identify asbestos type and content.

35% Chrysotile asbestos
Surface Sampling

Surface wipe sampling is conducted to assess surface contamination on:

- Skin
- Work surfaces
- PPE surfaces
- Sterile swabs for fungus and bacteria
- Gauze and disposable wipes for chemicals, metals, particulates
Tape Samples

Basic sample technique using readily available materials to detect surface contamination.

- Tape, baggie and markers

Examples:
- Mold
- Asbestos
Exposure Evaluation (con’t)

2. By Location
   a) Area sampling
   b) Personal sampling

3. By Duration
   a) Full period/partial period/integrated/grab

4. By Method
   a) Direct reading instruments
   b) Sample collection with lab analysis
Exposure Evaluation (con’t)

2. By Location

area sampling vs. personal sampling
Area Sample

A sample collected from a fixed location.

Purpose:
- Contaminant/parameter monitoring at a location
- Determine a source of contamination

Performed By:
- Typically place sampler at head height
- The testing device or sampler is (generally) stationary

Duration:
- Dependent on purpose

Not a recommended method for evaluating worker exposure
Personal Sample

Also called a Breathing Zone sample. A sample collected from a worker. The worker carries the sampler for a specified time.

Breathing Zone
A two-foot diameter half sphere around the front of a worker’s head

Purpose:
- Exposure monitoring for TWAs
Personal Sampling (Breathing Zone)
Personal Sample

Performed by:

- Air: Placing sampling media in the worker's breathing zone, pump is suspended from belt
- Noise: Placing dosimeter microphone close to ear attached to shirt collar, dosimeter on belt or in pocket

Duration:
- Predetermined period, work shift or a portion

Record as:
- Personal sample
- Parameter, result, activity, location (activity), time, date
Example of both area and personal monitoring.
Exposure Evaluation (con’t)

3. By Duration

- Full period sample
- Partial period sample
- Grab/spot sample
Full Period Sample

A measurement taken over the 8-hour work-shift.

Purpose:
- TWA estimate
- Comparison to OELs

Performed by:
- Direct reading equipment, detector tube, SLM

Limitations:
- Best estimate for that workday (may not be representative of all work days)
Partial Period Sample

A measurement taken over part of the work-shift or for periods over the work shift

Purpose:
- Measurement of peak concentrations for comparison to STELs or ceiling limits

Performed by:
- Direct reading equipment, detector tube, SLM

Limitations for use as a TWA:
- Adds variability
- Numerous assumptions need to be made for unsampled time periods
Instantaneous / Spot Sample

A measurement taken at one location at one point in time.

Purpose:
- Screening, source identification
- Peaks, ceilings

Performed by:
- Direct reading equipment, detector tube, SLM

Duration:
- Instantaneous or short term (minutes), as long as it takes to take the sample
Grab Sample

The same as a spot measurement except that it refers to the physical collection of an air sample for later laboratory analysis by using:

- Sample bags
- Evacuated containers
# Spot Check / Grab Sample

**Record As:**
- Parameter, result, location (activity), time, date

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Result</th>
<th>Location/Activity</th>
<th>Time</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>733 ppm</td>
<td>5th Floor, SW side</td>
<td>15:32</td>
<td>10/22/03</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.01 mg/m³</td>
<td>Behind Lab Bench #2</td>
<td>10:01</td>
<td>06/21/03</td>
</tr>
<tr>
<td>Noise</td>
<td>78 dBA</td>
<td>Punch press, worker position</td>
<td>14:09</td>
<td>12/14/99</td>
</tr>
</tbody>
</table>
Exposure Evaluation (con’t)

**Sampling Methods**

Direct –reading (real time) sampling vs. Integrated sampling
Sampling Methods

- **Direct reading**
  - A "live" immediate read-out
  - For physical agents (noise, radiation, vibration, temperature, etc.), only direct-reading instruments can be used.

