History of Occupational Exposure Limits

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Topics

- Parallels to the Evolution of EH&S
- Evolution of OELs over the last 60 years
- OEL Trivia
- Where are we today?
Evolution of EH&S vs Development of OELs

- Prior to the development of OELs, insights into industrial hygiene (occupational hygiene) and chemical exposure were developed
  - ca, 90-20 BC: Roman architect/engineer Marcus Vitruvius Pollio noted lead workers had pale gray complexions
  - ca, 23-79 AD: Roman Pliny the Elder described workers’ use of sheep bladders as masks to protect from mercury dust and vapors
  - ca, 1556: Agricola warned of “black lung” in miners (Italian)
  - ca, 1700: Ramazzini, “father” of occupational medicine recommended hygiene, posture, ventilation and protective clothing for workers (Modena, Italy)
  - ca, 1736: state of Massachusetts in USA prohibited use of lead in whiskey stills after fatalities of drinking alcohol from the stills.
  - ca 1840: France issued a policy discouraging the use of lead as a pigment in paint
  - ca 1912: Kobert of Germany published a list of acute exposure limits for 20 substances

Many of the repeated exposure levels "with minimal symptoms" are considered to be IDLH concentrations today!
## Kobert’s List of Exposure Guidance

<table>
<thead>
<tr>
<th>Chemical</th>
<th>For Human &amp; Animals Rapid Death</th>
<th>0.5 – 1 Hour Exposure Serious Threat to Life</th>
<th>0.5 – 1 Hour Without Serious Health Effects</th>
<th>Repeated Exposure Minimal Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Chloride</td>
<td></td>
<td>1,500-2,000 ppm</td>
<td>500-1,000 ppm</td>
<td>100 ppm</td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td></td>
<td>4,000-5,000 ppm</td>
<td>500-2,000 ppm</td>
<td>200-300 ppm</td>
</tr>
<tr>
<td>Hydrogen Cyanide</td>
<td>~3,000 ppm</td>
<td>1,200-1,500 ppm</td>
<td>500-600 ppm</td>
<td>200-400 ppm</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>30%</td>
<td>60-80,000 ppm</td>
<td>40-60,000 ppm</td>
<td>20-30,000 ppm</td>
</tr>
<tr>
<td>Ammonia</td>
<td></td>
<td>240-450 ppm</td>
<td>300 ppm</td>
<td>100 ppm</td>
</tr>
<tr>
<td>Chlorine</td>
<td>~10,000 ppm</td>
<td>400-600 ppm</td>
<td>40 ppm</td>
<td>10 ppm</td>
</tr>
<tr>
<td>Bromine</td>
<td>~10,000 ppm</td>
<td>400-600 ppm</td>
<td>40 ppm</td>
<td>10 ppm</td>
</tr>
<tr>
<td>Iodine</td>
<td></td>
<td>30 ppm</td>
<td>5-10 ppm</td>
<td></td>
</tr>
<tr>
<td>Phosphorus Trichloride</td>
<td>3,500 mg/m3</td>
<td>3-500 mg/m3</td>
<td>10-20 mg/m3</td>
<td>4 mg/m3</td>
</tr>
<tr>
<td>Phosphine</td>
<td></td>
<td>400-600 ppm</td>
<td>100-200 ppm</td>
<td></td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>10-20,000 ppm</td>
<td>5-7,000 ppm</td>
<td>2-3,000 ppm</td>
<td>1-1,500 ppm</td>
</tr>
<tr>
<td>Gasoline</td>
<td></td>
<td></td>
<td>15-25,000 mg/m3</td>
<td>5-10,000 mg/m3</td>
</tr>
<tr>
<td>Benzene</td>
<td></td>
<td></td>
<td>10-15,000 mg/m3</td>
<td>~5,000 mg/m3</td>
</tr>
<tr>
<td>Carbon Disulfide</td>
<td>10-12,000 mg/m3</td>
<td></td>
<td>2-3,000 mg/m3</td>
<td>1-1,200 mg/m3</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>3-400,000 mg/m3</td>
<td>~150-200,000 mg/m3</td>
<td>~25-40,000 mg/m3</td>
<td>~10,000 mg/m3</td>
</tr>
<tr>
<td>Chloroform</td>
<td>3-400,000 mg/m3</td>
<td>70,000 mg/m3</td>
<td>25-30,000 mg/m3</td>
<td>~10,000 mg/m3</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>20-30,000 ppm</td>
<td></td>
<td>5-10,000 ppm</td>
<td>2,000 ppm</td>
</tr>
<tr>
<td>Aniline</td>
<td></td>
<td></td>
<td>400-600 mg/m3</td>
<td>100-250 mg/m3</td>
</tr>
<tr>
<td>Toludine</td>
<td></td>
<td></td>
<td>400-600 mg/m3</td>
<td>100-250 mg/m3</td>
</tr>
<tr>
<td>Nitrobenzol</td>
<td></td>
<td></td>
<td>1,000 mg/m3</td>
<td>200-400 mg/m3</td>
</tr>
</tbody>
</table>
Recognition of the Need for OELs

- Chronology shows many major occupational chemical exposure problems known for almost 2,000 years
- Only the last 100-150 years have seen that these hazards are no longer acceptable
- Change in culture started in Europe in late 1880s
- 50 years later before this cultural change took hold in the USA
In Fact…. 

