Building owners and operators most often work hard to provide occupants with a healthy and comfortable indoor environment. Under certain conditions, however, the indoor environment can be adversely affected by soil gas intrusion. This article describes what soil gas intrusion is, why it is important to building owners and operators, and how it can be mitigated.
Soil gas intrusion, or more commonly referred to as vapor intrusion, is the process by which soil gases migrate from the ground into the indoor air of a building's first floor or basement. Problematic soil gases can be either natural or human-made. An example of a natural process is the migration and intrusion of radon gas, which is a product of uranium decay in soils or rock. Exposure to radon increases the risk of developing lung cancer. Damp basements are another example of a natural intrusion process, where water or water vapors can infiltrate through the basement walls or slab as a result of hydrostatic pressure, capillary pressure, or water vapor diffusion. Excessive humidity can lead to the growth of mold or mildew, which is associated with health concerns and can damage building structures.

Soil gas intrusion related to human-made processes typically results from nearby releases of volatile chemicals to the subsurface via leaky storage tanks, accidental spills, or improper disposal practices, possibly well in the past (i.e., decades or more) and perhaps even before the building was constructed. Examples of volatile chemicals include petroleum-type products (e.g., gasoline and other fuels) and chlorinated solvents, such as perchloroethylene or trichloroethylene, commonly used for dry cleaning and industrial degreasing operations. Once in the subsurface, these chemicals can migrate to adjacent buildings as contaminant vapors in soils or travel relatively long distances as dissolved groundwater contaminants before volatilizing and migrating as soil gas into the air of overlying buildings. Due to the volatility and toxicity of these chemicals, relatively small contaminant concentrations in groundwater or soil gas can create building indoor air concentrations that are large enough to create inhalation exposure concerns for the building occupants. Soil gas intrusion is typically a greater concern for chlorinated solvents than petroleum-type products because chlorinated solvents tend to be more persistent and less likely to readily degrade naturally (i.e., biodegrade) in the subsurface.

Intrusion of methane is an example of a process that could be either natural or human-made through the anaerobic degradation of organic matter or petroleum hydrocarbons. Potential methane intrusion issues are common in certain areas of the United States (e.g., Los Angeles area); they can occur when there is a significant source of methane nearby (e.g., landfill, oil field) and a driving pressure that is sufficient to create potentially explosive conditions within enclosed areas of a building.

Do I Have a Soil Gas Intrusion Problem?
When purchasing a building, the prospective owners should seek legal and technical advice to ensure they understand potential liabilities that may be associated with soil gas intrusion, if present, and any ongoing mitigation-related requirements that may be expected of the new owners. Absent a prior assessment or sufficient information, current owners should consider seeking assistance in conducting a soil gas intrusion assessment.

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Soil gas intrusion into buildings from natural or human-made sources can pose exposure risks above levels of health concern for building occupants.

Identifying potential soil gas intrusion issues depends on the type of soil gas being considered. Moisture intrusion can most often be identified during routine building inspection, but soil gas intrusion is generally not noticeable. Radon gas is odorless and concentrations of concern for volatile chemicals in indoor air are typically orders of magnitude below odor thresholds. If the soil gas intrusion potential has already been evaluated in a building, there should be documentation supporting the findings of this assessment. Such documents could include environmental site assessment reports, sampling or laboratory reports, or environmental covenants that may specify building use limitations. In some instances, there could be signs or placards within the building itself.

Absent any mitigation system or information that a soil gas intrusion assessment was conducted, the building and location histories may provide clues as to the potential for subsurface pollution-related issues to exist. The current owners or operators should consider evaluating building history, such as prior occupancy and use, including determining whether manufacturing activities and solvent usage may have occurred. Surrounding areas and nearby activities may also provide indications of potential human-made soil gas intrusion issues, including current or historical industrial areas, dry cleaning operations, gas stations, auto repair facilities, and other maintenance shops. Methane and radon intrusion-prone areas of the United States are generally well documented and previously reported radon levels can often be looked up by county or zip code. In addition, consumer-grade radon monitors are inexpensive and easy to use.