- **Integrated**
  - Air is drawn across a collecting medium and then the medium is analyzed later for contaminants.
  - Examples of collecting media include filters, solutions, solids (charcoal, others), evacuated sample bags.
Exposure Evaluation (con’t)

Sampling Methods

Direct –reading (real time) sampling
Light Scattering Detector

- Multiple Particle Optical Monitor: The MINIRAM
- Gives airborne particulate levels (dusts)
Infrared Detector

- MIRAN Analyzer
- Detects various gases
Photo Ionization Detectors (PID)
Flame Ionization Detectors (FID)
Electrochemical Sensors

Single Gas

Multi-Gas
Particulate Monitor
IAQ Monitor (Temp and RH)
Heat Stress Monitor
Electromagnetic Field Monitor
Radiation Detectors
Detector Tubes and Pumps
Exposure Evaluation (con’t)

Sampling Methods

Integrated Sampling
Integrated Sampling

- Draw air across a collection medium for a known period of time then analyze afterwards in a lab.

Examples:
- Sorbent tubes (charcoal or silica gel)
- Filters (PVC, glass fibre, cellulose, others)
- Impingers
Solid Sorbent Tubes

- Silica Gel
- Charcoal
- XAD-2 (PAHs)
- Treated Silica Gel with oxidizer tube (NO/NO₂)
- Hopcalite with prefilter (mercury)
Various types of filters are available depending on what you’re sampling for:

- PVC
- MCE
- Quartz
- Fibre
- Teflon
- PVC
Exposure Evaluation (con’t)

5. Validity
   a) Sampling strategy
   b) Standard methods
   c) Reference materials and calibration
   d) Limits of detection and quantification
   e) Accreditation/certification
Controls

1. Engineering
2. Substitution/Automation
3. Administrative
4. PPE
Principles of Hazard Control

1. **Substitute** one hazardous agent with a non-hazardous or less hazardous one
2. **Engineering controls** (enclosures, pipes, soundproofing, ventilation, etc)
3. **Administrative controls** (rotate workers)
4. **Personal Protective Equipment** (last line of defense)
Substitution – other examples

- Substituting an organic solvent like turpentine with a water-based solvent (lower toxicity)

- Historical examples – substituting lead-based paints with lead-free, or asbestos insulation with other types (asbestos-free)
Engineering Controls

- Engineering controls remove the hazard from the worker or the worker from the hazard by initial engineering design or by substituting, isolating, and/or ventilating.
Engineering Controls

- Isolation
Engineering Controls

- Isolation
Engineering Controls

- Ventilation
- General
Engineering Controls

Ventilation
- General
- Local
Administrative Controls

- Work periods / exposure times / job rotation
- Personal Hygiene
- Housekeeping

E.g. – repetitive motion jobs (meat packing plant) – workers rotate stations frequently
Personal Protective Equipment
Personal Protective Equipment

- Skin – gloves, sleeves, coveralls, etc
- Eye / face protection
- Respiratory – masks
- Hearing – plugs, muffs
- etc
One Size does not fit all!
Solvents: Control

1. Local Exhaust Ventilation (Engineering)
   Remove at source before it reaches the worker

2. General Ventilation
   Dilution, not removal of contaminant

3. Substitution
   1. Lower toxicity, flammability, volatility
   2. Aqueous (water-based) if possible

4. PPE (respirator, gloves)
   Only as good as the worker, requires education
Particulates: Controls

1. Engineering
   1. Closed processes
   2. Local or general ventilation

2. Substitution/Automation
   1. Automate process
   2. Change input materials

3. Administrative Controls
   1. Work practices
   2. Substitution (wet vs dry cleaning)
   3. Medical Surveillance (Lung function testing and questionnaires)

4. PPE
   1. Respirators appropriate for the hazard
Eliminate airborne emissions – models
Overview

- What is IH
- What is the importance to OM
- Definitions/Acronyms
- IH Process
  - OELs and TLVs
  - Assessing Exposure
  - Exposure Control
Questions
CASE STUDIES
Case

- 37 year old female
- 3-4 week history of frequent headaches
- Otherwise healthy
- Headaches only work related – start within a few hours, better evenings and weekends
- Notices other symptoms as well:
  - Dizzy, lack of coordination, lightheaded, fatigued, "sluggish"
- Co-worker similar
What’s his job?

