Highly Efficient Subsurface Investigations in Large Buildings on Active Installations

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Outline

• Why has VI been so difficult?
• An array of vapor intrusion investigation tools
• Case study for big buildings – High Volume Sampling
  – Technical issues
  – Logistical & personnel issues
Challenges: Why has VI suffered such Confusion?

Poor data interpretation driven by:
1. Consumer VOC sources
2. Temporal variability
3. Spatial variability

and exacerbated by:
• Too few sampling techniques
A Common Experience

1. Sample
   - Indoor air; and/or
   - Subslab soil gas

2. Get confusing result

3. Sample again
Today's Vapor Intrusion Investigation Tools

Other techniques:

• Pneumatic tests
• Potentiometric measurements
• Tracer tests
1. Consumer/Background VOC Sources
### Many Methods to Distinguish Typical or Background from VI

<table>
<thead>
<tr>
<th>Field</th>
<th>Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Outdoor air</td>
<td>• CSMs</td>
</tr>
<tr>
<td>• Building inspections: remove sources*</td>
<td>• USEPA VI database tool</td>
</tr>
<tr>
<td>• Building pressurization</td>
<td>• Numerical modeling</td>
</tr>
<tr>
<td>• Flux chambers</td>
<td>• Forensic methods</td>
</tr>
<tr>
<td>• Field GC-MS like HAPSITE or mobile lab</td>
<td>• Literature</td>
</tr>
<tr>
<td></td>
<td>• Stable isotopes</td>
</tr>
</tbody>
</table>

*Remove sources when practicable.

Easy to miss an important one.
Field Method: Building Pressure Control

- Induce VI
- Cut time
- Increase confidence
Building Pressure Control

- Differential Pressure (Pascals)
- VOC Concentration (μg/m³)
- Time or Air Exchanges

- Baseline Pressure
- Induced Vapor Intrusion
- Under-Pressurized
- Over-Pressurized
Carbon Tetrachloride – What’s the CSM?

Only Detections in Indoor Air

Buildings: n=63
IA samples: n=156

10^-6 IASL: 0.47
Chloroform – What’s the CSM?

Only Detections in Indoor Air

Buildings: n=63
IA samples: n=156

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2. Temporal Variability in Indoor Air

Daily Average Indoor Air Combined Data Set

Period for Annual Average Calculations

How can we better represent long term exposure?
Quantitative Passive Samplers (QPS)

Radiello

OVM

Waterloo Membrane Sampler

Navy SPAWAR Technical Report #2018; Improved Assessment Strategies for Vapor Intrusion Passive Samplers and Building Pressure Control; Sept 2013
QPS as Flux Chambers
Quantitative Passive Sampler Summary

QPS applications:
- Indoor air
- Outdoor air
- Crawlspace air
- Vent pipes (WMS only)
- Soil gas
- Perimeter monitoring

QPS strengths:
- Improved representativeness for chronic exposure: 2-30 day samples
- Lower RLs with longer deployment
- Reduced method-based variability
- Ease of use
- Discrete

QPS’s generally not applicable for:
- Grab samples
- Soil gas in tight soil
- Fixed & very light gases (O₂, CO₂, CH₄, ethane, etc.)
Spatial Variability in Subslab Soil Gas Data

We approach buildings with 1-D CSM in mind

2 different sample results =
- Bad data?
- OR
- Incomplete CSM?
Field Method to Manage Data Quality

- Materials & Seals
- Shut-in Test
- Helium Tracer Test
- Purging rate, volume, vacuum and permeability
- Field Screening
- TO-15, TO-17
Large Building Approach
HVS Field Data Conceptualization

Each trend implies a different source geometry

![Graph showing the relationship between PID (Total Organic Vapor) and Volume Purged. The graph has two lines intersecting, indicating different trends for different source geometries.](image-url)
Generalized CSMs for HVS
23-Acre Building: How many samples do I need?
We can do this the hard way...
...or a better way.
How did it go?

- 27 locations
- 2 weekends of work
- Demonstrated absence of sources
- Focused attention where needed
- No interruption to operations
High Volume Sampling-Not just a VI tool; It’s a CSM tool

- Clarify source geometry
- Significant cost savings
- Minimize risk of failing to identify significant source
- Limited access areas
- Design parameters for mitigation measures
Bolster CSM with Subslab O₂ and CO₂

O₂

CO₂

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During HVS Collect Data for Mitigation Design

Cycle fan & record with data-loggin pressure transducer

4 minutes of data
Curve Fitting to Time-Drawdown Data

Curve fitting yields $T$ and $r/B$ values

Parameters:
- $T = 175.4 \text{ ft}^2/\text{day}$
- $S = 0.0005635$
- $r/B = 0.424$
- $K_z/K_r = 1$
- $b = 0.5 \text{ ft}$
- $B = 14 \text{ ft}$
Calculations for Mitigation Design

\[ \text{Vacuum} = \frac{Q_w}{2\pi T} K_r (r/B) \]

\[ v(r) = \frac{Q_w}{2\pi b n B} K_r (r/B) \]

\[ \frac{Q(r)}{Q_w} = \frac{r}{B} K_r (r/B) \]

