Old unregulated landfills are a common source of biogas. *Photo: U.S. National Archives/ Wil Blanche*

METHANE INTRUSION RISKS

UNDERSTAND MITIGATION REQUIREMENTS FOR NEW AND EXISTING DEVELOPMENTS.

By David Vonasek, P.E.

DURING THE LAST several decades, methane gas has been a central issue in discussions around greenhouse gas emissions and their impact on air quality and global warming. However, methane is not limited to its effect on the atmosphere. It can also be found in subsurface soils, sometimes within densely populated areas. In locales where the potential for subsurface methane exists, many states and local governments have adopted regulations to mitigate any potential threat of subsurface methane intrusion when building or modifying existing or new developments. If the gas is present in the soil and goes unmitigated, the intrusion can cause a fire or even an explosion.

Origins

There are many sources of gas-laden soil. The most common source is biogas generated by the anaerobic decomposition of buried organic material. In its natural form, biogas is a mixture of approximately equal amounts of methane and carbon dioxide. Prime sources for this type of biogas are old landfill disposal sites.

Unlike today's state-of-the-art landfill facilities, many older sites from the 1950s through the 1980s were built without a containment liner system. As the organic waste decomposes, "landfill gas" (LFG) is continuously generated. As that happens, internal static pressure forms within the landfill, which then can force the gas out of the landfill and into the atmosphere and surrounding soils.

Over the years, numerous incidents have occurred in which LFG was able to freely migrate from the landfill and infiltrate adjacent structures, resulting in an oxygen-deficient condition and/or the potential for a fire or an explosion. In a few documented instances, fires or explosions have occurred that resulted in the loss of both life and property.

These occurrences led the U.S. Environmental Protection Agency to adopt initial regulations under the Resource Conservation and Recovery Act of 1976 that established control requirements for landfills, which limited the allowable concentration of methane in the subsurface soils for onsite structures, as well as along the landfill's property boundary.

Beyond landfills

However, biogas is not limited to landfills. Other forms of the gas can be found in areas containing swamps or marshes. Local vegetation in the swamps and marshes dies and settles to the bottom, forming layers of peat. Over time, the peat begins to decompose, which generates biogas.

Sewer gas is another form of biogas that generally exists in buried sewer lines that are sometimes accessed by maintenance workers. The risk associated with sewer gas is not only the flammable gas but also the potential for oxygen-deficient conditions that have been known to affect workers who are not suitably trained and equipped before entering these confined spaces.

Another form of biogas is more commonly found in northern regions where glaciers moved across vegetated areas thousands of years ago. As the glaciers advanced, they stripped the land of surface vegetation and buried it under tons of ice, soil, and rock. Over time, decomposition of the buried vegetation formed biogas, or glacial drift gas, that still exists today. Other studies suggest that glacial drift gas may also be the result of an upward migration from buried coal or petroleum in the bedrock.

In a few cases, shallow, near-surface deposits of natural gas have been detected in regions of known petroleum fields, both oil and natural gas, as well as in other places where organic material is buried or stockpiled (e.g., dairies). Some of these forms of biogas may also contain other constituents that can have a toxic effect on humans, such as hydrogen sulfide and various volatile organic compounds.

Given the long history of oil and gas exploration and production in Southern California, local municipalities and real estate investors must continually confront methane issues from petroleum and landfill sources. In response, a complicated mosaic of local methane

Areas of known oil and gas exploration are potential sources of biogas.

A geomembrane liner system is being installed at the future site of an occupied structure.

regulations have emerged, requiring both investigation and mitigation as part of any new or redevelopment projects.

Some California jurisdictions, such as the County and City of Los Angeles, Orange County, City of Riverside, City of Santa Fe Springs, and the City of San Diego, have developed specific guidance for site assessments and remediation efforts for new or modified developments.

In some areas, the level of remediation is based on a tiered-concentration basis determined by the presence and concentration of subsurface methane. Other jurisdictions have less-developed requirements — perhaps with limited guidance for methane investigation and mitigation — during development or redevelopment within an established distance of a current or former oil/gas well. Others may simply leave investigations to the discretion of the local fire chief or fire marshal. Some locations in Southern California have an extensive history of abandoned oil and gas wells but do not have any guidance at all, leaving potential buyers open to potential safety and investment risks.

Who's in charge?

As a result, requirements can vary by jurisdiction, even within short distances of one another. The State of California Department of Toxic Substances Control has also developed provisions for school sites that may be constructed or modified in an area potentially containing subsurface methane. Again, the level of corrective action is dictated by the methane concentrations detected during site assessments.

