Are the OSHA Standards Appropriate for Assessing the Vapor Intrusion Pathway in Occupational Settings

- PO109 -

AIHce
64th Annual Conference and Exposition
May 2004, Atlanta, Georgia

F.W. Boelter, CIH, PE
D.M. Podraza, CHMM
M.W. Reese, LPG

Boelter & Yates, Inc.
Park Ridge, IL
Key Points

- Stakeholders = Decision Makers
- Risk Assessment = Science
- Risk Management = Policy
- Informed decisions
- Not intuitive outcomes
Vapor Intrusion

- Migration of vapors
- Complex pathway
- Transport through soils
- Influenced by construction techniques
- Dose via air pathway > than other pathways
- Emotional issue
- Focus has been residential

Source: US EPA Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils.
Environmental Indicators

- Volatiles within 100’ of ground surface
- Volatiles underlying or within 100’ of structure
- Preferential migration pathways
  - Utility backfill
  - Soils
“… there may be instances (under CERCLA and other cleanup programs) where standards other than the OSHA standards are used to determine whether the exposure pathway presents a risk to human health.”
Occupational Risk Assessment

- Indoor Air Screening Levels
- US EPA Equations/URFs/RfCs
- Indoor Worker Exposure Factors
- Occupational Exposure Frequencies

US EPA Vapor Intrusion Guidance Document
Indoor Worker Receptor

- Variety of Jobs/Tasks
  - Administrative/Office
  - Production
  - Retail
  - Warehouse
- 40 hrs/week
- Mostly indoors
- May use chemicals
- Primary Pathways:
  - Vapor Intrusion
  - Indoor Dust
  - Groundwater

### Summary of the Commercial/Industrial Exposure Framework for Soil Screening Evaluations

<table>
<thead>
<tr>
<th>Exposure Characteristics</th>
<th>Outdoor Worker</th>
<th>Indoor Worker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substantial soil exposures</td>
<td>Minimal soil exposures (little or no direct contact with outdoor soils, potential for contact through ingestion of soil tracked in from outside)</td>
<td></td>
</tr>
<tr>
<td>High soil ingestion rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term exposure</td>
<td>Long-term exposure</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pathways of Concern</th>
<th>Outdoor Worker</th>
<th>Indoor Worker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingestion (surface and shallow subsurface soils)</td>
<td>Ingestion (indoor dust)</td>
<td></td>
</tr>
<tr>
<td>Dermal absorption (surface and shallow subsurface soils)</td>
<td>Inhalation (indoor vapors)</td>
<td></td>
</tr>
<tr>
<td>Inhalation (fugitive dust, outdoor vapors)</td>
<td>Inhalation of contaminated ground water</td>
<td></td>
</tr>
<tr>
<td>Ingestion of contaminated ground water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Default Exposure Factors

<table>
<thead>
<tr>
<th>Exposure Frequency (d/yr)</th>
<th>225</th>
<th>250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure Duration (yr)</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Soil Ingestion Rate (mg/d)</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Inhalation Rate (m³/d)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Body Weight (kg)</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Lifetime (yr)</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

Source: US EPA Supplemental Guidance For Developing Soil Screening Levels
Indoor Air Screening Levels
Carcinogens

\[
C_{cancer} = \frac{(TCR \times AT_c)}{(EF \times ED \times URF)} \times 0.001 \text{mg/\mu g}
\]

- \(C_{cancer}\) = Indoor Air Screening Level (1E-6, 1E-5, 1E-4)
- \(TCR\) = Target Cancer Risk
- \(URF\) = Unit Risk Factor (IRIS, HEAST, etc.)
- \(AT_c\) = Averaging Time for Carcinogens
- \(EF\) = Exposure Frequency
- \(ED\) = Exposure Duration

* Integrated Risk Information System (IRIS)
* Health Effects Assessment Summary Tables (HEAST)
Target Indoor Air Concentrations
Non-Carcinogens

\[ C_{non-cancer} = THQ \times RfC \times WP_{EF} \]

- \( C_{non-cancer} \) = Indoor Air Screening Level
- \( THQ \) = Target Hazard Quotient (=1)
- \( RfC \) = Reference Concentration (IRIS, HEAST)
- \( WP_{EF} \) = Workplace Exposure Factor
  (8hr/d, 250d/yr)

* Integrated Risk Information System (IRIS)
* Health Effects Assessment Summary Tables (HEAST)
Benzene
3 Orders Different

TCR = 10^{-6}

TCR = 10^{-5}

TCR = 10^{-4}

PEL (1ppm)

mg/m^3

0.001 0.01 0.1 1 10

0.002

0.016

0.157

3.19

0.001 0.01 0.1 1 10
Xylene
1 Order Different

THQ = 1

PEL (100ppm)

mg/m³

30.7

434
Trichloroethene (TCE)

6 Orders Different

TCR = $10^{-6}$

TCR = $10^{-5}$

TCR = $10^{-4}$

PEL (100 ppm)

mg/m$^3$
Tetrachloroethylene (PCE)
5 Orders Different

TCR = $10^{-6}$
- 0.004

TCR = $10^{-5}$
- 0.041

TCR = $10^{-4}$
- 0.409

PEL (100 ppm)
- 678

mg/m$^3$
Vinyl Chloride (VC)

3 Orders Different

TCR = $10^{-6}$
- PEL (1ppm) = 0.001 mg/m$^3$

TCR = $10^{-5}$
- PEL (1ppm) = 0.014 mg/m$^3$

TCR = $10^{-4}$
- PEL (1ppm) = 0.139 mg/m$^3$
- TCR = $10^{-3}$
- TCR = $10^{-2}$
- TCR = $10^{-1}$
- TCR = 1

mg/m$^3$
Findings

- **Order of Magnitude Differences**
  - Exposure standards have different purposes

