Vapor Intrusion Mitigation of Non-Residential Buildings by Sub-Slab Depressurization

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Vapor Intrusion in Commercial and Industrial Buildings: Assessment and Mitigation

NEWMOA & Brown University
Westford MA September 23, 2008
Providence, RI September 24, 2008
Commercial/Industrial Building Mitigation

- Institutional controls
- Source removal
- Building positive pressurization
- Passive barriers (new buildings)
- Sub-slab depressurization (SSD)
Sub-Slab Depressurization

- Originally developed for radon control
- Residential Homes
  - Highly effective (99.5% + reduction)
  - Typically low cost
    - $1500 - $3000 (install only)
Sub-Slab Depressurization

- Commercial Buildings
  - More challenging
  - Barriers often included
  - Higher cost
    - 1-5 $/sf + (ITRC, 2007)
SSD Case Histories

- Manufacturing Building, CO
- Dance Studio, CO
- Recreation Center, NY
- Warehouse, NY
- Charter School, CO
- Office Building, WY
- Law Office, KS
- Vocational School, KS
- Condominium Complex, CO
- Toronto Ferry Terminal, Canada
Manufacturing Building, CO

- 70,000 sf warehouse & manufacturing space (single story)
- 15,000 sf office space (two story)
Manufacturing Building, CO

- Chlorinated solvents in soil and groundwater below building
- Highest soil vapor levels near office area
Solution

- Focused system
- Suction points between offices & plume
- Suction points in unfinished areas
- Pipe runs in single story warehouse
Manufacturing Building, CO

- Solution
  - Suction points in unfinished areas
  - Pipes run to ceiling in single story warehouse
Manufacturing Building, CO

- Multiple suction points manifolded to one blower on roof
- $40,000 total cost
  - ~$0.50 sf total building
  - ~$2 sf mitigated
Dance Studio, CO

- Chlorinated solvents in groundwater
- Small single story building
- Roof unable to support large blower
- Large open room, no interior columns
Dance Studio, CO

Solution:

- 4 - 90 watt roof mounted fans
- 2 suction points per fan (8 total)
Dance Studio, CO

- **Solution:**
  - $24,000 total cost
  - $3.40/sf

![Diagram showing a 90 W fan and a suction pit]
Recreation Center, NY

- Chlorinated solvents in groundwater
- Multi-story building
- 20,000 SF total
  - 2,000 SF basement
  - 18,000 SF SOG
- Day care area
Recreation Center, NY

- Basement suction points in floor
- SOG suction points in floor and basement walls
- Sumps and crawl space openings sealed
Recreation Center, NY

- Cost issues:
  - City required 4” cast iron pipes
  - Multi-story pipe runs to roof
  - Finished space

Courtesy T. Hatton, Clean Vapor Inc.
Recreation Center, NY

- Four blowers required:
  - 3 low vacuum high flow
    - Max 18” WC, 110 cfm
  - 1 high vacuum low flow
    - Max 50” WC, 53 cfm
Recreation Center, NY

Cost:
- > $10/sf to achieve 0.003” suction over entire footprint of building, including diagnostics
Warehouse, NY

- Large warehouse complex with elevated indoor air levels throughout
Warehouse, NY

Solution:
- Depressurize crawl space below office
Problem:
- IA concentrations in office increased
Warehouse, NY

- **Cause:**
  - Depressurizing crawl space also depressurized office, pulling in warehouse air

![Diagram showing warehouse, office, and crawl space with airflow arrows and labeled areas.](image)
Warehouse, NY

Better Solution:
- Pressurize office space
Charter School, CO

- Old gasoline plume below school
- Basement area used for pre-school and kindergarten ages
- Existing SVE system being used for UST source area
Charter School, CO

- Economic solution:
  - Foundation drains connected to SVE system
  - Limited new infrastructure
- Depressurized slab
  - Increased O₂ below slab to near 21%
Office Building, WY

- Former petroleum refinery site
- Redeveloped as golf course and office park
Office Building, WY

- Need for active VI control based on elevated soil gas levels (100X IA target levels)
Office Building, WY

- Designers chose crawl space with membrane design
- Soils below membrane depressurized
Office Building, WY

- Membrane must not be damaged
- Seals to foundations must be maintained
- Slab on grade generally more robust
Law Office, KS

- Gasoline plume caused building to explode
- Resulting fire suppression water forced plume under neighboring law office
Law Office, KS

- Mitigation of Law Office
  - Protect against vapors
  - Prevent explosions
  - Deal with high water table

High Water Table
Law Office, KS

- **Solution:**
  - Multiple suction points
  - Intrinsically safe fan
  - ~$4/sf
Vocational School, KS

- Chlorinated solvents in groundwater below school
- Groundwater collects in open sump in basement
- Air stripper installed in basement to treat groundwater
- Elevated indoor air concentrations of TCE
Vocational School, KS

- Solution
  - Sump sealed and depressurized
  - Also depressurized french drain pipes
  - Exterior wall mounted fan
  - Total cost ~$4,000
Condominium Complex, CO

- Brownfields site
  - disseminated sources of chlorinated solvents
  - Condominiums being constructed
- Challenge:
  - Minimize number of active systems
  - No indoor air testing desired
Condominium Complex, CO

Solution:
- Perforated pipe placed below each unit
- Pipes manifolded to one riser every 4 units
- Initially passive
- Fan added if sub-slab vapor exceeds 10 times indoor air target level
Toronto Ferry Terminal

- New terminal for ferry between Toronto and Rochester
- Methane present in soil
- Poor load bearing conditions
- High water table
Toronto Ferry Terminal

- **Solution:**
  - Aerated floor system
  - Slab poured on patented forms
  - Passively ventilated voids formed in slab
  - No sub-excavation required
  - No venting media required
  - 80% concrete & rebar of normal slab

Courtesy Pontarolo Engineering, Inc.
Toronto Ferry Terminal

- Pontarolo ICF Wall
- Beton Stop Form
- Cupolex Form
- Concrete Topping Above Cupolex Min. 1.5" (3cm)
- WW Mesh or Fiber Reinforcement
- Venting Pipes
- Finished Grade
- Scudox Drainage Layer
- Optional Deeper Foundation
- Re: Plan
- Soil Gasses

Available 4" (10cm) - 28" (70cm)

Courtesy Pontarolo Engineering, Inc.
SSD is an effective mitigation technique for commercial & industrial buildings.

Focus systems:
- May not be necessary to depressurize entire footprint.

Consider most cost effective fan arrangement:
- Manifold several suction points to one blower, or
- Multiple smaller fans.

Costs can exceed $10/sf due to:
- Multi-story pipe runs
- Permit requirements (e.g., cast iron pipes)
Summary of Key Points

- Understand the effects of depressurizing
  - Air can be pulled from adjoining rooms or buildings
- Use existing building and remediation infrastructure
  - Depressurize french drains and sumps
  - Use SVE blowers if available
Summary of Key Points

- Depressurization can occur at
  - slab interface, below membranes, in drains, in crawl spaces
- Use explosion-proof equipment when appropriate
- Passive systems should be convertible to active, based on performance tests
Summary of Key Points

- Consider aerated floor systems for new buildings
  - Avoid sub-surface venting layers
  - More efficient sub-slab void network
  - Cost effective compared to traditional systems