Occupational Exposure Banding 2.0: A Preliminary Case Study

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Occupational Exposure Banding Objective

To create a consistent and documented process to characterize chemical hazards so timely and well-informed risk management decisions can be made for chemicals lacking OELs.
What is Occupational Exposure Banding?

A mechanism to quickly and accurately assign chemicals into “categories” or “bands” based on their health outcomes and potency considerations.
# NIOSH Occupational Exposure Bands

<table>
<thead>
<tr>
<th>Occupational Exposure Band</th>
<th>Airborne Target Range for Particulate Concentration (mg/m³)</th>
<th>Airborne Target Range for Gas or Vapor Concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt;10 mg/m³</td>
<td>&gt;100 ppm</td>
</tr>
<tr>
<td>B</td>
<td>1 to 10 mg/m³</td>
<td>10 to 100 ppm</td>
</tr>
<tr>
<td>C</td>
<td>0.1 to 1 mg/m³</td>
<td>1 to 10 ppm</td>
</tr>
<tr>
<td>D</td>
<td>0.01 to 0.1 mg/m³</td>
<td>0.1 to 1 ppm</td>
</tr>
<tr>
<td>E</td>
<td>≤0.01 mg/m³</td>
<td>≤0.1 ppm</td>
</tr>
</tbody>
</table>
How is the Banding Process Organized?

Bands are assigned based on:

- acute toxicity
- skin corrosion and irritation
- serious eye damage and irritation
- respiratory sensitization
- skin sensitization
- genotoxicity
- carcinogenicity
- reproductive/developmental toxicity
- specific target organ toxicity resulting from repeated exposure
Tier 1 — GHS Hazard Codes
User: Health and safety generalist
A Tier 1 evaluation utilizes GHS Hazard Statements and Categories to identify chemicals that have the potential to cause irreversible health effects.

Tier 2 — Secondary Data Sources
User: Properly trained occupational hygienist
A Tier 2 evaluation produces a more refined OEB, based on point of departure data from reliable sources. Data availability and quality are considered.

Tier 3 — Expert Judgement
User: Toxicologist or experienced occupational hygienist
Tier 3 involves the integration of all available data and determining the degree of conviction of the outcome.
Chemical of interest has no OEL

Locate GHS hazard codes and categories in recommended databases

Compare hazard codes and categories with NIOSH criteria for each health endpoint

Assign band for each relevant health endpoint based on criteria

Assign a Tier 1 OEB for the chemical based on most protective endpoint band (C, D, or E)
<table>
<thead>
<tr>
<th>TIER 1 Criteria</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Particle</strong> OEL Ranges</td>
<td><strong>Particle</strong></td>
<td><strong>Vapor</strong></td>
<td><strong>Vapor</strong></td>
</tr>
<tr>
<td></td>
<td>&gt; 0.1 to ≤ 1 mg/m³</td>
<td>&gt; 0.01 to ≤ 0.1 mg/m³</td>
<td>≤ 0.01 mg/m³</td>
</tr>
<tr>
<td></td>
<td>&gt; 1 to ≤ 10 ppm</td>
<td>&gt; 0.1 to ≤ 1 ppm</td>
<td>≤ 0.1 ppm</td>
</tr>
<tr>
<td><strong>Acute Toxicity</strong></td>
<td>H301 Category 3</td>
<td>H300 Category 2</td>
<td>H300 Category 1</td>
</tr>
<tr>
<td></td>
<td>H302 Category 4</td>
<td>H330 Category 2</td>
<td>H330 Category 1</td>
</tr>
<tr>
<td></td>
<td>H331 Category 3</td>
<td>H310 Category 2</td>
<td>H310 Category 1</td>
</tr>
<tr>
<td></td>
<td>H332 Category 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H311 Category 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H312 Category 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Skin Corrosion/ Irritation</strong></td>
<td>H315 Category 2</td>
<td></td>
<td>H314 Category 1, 1A, 1B, or 1C</td>
</tr>
<tr>
<td><strong>Serious Eye Damage/ Eye irritation</strong></td>
<td>H319 Category 2, 2A or 2B</td>
<td>H317 Category 1B</td>
<td>H318 Category 1</td>
</tr>
<tr>
<td><strong>Respiratory and Skin Sensitization</strong></td>
<td>H317 Category 1B</td>
<td>H334 Category 1B</td>
<td>H334 Category 1 or 1A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Genotoxicity</strong></td>
<td></td>
<td>H341 Category 2</td>
<td>H340 Category 1, 1A or 1B</td>
</tr>
<tr>
<td><strong>Carcinogenicity</strong></td>
<td></td>
<td>H350 Category 1, 1A, or 1B</td>
<td>H351 Category 2</td>
</tr>
<tr>
<td><strong>Toxic to Reproduction</strong></td>
<td>H361 (including H361f, H361d, and H361fd) Category 2</td>
<td>H360 (including H360f, H360d, and H360fd) Category 1B</td>
<td>H360 (including H360f, H360d, and H360fd) Category 1 or 1A</td>
</tr>
<tr>
<td><strong>Specific Target Organ Toxicity</strong></td>
<td>H371 Category 2</td>
<td>H370 Category 1</td>
<td>H370 Category 1</td>
</tr>
<tr>
<td></td>
<td>H373 Category 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Tier 2 is always recommended, but especially useful when:

