SKC WHITE PAPER ON VAPOR INTRUSION
An Emerging Indoor Air Issue

"No one anticipated that old spills of common industrial solvents could slowly create toxic plumes with the power to spread underground for miles before snaking up through pipes, foundation cracks, or porous materials to fill indoor air with carcinogens and other toxic substances". This statement published in a 2007 *Vapor Intrusion Report* by the Air and Waste Management describes an emerging health and safety issue called vapor intrusion.

Vapor Intrusion Defined

Vapor intrusion is the migration of volatile chemicals from underground into overlying structures. The source of the chemicals is typically buried waste and/or contaminated groundwater. Volatile chemicals underground migrate through the subsurface soils and into indoor air spaces of overlying buildings in ways similar to that of radon gas. The end result is an indoor air quality problem.

Vapor intrusion can occur in any structure built on a site where volatile chemicals were leaked, spilled, or dumped into the soil or groundwater. Vapor intrusion problems have been found in structures located on property formerly occupied by industrial plants, dry cleaners, gas stations, tank farms, and landfills.

Protocol for Assessing the Risk

U.S. EPA's Office of Solid Waste and Emergency Response (OSWER) has published a draft guidance document with a protocol on assessing the risk of vapor intrusion[1]. (See www.epa.gov and search using *vapor intrusion guidance).* In December 2009, the Office of Inspector General issued a report faulting EPA for not updating and finalizing this draft guidance since its 2002 release. Realistically, it will take some time for the guidance document to be finalized as directed by the Inspector General. Users should consult the U.S. EPA website for any updates as this issue continues to evolve.

In the existing draft guidance document, EPA describes a step-wise process to evaluate the potential for vapor intrusion. The very first step is to develop a Conceptual Site Model (CSM). A CSM is a narrative and visual representation of the site conditions and includes historical uses of the site, suspected contaminant sources, vapor transport pathways, building/land use, and potential human exposures. The CSM basically tells the story of the site and serves as a management and communication tool during the project.

For the next phase of the vapor intrusion study, EPA provides a series of questions to be answered about the site conditions. By working through the series of questions, health and safety professionals can determine if the vapor intrusion pathway poses an exposure risk to building occupants or not. These questions are divided into three tiers or levels of investigation:

- **Tier 1 Primary Screening**-Potential contaminants are identified and the potential for vapor intrusion is determined based on general knowledge of the site and chemicals known/suspected to be present.
- **Tier 2 Secondary Screening**-A basic site evaluation is conducted with collection of limited site-specific data on target chemicals in various matrices such as soil vapor and groundwater.
- **Tier 3 Site-specific Pathway Assessment**-Detailed site-specific data is collected including subslab vapor, indoor air measurements, as well as ambient air measurements for comparison purposes.

Conducting the Investigation

The first question in Tier 1 primary screening asks if there are chemicals present in the subsurface that are a) VOLATILE enough to result in vapor intrusion and b) TOXIC enough pose a significant health risk. Health and safety professionals typically use historical data on-hand to identify the contaminants at the site and then use Table 1 of the EPA guidance document to answer questions related to toxicity and volatility.

If it is determined that there are sufficiently toxic and volatile chemicals at the site, the next question to answer is whether the chemicals are *near* to existing or potentially inhabited buildings. Subsurface contaminants that are within 100 ft laterally or vertically of the building are considered by U.S. EPA to be *near* to the structure. Professionals should exercise judgment, however, when using the 100 ft rule. So-called significant preferential pathways must also be considered.

Significant preferential pathways are defined as a naturally occurring or man-made condition that is expected to enhance gas permeability and influence vapor intrusion into the building. These pathways include cracks in foundations, gaps around piping or utility lines, and subsurface drains that intersect vapor sources. If these circumstances exist at the site under study, buildings should be evaluated for vapor intrusion even if they are further than 100 ft from the contamination source.

Even in the primary screening phase, investigators should determine if there is any evidence to suggest immediate action may be warranted to mitigate imminent risks. Indicators of imminent risk include:

1. Chemical odors by occupants
2. Health problems reported by occupants
3. Wet basements in areas where chemicals are known to be in the groundwater
4. Explosive or acutely toxic vapor levels in the building

An example of imminent risk is the presence of methane gas at explosive levels. This can exist when a structure is built on the site of a former landfill. In this case, methane gas is produced by anaerobic decomposition of organic matter dumped in the landfill. Methane then permeates into the overlying structure via cracks, gaps, and other pathways with gas concentrations gradually building up to explosive levels.