- Radius of influence
- Pore velocity
- Soil gas travel times
- Leakage across slab
- Portion of flow from below the slab
- Portion of flow from leakage
HVS Advantages

- Demonstrate absence of significant sources
- Better assessment of slab integrity
- Assess areas of limited access
- Conducted in 16 states
- Get mitigation design data
Owner Coordinating with Tenant

- Worked with Environmental Dept.
- Shut down of Automated Guided Vehicles (AGVs) and no manufacturing interference
- Worked 2\textsuperscript{nd} shift & weekends
- Escorts required
- Unionized workers filed grievances against sampling crews
Features in Source Area
Chemical Carts as Indoor VOC Sources
Another Source: Liquid Adhesive

MATERIAL SAFETY DATA SHEET

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product name: LORD ACCELERATOR 4
Product Use/Class: ACRYLIC ADHESIVE, PART 2 OF 2

LORD Corporation
111 LORD Drive
Cary, NC 27511-7923

Telephone: 814 808-0924
Non-Transportation Emergency: 814 763-2345
Chemtrec 24 Hr Transportation Emergency No.
800 424-9300 (Outside Continental U.S. 703 527-3887)

EFFECTIVE DATE: 04/22/2013

2. COMPOSITION/INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>CAS Number</th>
<th>Weight % by Less Than</th>
<th>ACGIH TLV TWA</th>
<th>ACGIH TLV STEL</th>
<th>OSHA PEL TWA</th>
<th>OSHA PEL CEILING</th>
<th>Skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylene chloride</td>
<td>75-09-2</td>
<td>70.0 %</td>
<td>50 ppm</td>
<td>N.E.</td>
<td>25 ppm</td>
<td>N.E.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>79-01-6</td>
<td>75.0 %</td>
<td>50 ppm</td>
<td>100 ppm</td>
<td>100 ppm</td>
<td>100 ppm</td>
<td>N.A.</td>
</tr>
<tr>
<td>Methyl isobutyl ketone</td>
<td>108-19-1</td>
<td>10.0 %</td>
<td>50 ppm</td>
<td>75 ppm</td>
<td>410 mg/m³</td>
<td>100 ppm</td>
<td>N.E.</td>
</tr>
<tr>
<td>Benzoyl peroxide</td>
<td>94-36-0</td>
<td>10.0 %</td>
<td>5 mg/m³</td>
<td>N.E.</td>
<td>5 mg/m³</td>
<td>N.E.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Methyl methacrylate</td>
<td>80-62-6</td>
<td>5.0 %</td>
<td>50 ppm</td>
<td>100 ppm</td>
<td>410 mg/m³</td>
<td>100 ppm</td>
<td>N.E.</td>
</tr>
</tbody>
</table>

N.A. - Not Applicable, N.E. - Not Established, S - Skin Designation
Comparison: Screening Levels & Indoor Air Monitoring Data

<table>
<thead>
<tr>
<th>Occupational Screening Levels</th>
<th>EPA Commercial Screening Levels</th>
<th>CCAD Indoor Air Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSHA PEL</td>
<td>ACGIH TLV TWA</td>
<td>Maximum Concentration</td>
</tr>
<tr>
<td></td>
<td>Non-Cancer* HQ=1</td>
<td></td>
</tr>
<tr>
<td>537,000</td>
<td>269,000</td>
<td>890</td>
</tr>
<tr>
<td></td>
<td>8.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>88</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cancer 10^{-4} Risk</td>
<td></td>
</tr>
</tbody>
</table>

*Note: TCE toxicity driving non-cancer screening levels is based on a controversial study suggesting potential for fetal heart malformations. Dispute continues among toxicologists.
Coordinating Results with Tenant

• Notified Industrial Hygienist and Environmental Management
• Tenant notified Union
• Tenant IH discussed with females in the Occupational Health Clinic
• Tenant IH deployed personal air samples for workers
Steps to Address TCE Source Area

• Tenant Facilities & Maintenance
  o Sealed holes and cracks in walls
  o Sealed SUMP cover in Mechanical Room
  o Increased HVAC makeup air from ~0% to 30%

• Navy
  o 2017 Installed Air Purifying Units
  o 2018 Complete delineation & designs
  o 2019 SVE pilot (building now)
  o 2019 Subslab venting system (building now)
  o 2019 GW pilot studies (summer)
Sealing a Sump with TCE @1,500,000 $\mu$g/m$^3$
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