- 1918 Worker’s Compensation denied an 18-year old painter’s compensation for exposure to deadly paint fumes and gases 2 days after warming the paint so it would brush onto the building walls.

  - Since lead poisoning was considered usual and customary incident to painters, compensation was denied.

- Today, lead poisoning would be covered under worker’s compensation in most countries with occupational safety and health legislation.
1916 - 1917

- South Africa published Quartz OEL 8.5 mppcf (million particles per cubic foot)
- U.S. Bureau of Mines published Quartz OEL 10 mppcf

In the late 1920’s a company in West Virginia ignored the 1917 OEL and allowed 2,000 miners to be grossly over exposed to over 98% pure silica quartz dust as they tunneled through a mountain.

- >400 workers died within 2 years
- Almost all remaining workers eventually died of silicosis
1920’s

- U.S. Bureau of Mines published 33 OELs
- International Critical Tables published 27 OELs
1930’s

- Russia published first MAC list of 30 OELs
- Germany published list of about 100 OELs
1940’s


  Note that this was 58 years after Germany published the original OEL list in 1912!

- Thresholds Committee of ACGIH published first table of 63 exposure limits (MACs) – later to be known as “Threshold Limit Values”

- Germany outlawed use of asbestos for insulation in ships

- India passed the Factories Act with a table of exposure limits
1950’s

- People’s Republic of China published their first list of exposure standards
1960’s

- U.S. includes ACGIH and ANSI exposure limits in the OSH act finally passed in 1970
  - First documentation of the TLVs was published
1970’s

- Many countries adopt the latest version of the ACGIH TLVs® as the basis for their exposure standards and health laws
- U.S. Consumer Product Safety Commission outlawed lead in commercial paint

Note that this was 138 years after France outlawed lead in paint in 1840!
1980’s

- “Control Banding” concept is first proposed
- U.S. updated OSHA Permissible Exposure Limits in Table Z-1 (1989)
1990’s

- U.S. Litigation sees repeal of 1989 OSHA PELs – (100% 1989 PELs repealed in 1992)
2000

- Global Harmonized System (GHS) for chemical labeling introduced by the European Union to further chemical safety
2002

- International Labor Organization (ILO) issued “Control Banding” Toolkit based on Global Harmonized System for labeling to reduce chemical exposures worldwide – particularly where OELs don’t exist or where EH&S support is limited
2006

- Virtually all countries update their OELs every 1 to 5 years

  EXCEPT India and the United States!
Trivia – But are the Hazards really different?

- Most countries have OELs that date from 2003 or more recently
  - Except India and USA
- G8 countries have active committees to study, develop and update federally-enforceable OELs
  - USA does not
- Germany has most advanced system for developing OELs and store all occupational hygiene data in a database.
  - Exposure data used with national health care data system to look for health effects of chemicals in workers
Minutia

- Most countries have 3 sets of OELs
  - Dusts
  - Carcinogens
  - Volatile or gaseous chemicals

- Russia has OELs for more substances than any other country (>3,500) including ~100 OELs for species of mold and bacteria

- Largest number of No Observable Effect Level (NOEL) stands set by the State of California

- Many countries state that OELs do not protect sensitive workers

- Russian OELs designate minimizing health effects for works and for ‘workers’ future generations’
Is there any wonder we have different OEL values?

- Some EU countries list an OEL of “0” for certain chemicals – these are banned chemicals in those countries.

- Hungary has the most comprehensive OELs for carcinogens and mutagens.

- Japan differentiates inhalation sensitizers and skin sensitizers.

- New Zealand adjusts the OELs for respiration rate of the worker.

- Some countries adjust OELs for altitude, standard temperature and pressure or for a 48-hour work week.
Re-Examining the Value of OELs

- **60 years of developing OELs**

- **Changes during those 60 years include:**
  - Regulatory changes
  - Litigation in some countries
  - Shifting centers of manufacturing growth
  - More global view on issues
  - Better science and testing
  - Better communication of hazards globally
  - Differences in risk tolerance and access to relevant data results in many OEL values around the world
Where We Go From Here

- For a global economy to work, the workforce must be valued and not squandered
  - All OEL-setting bodies should harmonize worker protection using the same standard of care

- The accumulated research globally on OELs is huge
  - Why are the OELs different in many countries?
  - How do we make available the ‘hazard data’ on materials so that control strategies and risk management can be prepared?

- As shown in this brief overview of the history, the hazards have been known for many chemicals for thousands of years.