

Understanding Vapor Intrusion: Hazards, Detection and Mitigation

September 3, 2024 | Gas Detection (<https://industrialhygienepub.com/category/gas-detection/>), Industrial Hygiene in the Workplace (<https://industrialhygienepub.com/category/industrial-hygiene-in-the-workplace/>)



(photo courtesy SCS Engineers)

By: **Alissa Barrow**, Contributor

Vapor intrusion is an environmental and occupational health issue where hazardous substances from contaminated soil or groundwater migrate into indoor spaces. This phenomenon can pose serious risks to workers and building occupants, especially in industrial and commercial settings.

Effective management of vapor intrusion requires a thorough understanding of its nature, potential hazards, detection methods and mitigation strategies. This article provides an in-depth exploration of vapor intrusion, its associated risks, and best practices for detection and mitigation.

What is Vapor Intrusion?

Vapor intrusion occurs when volatile organic compounds (VOCs) or other hazardous substances (such as methane) present in soil, soil vapor (the air space between soil particles) or groundwater migrate into buildings through cracks in building foundations or other pathways such as utilities (e.g., sewer).

This process involves the movement of these vapors from a high concentration source in the subsurface to lower concentration areas inside buildings—a phenomenon known as “advection.” As vapors accumulate in indoor air, they can pose significant health risks to occupants.

Hazards Posed to Workers

1. Health Risks:

- **Short-term Exposure:** Acute exposure to high concentrations of VOCs can lead to immediate health effects such as headaches, dizziness, nausea, and irritation of the eyes, nose and throat. These symptoms can disrupt daily activities and impact overall well-being.
- **Long-term Exposure:** Prolonged exposure to certain VOCs has been associated with chronic health issues. For instance, exposure to benzene can lead to blood disorders such as leukemia, while trichloroethylene and perchloroethylene have been linked to liver and kidney damage, respiratory issues and an increased risk of cancer. The EPA has identified many VOCs as carcinogenic (cancer-causing), while others are considered toxic at certain concentrations. The long-term health effects can significantly impact quality of life and work performance.

2. Safety Concerns:

- **Flammability:** Many VOCs, as well as methane at certain concentrations in air (i.e., between the lower explosive limit [LEL] at 5% by volume and the upper explosive limit [UEL] at 15% by volume), are highly flammable. In extreme cases of vapor intrusion, these chemicals can accumulate to unsafe levels and pose a risk of explosions or fires, particularly in environments with ignition sources such as machinery or electrical equipment. This risk is especially pronounced in industrial settings where flammable materials are present.
- **Environmental Impact:** Beyond health and safety concerns, the presence of chemicals in soil and groundwater cause broader environmental issues, affecting water resources and ecosystems, and potentially harming wildlife.



Collection of soil vapor sample using Summa canister. (photo courtesy SCS Engineers)

Detecting Vapor Intrusion

Detecting vapor intrusion involves several steps, from initial site assessment to ongoing monitoring. Here's a detailed overview of the detection process:

1. Site Assessment:

- **Historical Data Review:** Begin by examining the historical use of the site to identify potential sources of contamination. This includes reviewing past industrial activities, waste disposal practices and any previous environmental assessments. Understanding the history helps in pinpointing areas of concern and guiding the investigation.
- **Subsurface Sampling and Analysis:** Collect soil, soil vapor and/or groundwater samples for analysis to evaluate the concentration and distribution of contaminants. Techniques such as gas chromatography-mass spectrometry (GC-MS) are employed to identify and quantify VOCs.
- **Sub-Slab Sampling:** Install sampling points beneath the building's foundation to measure vapor concentrations directly beneath the slab using GC-MS. This method helps determine whether chemicals are present beneath the building and identifies areas of higher contamination where vapor intrusion is more likely to occur.
- **Indoor Air Sampling:** Measure indoor air quality to detect the presence and concentration of harmful chemicals and evaluate the potential exposure risk to occupants. This involves using specialized equipment to collect air samples from various locations within the building, which are then analyzed using GC-MS to evaluate for potential health risks.