- Aircraft maintenance
- 4 Months ago her company got a contract to repair / inspect military C-130 Hercules aircraft
- Her job has been inspecting the fuel tanks in airplanes
- Frequent exposure to jet fuel fumes
SINCLAIR
MATERIAL SAFETY DATA SHEET
SINCLAIR JP-8, JET A, TURBINE FUEL, AVIATION FUEL MSDS NO. 62

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

<table>
<thead>
<tr>
<th>TRADE NAME</th>
<th>Jet Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRIPTION:</td>
<td>Jet Fuel is a complex blend of paraffinic, olefinic, naphthenic and aromatic hydrocarbons</td>
</tr>
<tr>
<td>CHEMICAL FAMILY:</td>
<td>Liquid Hydrocarbon</td>
</tr>
</tbody>
</table>

EMERGENCY TELEPHONE: CHEMTREC - (800) 424-9300 or (703) 527-3887 (collect)
SUPPLIER: Sinclair Oil Corporation
P. O. Box 30825
Salt Lake City, Utah 84130

TELEPHONE: (888) 340-3466
FAX: (801) 524-2740

2. COMPOSITION, INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>CAS Registry Number(s):</th>
<th>50834-94-9, 8006-20-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPOSITION</td>
<td>Typical wt. %</td>
</tr>
<tr>
<td>Xylene</td>
<td>0.9</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.9</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>3.3</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>0.5</td>
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<tr>
<td>Toluene</td>
<td>0.8</td>
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</table>

<table>
<thead>
<tr>
<th>COMPONENTS:</th>
<th>TWA</th>
<th>STEL</th>
<th>CEILING</th>
<th>TWA</th>
<th>STEL</th>
<th>UNIT</th>
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<tbody>
<tr>
<td>Xylene</td>
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<tr>
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<tr>
<td>Naphthalene</td>
<td>10</td>
<td></td>
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<td>10</td>
<td></td>
<td>ppm</td>
</tr>
<tr>
<td>Benzene</td>
<td>10*</td>
<td></td>
<td></td>
<td>300</td>
<td></td>
<td>ppm</td>
</tr>
</tbody>
</table>

* Applies to industry segments exempt from the 1 ppm 8 hour TWA and 5 ppm STEL of the Benzene Standard at 29 CFR 1910.1028.
3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:
Colorless liquid with a kerosene odor. Can cause irritation to the eyes, skin and respiratory tract.

POTENTIAL HEALTH EFFECTS:
Trauma and burns secondary to explosions and fires can result. In enclosed spaces, oxygen may be displaced by vapors or consumed by combustion. Incomplete combustion will produce carbon monoxide and other toxic gases.

INHALATION:
Overexposure may cause weakness, headache, nausea, confusion, blurred vision, drowsiness and other central nervous system effects. Extremely high-level exposure may result in dizziness, irregular heartbeat, coma, collapse and death.

EYE CONTACT:
Contact may cause eye irritation. Naphthalene vapor causes eye irritation.

SKIN CONTACT:
Contact may irritate or burn skin. Absorption through the skin may cause symptoms of intoxication.

INGESTION:
Based on acute toxicity studies in animals, Jet Fuel is practically non-toxic by ingestion. If aspirated (liquid enters lung) following ingestion, severe lung irritation and pulmonary edema (swelling of lung tissue) may occur. Aspiration may also result in central nervous system depression or excitement. Serious, permanent lung damage may result. Nausea, vomiting, diarrhea and abdominal pain may occur following ingestion.
Assessing exposure

- Ask
- Observe
- Measure (quantify, if you can)
# SINCLAIR
## MATERIAL SAFETY DATA SHEET
### SINCLAIR JP-8, JET A, TURBINE FUEL, AVIATION FUEL  MSDS NO. 62

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<td>0.3</td>
<td>91-20-3</td>
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### COMPONENTS:

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