**Mitigation of Soil Gas Intrusion**

Assuming soil gas intrusion-related risks were determined to exceed levels of concern, previous building owners or
occupants, responsible parties, or a government-led program may have completed the installation of a soil gas intrusion mitigation system. Most commonly, particularly for older buildings, mitigation will be a retrofit in the form of a sub-slab venting or depressurization system, where one or more vertical PVC pipes—typically two to four inches in diameter—draw soil gas from beneath the slab (see Figure 1) to a passive roof turbine vent or electrical fan vented to the outside (see Figure 2), thereby preventing or limiting soil gas migration into the indoor air of the building. Operation of a sub-slab depressurization system will also have a beneficial effect on moisture and provide some moisture reduction in basements. Additional indicators that soil gas intrusion mitigation measures have been implemented include the sealing of cracks visible on the floor slab, epoxy coating of floors overlying ground surface, or the filling of gaps around utility piping entering the basement or penetrating the slab.

On occasion, mitigation may have been achieved by adjusting the heating, ventilation, and air conditioning (HVAC) systems. For instance, increasing the amount of make-up air can both pressurize the building relative to the sub-slab and dilute contaminant concentrations in indoor air. While this approach may increase energy consumption, it can sometimes be more cost effective for large buildings than designing and installing a complex depressurization system and may, in some cases, effectively mitigate soil gas intrusion that is more difficult to address by other approaches (e.g., shallow groundwater, soil gas intrusion via preferential pathway such as sewer lines).

For newer buildings, soil gas intrusion mitigation may have been part of the design and implemented during construction. A typical example is the inclusion of an impervious vapor barrier or membrane placed beneath the slab and along utility entry points, which physically prevents the migration of sub-slab soil gas into the building (see Figure 3). This barrier may be supplemented with a depressurization or venting system, though not always.

When a soil gas intrusion mitigation program is in place, there will typically be an access agreement for conducting indoor air monitoring, as may be required, and equipment verification and maintenance. The agreement may also indicate which party will be responsible for these tasks. Responsible parties for human-made pollutants will typically provide ongoing maintenance, but government-led programs for “orphan sites” without financially solvent responsible parties generally do not. Radon mitigation systems are typically maintained by building owners.

Regardless of the presence of a soil gas intrusion mitigation system or, if mitigation exists, regardless of the entity in charge of maintaining it, building owners or operators can do their part in providing adequate indoor air quality. They can do this by ensuring radon and moisture levels are within acceptable limits and that there is no evidence of mold and mildew growth. If no recent assessment was conducted, HVAC systems should be evaluated to verify that they provide an adequate supply of fresh air and are properly balanced for temperature and pressure. These systems should operate in compliance with local energy codes, as well as standards and best practices set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) or the Occupational Safety and Health Administration (OSHA).

For buildings constructed with a vapor barrier, owners or operators should ensure that liners are not punctured during subsequent work by parties that are not necessarily aware of the barrier’s presence or function (e.g., plumbing or electrical contractors). Building maintenance personnel should also become familiar with the location and key components of an existing soil gas mitigation system, so that they can readily identify and respond to anomalous operating conditions, such as inoperative fans or abnormal U-tube manometer readings (see Figure 4).
Soil gas intrusion into buildings from natural or human-made sources can pose exposure risks above levels of health concern for building occupants. Soil gases of concern include radon, methane, volatile chemicals, and mold-inducing moisture (water vapor). Existing or prospective building owners and managers need to become familiar with the risks and liabilities related to soil gas intrusion, and to properly maintain soil gas intrusion mitigation systems that may already be present on the premises. If no systems are present, they should review available information to assess whether soil gas intrusion sources may exist and, if necessary, conduct an investigation to determine if mitigation is needed. Technical and legal assistance is recommended to ensure effective mitigation of soil gas intrusion, and to manage legal risks and liabilities, particularly in cases of soil vapor intrusion related to human-made processes.

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