- **Risk Based Levels**
  - Duration, concentration, toxicity
  - Prevention
  - Public Health Protection

- **PELs**
  - Incident Reduction
  - Workers trained on use and hazards
Screening a Site

- **Air Sampling**
  - Not Usually Available
  - Not an Appropriate Starting Point

- **Soil Gas Sampling**
  - Not Typically Available

- **Groundwater Sampling/Screening**
  - Look for Environmental Indicators
  - Most Sites Have GW Data
  - Consider Proximity/Contaminants
  - Degree of Characterization
  - Seasonal Variations
Groundwater Screening Levels

\[ C_{gw} = C_{ia} \times 0.001 \frac{m^3}{L} \times (H)^{-1} \times (\alpha)^{-1} \]

- \( C_{gw} \) = Groundwater Screening Level (mg/L)
- \( C_{ia} \) = \( C_{cancer} \) or \( C_{non-cancer} \)
- \( \alpha \) = Vapor Attenuation Factor
- \( H \) = Henry’s Law Constant
Attenuation Factors

- **Ratio of Indoor Air Conc./Source Vapor Conc.**
  - $\times 100 = \%$ migrating into building

- **Lower** = Less Intrusion

- **Higher** = More Intrusion

- **Influences**
  - Building Characteristics
  - Soil Type
  - Source Depth
Selecting an Attenuation Factor

If your boring log indicates that the following materials are the predominant soil types ...

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Description</th>
<th>Soil Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sand or Gravel</strong> or <strong>Sand and Gravel</strong>, with less than about 12 % fines, where “fines” are smaller than 0.075 mm in size.</td>
<td>Sand</td>
<td><strong>Sand or Silty Sand</strong>, with about 12 % to 25 % fines</td>
</tr>
<tr>
<td><strong>Sand or Silty Sand</strong>, with about 12 % to 25 % fines</td>
<td>Loamy Sand</td>
<td><strong>Silty Sand, with about 20 % to 50 % fines</strong></td>
</tr>
<tr>
<td>Silt and Sand or Silty Sand or Clayey, Silty Sand or Sandy Silt or Clayey, Sandy Silt, with about 45 to 75 % fines</td>
<td>Sandy Loam</td>
<td><strong>Sandy Silt or Silt, with about 50 to 85 % fines</strong></td>
</tr>
</tbody>
</table>

Then you should use the following texture classification when obtaining the attenuation factor.
## Groundwater Screening Levels

*(Parts Per Million)*

<table>
<thead>
<tr>
<th>COPC</th>
<th>(\alpha = 10^{-4})</th>
<th>(\alpha = 10^{-3})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>0.069</td>
<td>0.007</td>
</tr>
<tr>
<td>Toluene</td>
<td>64.4</td>
<td>6.44</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>0.7 (MCL)</td>
<td>0.7 (MCL)</td>
</tr>
<tr>
<td>Xylenes (total)</td>
<td>1,230</td>
<td>123</td>
</tr>
<tr>
<td>1,1-DCA</td>
<td>95.2</td>
<td>9.52</td>
</tr>
<tr>
<td>PCE</td>
<td>0.054</td>
<td>0.005 (MCL)</td>
</tr>
<tr>
<td>TCE</td>
<td>0.005 (MCL)</td>
<td>0.005 (MCL)</td>
</tr>
<tr>
<td>VC</td>
<td>0.013</td>
<td>0.002 (MCL)</td>
</tr>
</tbody>
</table>

\(\alpha = 10^{-4}\) and \(\alpha = 10^{-3}\) refer to different risk assessment criteria.

TCR = 1 \times 10^{-6}; THQ = 1

COPC = Chemical Of Primary Concern.
Appropriateness

Stakeholder Science vs. Policy

US EPA

Residential/Public Buildings

Office/Retail/ Warehouse
No Chemical Use

Manufacturing/ Industrial
Dissimilar Chemical Use

Manufacturing/ Industrial
Similar Chemical Use

OSHA

Risk Assessment

PELs

Risk Assessment
Define Use
Market/Financial Factors
Risk Threshold/Perception
Regulatory Experience
Case Studies

1. Former Manufacturing
2. Solvent Contamination
3. Similar Concentrations
4. Similar Geology
5. Similar Vapor Attenuation
6. Similar Predicted Indoor Air Concentrations
7. Restricted Use NFR Letters
Case Study #1

- **Future Warehouse**
  - No Chemical Use
- **Stakeholder**
  - Unusual Exposure
  - Risk Assessment Needed
- **Results**
  - Solvents Detected
  - Below Risk-Based Levels
Case Study #2

- Future Manufacturing
  - Similar Chemical Use
  - Greater Quantities
- Stakeholder
  - Not Unusual Exposure
  - PELs were the concern
Summary

- Vapors may be a concern
- Are 1E-5 and 1E-6 too protective or costly
- Evaluation “Data Gap”
- Stakeholders are policy makers
- Neither RBCA nor PELs are 100% Appropriate
Two nearly identical situations – different outcomes

Stakeholders = Decision Makers

Risk Assessment = Science

Risk Management = Policy
Are the OSHA Standards Appropriate for Assessing the Vapor Intrusion Pathway in Occupational Settings

- PO109 -

Fred W. Boelter, CIH, PE
Boelter & Yates, Inc.
Park Ridge, Illinois
847/692-4700
fboelter@boelter-yates.com