- there are no GHS H codes
- the outcome of the Tier 1 analysis is incomplete, or an insufficient reflection of the health potency of the chemical
Tier 2

Tier 2 — Both Qualitative and Quantitative

- Some training in toxicology
- Based on readily available secondary data from authoritative sources (government, professional health agencies, authoritative toxicological benchmarks)
- Needs sufficient data to generate reliable OEB
- Prescriptive analytical strategy to ensure consistency
- Potential for chemicals to be moved from the Tier 1 OEB to a more or less protective OEB
Begin Tier 2 process

- Search recommended databases for toxicity information
- Compare data to NIOSH criteria for each health endpoint and assign endpoint band
- Ensure that total determinant score is sufficient for banding
- Assign a Tier 2 OEB for the chemical based on most protective endpoint band
### Recommendation --- Rane Test 1(1)

**Chemical Name:** Rane Test 1  
**CAS Number:** 1  

**Liquid/Vapor Range:** <= 0.1 ppm  
**Particle Range:** <= 0.01 mg/m³

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Source</th>
<th>Data</th>
<th>EDS</th>
<th>Endpoint Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcinogenicity Quant</td>
<td>EPA IRIS Slope Factor</td>
<td>1 x 0.000001 (mg/kg-day)^1</td>
<td>30</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>California Slope Factor</td>
<td>1 x 0.0000001 (mg/kg-day)^1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carcinogenicity WOE</td>
<td>U.S. EPA IRIS</td>
<td>Group C (possible human carcinogen)</td>
<td>20</td>
<td>D</td>
</tr>
<tr>
<td>Reproductive Toxicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target-Organ Toxicity</td>
<td>U.S. EPA: IRIS</td>
<td>Rank 1; NOAEL; 90 hrs; 4.8 ppm</td>
<td>30</td>
<td>E</td>
</tr>
<tr>
<td>Genotoxicity Toxicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory Sensitization</td>
<td>WHO: International Programme on</td>
<td>Rank 1; Results: Mixed</td>
<td>10</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Chemical Safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin Sensitization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute Toxicity</td>
<td>National Library of Medicine</td>
<td>Rank 1; Type: Oral LD50; Duration: 4.00</td>
<td>5</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>ChemID Plus</td>
<td>hrs; Input: 661</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin Irritation</td>
<td>WHO: International Programme on</td>
<td>Rank 1; Results: Skin corrosion/irreversible</td>
<td>5</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Chemical Safety</td>
<td>effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organization for Economic Co-operation and Development</td>
<td>Rank 1; Results: Moderate to severe irritation</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Eye Irritation</td>
<td>WHO: International Programme on</td>
<td>Rank 1; Results: Irreversible eye damage</td>
<td>5</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Chemical Safety</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**  
- **Carcinogenicity:** Cancer Test Information: https://ntp.niehs.nih.gov/pubs/health/roc/index.html  
- **STOT:** STOT Test Information: https://ntp.niehs.nih.gov/testing/types/healthandsafety/index.html  
- **Acute Tox:** Acute Toxicity Information: http://www.inchem.org/
Tier 2 Endpoints with Quantitative Criteria

- Carcinogenicity
  - Potency estimate (inhalation unit risk, slope factor)
  - *Qualitative assessment (Y/N in absence of potency determination)*
- Reproductive toxicity (includes developmental toxicity)
  - Potency based on NOAEL, BMDL, BMCL
- Specific target organ toxicity
  - Potency based on NOAEL, BMDL, BMCL
- Skin sensitization
  - Potency based on LLNA, GPMT, Beuhler
  - *Qualitative assessment (Y/N in absence of potency determination)*
- Acute toxicity
  - Potency based on LD_{50}, LC_{50}
Tier 2 Endpoints with Qualitative Criteria

- Genotoxicity
  - Positive, mixed, negative results
- Respiratory Sensitization
  - Positive, mixed, negative results
- Skin Irritation or Corrosion
  - Non-irritating, mild to moderate, moderate to severe, irreversible
- Eye irritation or Damage
  - Non-irritating, mild to moderate, moderate to severe, irreversible
Tier 3 banding process

- Requires expert in toxicology
- Requires intensive review and evaluation of primary data
- Is required when insufficient data for Tier 2 banding
- No detailed guidance is available
Problem

- Many chemicals would not meet minimum data set requirement
  - What is the best way to consider chemicals with insufficient data?
- Are read-across or QSAR methods reliable enough to use?
- Are read-across or QSAR methods simple enough to use with a broad audience?
  - What are the uncertainties associated with these methods?
- How can these methods be reliably and reproducibly used to predict toxicity?
Potential Solution?

- **Read-across methods**
  - Strengths and weaknesses?
  - How much data is needed on other chemicals?
  - How are classes of chemicals defined reproducibly?

- **QSAR**
  - Expert- or data-driven?
  - What are the boundaries of the chemical structures that could be considered?
  - Strengths and weaknesses?
Other Solutions?

- What other methods should NIOSH consider?
- Are there existing methods that would serve or could be adapted?
  - Strengths and weaknesses?
  - Reproducibility?
  - Reliability?
Let’s Discuss!