History of Occupational Exposure Limits

Susan D. Ripple, MS, CIH, AIHA Fellow
Sr. Industrial Hygiene Manager
The Dow Chemical Company
Midland, MI

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

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

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

- American National Standards Institute (ANSI) Z-37 published U.S. exposure "standard" for Carbon Monoxide - 100 ppm

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.