Vapor intrusion mitigation system (i.e., vapor barrier) installation during building construction at aerospace facility. (photo courtesy SCS Engineers)

2. Risk Assessment:

- **Health Risk Evaluation:** Compare detected vapor concentrations with established health-based standards and guidelines. Regulatory agencies such as the Environmental Protection Agency (EPA) provide criteria for assessing potential health risks. This evaluation helps determine whether detected chemical concentrations pose a significant risk to workers and if further action is necessary.
- **Modeling:** Utilize models (e.g., Johnson and Ettinger) to predict vapor intrusion potential based on site-specific data. These models consider factors such as the type of contaminants, soil properties, building characteristics and environmental conditions. Modeling helps in understanding how vapors might move and accumulate within a building.



Soil vapor extraction equipment in former industrial dry cleaner. (photo courtesy SCS Engineers)

Mitigating Vapor Intrusion

Mitigating vapor intrusion involves a combination of engineering controls, building modifications and administrative measures. Here's a comprehensive look at effective mitigation strategies:

1. Source Control:

- **Contaminant Removal:** Address the root cause of vapor intrusion by removing or treating the contaminated soil or groundwater. Techniques such as soil excavation, groundwater pump-and-treat systems and bioremediation (using microorganisms to degrade contaminants) are commonly employed. Removing the source of contamination reduces the potential for vapor intrusion.
- **Soil Vapor Extraction:** Address VOCs directly beneath a building to prevent vapor intrusion. This is accomplished by installing perforated pipe (via horizontal drilling from the building exterior) or vapor extraction wells/suction points inside the building, which are connected to a blower which provides vacuum. The extracted vapors are routed through carbon to capture the harmful chemicals before the extracted vapor is released into the atmosphere.

2. Building Modifications:

- **Vapor Barriers:** For new building construction, install vapor barrier membranes beneath the building's foundation to block the migration of vapors into indoor spaces. These barriers are typically made from materials like high-density polyethylene or bituminous membranes, which are designed to be resistant to vapor transmission. These vapor intrusion barriers often are paired with passive venting systems beneath the membrane, as well as utility seals, to further improve effectiveness.
- **Sub-Slab Ventilation:** For existing buildings, incorporate a sub-slab depressurization system (SSDS) to create negative pressure beneath the building's foundation. This prevents vapors from entering the indoor air by drawing them away from the building.

3. Ventilation Systems:

- **Indoor Air Handling:** Enhance indoor air quality by improving ventilation systems. This includes increasing air exchange rates (particularly fresh air) and using air-filtration systems to remove contaminants from the indoor environment. Proper ventilation helps dilute and remove residual chemicals present in the indoor air.
- **Monitoring and Maintenance:** Regularly inspect and maintain ventilation systems to ensure they are functioning correctly. Scheduled maintenance helps prevent system failures and ensures that air quality remains within safe levels.

4. Regulatory Compliance:

- **Standards and Guidelines:** Follow environmental regulations and standards set by agencies such as the EPA and OSHA. These guidelines provide thresholds and procedures for managing vapor intrusion and protecting worker health. Compliance with these standards ensures that appropriate measures are taken to address vapor intrusion risks.
- **Documentation and Reporting:** Maintain comprehensive records of vapor intrusion assessments, mitigation measures and ongoing monitoring efforts. Documentation is essential for demonstrating compliance with regulations; tracking the effectiveness of mitigation strategies; and providing transparency to stakeholders.

Vapor intrusion is a complex issue that demands a multifaceted approach to effectively manage and mitigate its risks. By understanding the nature of vapor intrusion; recognizing its potential hazards; and employing robust detection and mitigation strategies, organizations can safeguard worker health and maintain a safe working environment. Continuous monitoring, adherence to regulatory guidelines and proactive management are key to addressing vapor intrusion challenges and ensuring long-term protection for all building occupants.

Addressing vapor intrusion not only helps minimize health risks but also contributes to broader environmental safety and compliance. Through diligent efforts and the application of best practices, the risks associated with vapor intrusion can be effectively managed—thus creating safer and healthier workplaces for everyone involved. **IHW**

About the Author:

Alissa Barrow (SCS Engineers) is a professional Civil Engineer with 14 years of environmental consulting experience specializing in assessment, remediation and compliance, with an emphasis on vapor intrusion assessment and mitigation. Barrow can be reached at abarrow@scsengineers.com (<mailto:abarrow@scsengineers.com>).