If there is no imminent risk, but vapor intrusion could not be ruled out in Tier 1 primary screening, the investigation should continue to Tier 2 secondary screening. The question to answer at this level is whether measured or “reasonably estimated concentrations” of target chemicals in groundwater and soil vapor are above the screening levels in Table 2 of the EPA guidance document.

If the chemical levels in groundwater and soil vapor are at or above the screening levels, the investigation should continue to Tier 3. At this level, direct measurements are done of subslab soil vapor or crawl space vapor concentrations along with indoor air measurements. Ambient air measurements are also done for comparison purposes.

Air Measurement Methods for Vapor Intrusion Studies

Vapor intrusion studies typically include air measurements of contaminants in (a) soil gas and (b) indoor/ambient air. There are published air sampling methods for each sample type.

Soil Gas

For soil gas sampling, ASTM has published a standard guide D5314-92. (See www.astm.org). In this standard, ASTM recommends the collection of soil gas by using a whole air or sorbent method. With this method, holes are drilled through the floor of the building as close to the center of the floor space as possible or holes are drilled outside under the foundation. Then a stainless steel probe is inserted into the hole, the hole is sealed around the sides of the probe, and an air sample is drawn through the probe into a sample collection device for analysis.

Soil gas methods using whole air sample collection devices employ sample bags or evacuated stainless steel canisters. The SKC Vac-U-Chamber described at http://www.skcinc.com/prod/231-939.asp can be used for soil gas sampling with sample bags. The rigid container houses the sample bag and a pump is used to create negative pressure within the closed, airtight container. In this way, the soil gas sample is drawn into the bag from the underground sample site without passing potentially contaminated air through the pump. Bag samples are sent to a qualified laboratory for analysis. Alternatively, stainless steel canisters that have been evacuated to a specified vacuum level can be used to collect a whole air sample “passively” without a pump. In this case, a designated flow controller controls the rate of air flow into the evacuated canister. Following sample collection, canisters are sent to a qualified laboratory for analysis.

Soil gas methods using sorbent based collection devices employ specially designed sorbent sample tubes attached to calibrated sampling pumps for specified periods of time. Due to the low levels being measured, specialty sorbent tubes called thermal desorption tubes are typically used for this application. Thermal desorption tubes contain ultra clean sorbent that must be heat purged and used within 30 days to ensure low background levels. After sampling, the tubes are desorbed again by heat for laboratory analysis by gas chromatography. Thermal desorption tubes provide a high level of sensitivity and provide a detection limit of ≤0.5 ppb as required by U.S. EPA protocol. See http://www.skcinc.com/prod/226-356.asp for a list of thermal desorption tubes from SKC with a variety of sorbents.

Indoor/Ambient Air
Stainless steel canisters and thermal desorption sorbent tubes described above can also be used for low level air measurements of indoor or ambient air. U.S. EPA Methods TO-15 and TO-17 are reference methods for the use of canisters and sorbent tubes, respectively[2]. (See www.epa.gov.)

A new sorbent-based passive diffusive sampler is also now available from SKC for this application. With passive diffusive samplers, airborne gases and vapors simply diffuse from the test atmosphere onto the sampler at a fixed rate without the use of a sampling pump or external flow regulator. Each gas or vapor being sampled has a specific sampling rate determined by the manufacturer of the sampler. This rate is based upon the chemical's unique diffusion coefficient and the geometry of the passive sampler itself. Passive samplers are smaller, easier, and less expensive to ship than canisters. The smaller size and cost also allow users to practically collect more samples within the structure.

The SKC Ultra sampler contains thermally purged sorbent that traps contaminants even at sub-ppb levels. Simply clip the badge in the breathing zone at the test site to trap designated compounds over the 24-hour sampling period recommended by EPA. After sampling, the sampler is sent to a qualified analytical laboratory. There the laboratory will transfer the sorbent from the passive sampler to a thermal desorption tube for analysis using gas chromatography. The Ultra sampler shows very good correlation to stainless steel canisters in field studies with accommodation for low face velocity and with proper sorbent selection[3]. See http://www.skcinc.com/prod/590-100.asp for more information.

Vapor intrusion is a new and emerging indoor air issue. A proper vapor intrusion investigation requires the expertise of many to address all the complex issues. Health and safety professionals with experience in indoor and ambient air measurements are key members of a vapor intrusion investigative team.

References:
1. U.S. EPA OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), November 2002.

2. U.S. EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, January 1997.

3. Coyne, L., Havalias, G. and Echarte M. “Vapor Intrusion Sampling Options: Performance Data for Canisters, Badges, and Sorbent Tubes for VOCs”.