As a developer or investor, navigating these regulations can be challenging and costly. During the planning stages of any development project in impacted areas, sufficient due diligence must be done to determine the design and building requirements necessary to comply with regulations. Many projects have been delayed and subjected to substantial cost increases because of a lack of awareness of the requirements.

The good news is that nearly all municipalities post their regulations online. However, researching and understanding these regulations can sometimes be overwhelming. Retaining the services of a licensed professional engineer who understands the regulations and has the technical expertise needed to comply is often worth the added cost.

Mitigation measures

The extent of methane mitigation can range from simple passive barriers to an active subsurface gas collection system consisting of wells, collection piping, and a mechanical blower/gas disposal system. All methane mitigation systems in California must be designed by a California-licensed professional engineer.

Static barriers typically include a membrane liner system installed over a one- to two-foot-thick layer of aggregate material embedded with horizontal runs of perforated high-density polyethylene (HDPE) pipe. This passive system is typically installed below the building foundation with the ends of the perforated collection pipe connected into a common header. The header extends up through a pipe chase or perimeter wall to daylight above the top of the building. The liner acts to contain the gas and prevent any gas from making its way into interior spaces. The embedded perforated piping acts to redirect the methane up into the header pipe where it can vent and dissipate into the atmosphere. Once the membrane and passive collection piping have been installed, the building's foundation can be built.

Make sure all slab penetrations (e.g., utilities) are adequately sealed to prevent any gas from infiltrating around the penetrations, and that all electrical conduits entering the structure from below ground are equipped with gas-tight safety seals. Depending on the development, areas may be designated as hazardous environments for any electrical equipment and wiring. If that's the case, construction may include explosion-proof electrical motors, fixtures, switches, etc.

If a more aggressive methane mitigation system is required, it may mean installation of an elaborate subsurface methane gas extraction system. This could require vertical extraction wells or horizontal collection trenches installed into the subsurface soils in the immediate vicinity of the structure(s). Buried gas collection piping typically connects the wells to a mechanized blower/gas disposal system. The operating gas blowers generate a vacuum that extracts gas from the soils. The extracted gas is then conveyed to the blower and discharged to the gas disposal system.

Depending on the location and local air quality management district requirements, gas disposal may be as simple as direct discharge into the atmosphere, through a carbon filtration system, or an automated flare system. The site may also need a series of subsurface monitoring probes around the facility for routine monitoring. The probe data confirms that the gas-mitigation system is functioning as intended and is providing the environmental control needed to protect the structure and its occupants.

In some instances, the development may require a continuous methane monitoring system. Again, the type of system may vary depending on site-specific conditions and local regulatory requirements. The methane sensors may consist of simple, wall-mounted, battery-operated continuous monitors, similar to smoke detectors.

In other situations, the monitoring system may need to be more elaborate, with remote continuous monitoring sensors located throughout the facility. The sensors can be tied into a central computer system that is interfaced with a separate building ventilation system. In that case, if a methane sensor detects the presence of methane, it determines the concentration and triggers an appropriate response. If the concentration is sufficiently low, the system may simply notify site personnel of the presence of gas and the location of the sensor, which then can be safely investigated and mitigated. However, if an activated sensor detects dangerous gas concentrations, the system instantly sends an alarm so occupants can be safely evacuated. At the same time, it activates the ventilation system to begin purging interior areas, using fresh air to dilute gas accumulations.

Typically, these ventilation systems are designed for a much higher air exchange rate than normal building ventilation systems and are used only in the event of a potentially dangerous gas accumulation. For a large commercial building, the cost for such a system can be enormous. More elaborate systems also require the sensors to be checked routinely and re-calibrated to maintain accuracy, which adds to operation and maintenance costs.

Saving time and money

Urban growth in Southern California continues at a steady upward pace. In some areas, this means new construction in undeveloped areas that have had oil or gas exploration or old abandoned oil/gas wells. In others, it can mean redeveloping brownfields on old landfill or oil exploration sites. Old landfill sites may also pose a risk to proposed developments located adjacent to or near the site, even though the landfill hasn't received waste for many decades.

It is imperative that any real estate developer or investor understand and research these potential methane issues before spending thousands of dollars and hundreds of hours on project design and construction. Proper planning and negotiation with regulatory agencies will save money and provide the basis of a reasonable approach to methane gas mitigation and protection.

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