Guidance for Explosive Gas Monitoring and Control at Landfills

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Regulatory Framework

The Montana Department of Environmental Quality (DEQ) regulations regarding explosive gases control at solid waste management facilities are contained in Administrative Rule of Montana (ARM) 17.50.1106. These rules contain the minimum requirements for the monitoring and control of explosive gases generated by Class II and Class IV landfills. This guidance is intended to provide more detail on the production, nature, and movement of landfill gas, the systems, equipment, and procedures used to implement an effective explosive gas monitoring program, and the steps necessary to design, construct, operate, and maintain an explosive gas control system when necessary. This guidance also serves to clarify the DEQ interpretation of the rules contained in ARM 17.50.1106.

Background

Landfill gas (LFG) is formed as a byproduct of bacteria breaking down organic matter in the waste and consists primarily of methane (CH_4) and carbon dioxide (CO_2), with trace amounts of carbon monoxide (CO), hydrogen sulfide (H_2S), and various volatile organic compounds (VOCs). The rate of decomposition of the waste and generation of landfill gas is dependent on moisture, thus at Montana landfills gas is generally produced at a slower rate over a longer period of time than in wetter climates.

Because of its explosive potential, methane is the primary concern at landfills. Methane is lighter than air and tends to migrate upwards and escape to the atmosphere. Carbon dioxide is heavier than air and thus often remains in the soil. Landfill gas may mix with and/or displace the nitrogen (N_2) and oxygen (O_2) which are the primary components of air. Because of its wide range of possible chemical compositions, a bulk mixture of landfill gas can range from lighter to heavier than air, making its movement unpredictable. Many factors affect the movement of landfill gas including landfill design and operations, geology and soil type, landfill gas temperature, soil moisture content, frozen ground and snow cover, and even air temperature and barometric pressure.

Methane is measured as either percent by volume or as percent of the lower explosive limit (LEL). The LEL is the smallest percent of methane in air which can explode at standard temperature and pressure, and is five percent by volume. Thus, five percent methane by volume equals one hundred percent of the LEL. A variety of instruments can be used to measure methane. The simplest instruments measure only percent LEL, and sometimes also oxygen. Others measure total methane or LEL plus oxygen, carbon monoxide, and hydrogen sulfide. Some also measure nitrogen, the dominant component of air. The most commonly used instruments measure total methane, oxygen, and carbon dioxide.

Standards, Compliance Locations, and Applicability

The standards for methane at landfills have two components as described in ARM 17.50.1106(1)(a) and (b). According to ARM 17.50.1106(1)(a) methane may not exceed 25% of the LEL in facility structures, excluding gas control or recovery system components. Typical structures at landfills are gate/scale houses, shops, and offices. Structures are not considered to include manholes, outdoor sumps, and culverts, although these locations are sometimes included in methane monitoring to protect worker safety. According to ARM 17.50.1106(1)(b) methane may not exceed the LEL at the facility property boundary. The DEQ considers the facility property boundary to be the license boundary for that facility, as defined in ARM.17.50.502(22), regardless of the ownership of adjacent property outside the license boundary. The owner or operator of a Class II landfill unit is required by ARM 17.50.1106(2) to implement a routine methane monitoring program to ensure these standards are met, and the owner or operator of a Class IV landfill unit is required to meet these same requirements by ARM 17.50.1118(2)(c).

Methane Monitoring Program

Solid waste management facilities are required by ARM 17.50.509(2)(i) to include a methane monitoring plan as part of the facility operations and maintenance (O&M) plan. As part of the O&M plan, the methane monitoring plan for a facility should be reviewed at least every five years and updated as necessary, as required in ARM 17.50.509(3). Although the contents of the methane monitoring plan are not described in rule, the methane monitoring plan should include at least the following elements to accurately describe how the facility will comply with ARM 17.50.1106:

Description of the Facility

The description of the facility should at least include a map showing the location of the waste units, the license boundary, all facility structures, and any off-site structures located within 1,000 feet of the license boundary. Also included should be a description of the geology and soils at the facility and their effects on landfill gas movement.

Description of Monitoring Points

Methane at landfill license boundary is typically monitored using soil gas probes. The depth and locations of these probes vary, based on site specific features. The number of probes required and their locations, construction, and depths are approved by the DEQ through approval of a work plan prior to probe installation. Because landfill gas can move in any direction, probes are typically placed on all sides of the landfill. Probes should be placed 500 to 1,000 feet apart, depending on the geology and soils at the facility, and the proximity of potential receptors. For larger facilities there may be multiple probes on each side of the facility. Generally, if an off-site structure is located near the facility license boundary, a probe should be placed between that structure and the waste unit to ensure protection of human health. In some cases the facility license boundary may be far enough removed from the waste unit, that probes may not be required on all sides of a facility. The locations of the monitoring probes and any structures which are monitored should be labeled on a map of the facility included with the methane monitoring plan.

Soil gas probes can vary greatly in design, but must be designed to allow a discrete, representative sample of the soil gas to be extracted from the subsurface for monitoring. Probes typically consist of a slotted PVC pipe in a boring and surrounded by gravel. A solid PVC standpipe extends to above the surface of the ground and is fitted with a sealed cap and in some cases a monitoring port. All joints in the probe standpipe should be threaded and tightly sealed with a rubber gasket to prevent leakage of the gas. PVC glue should never be used in the construction of a gas monitoring probe because it can release VOCs which may interfere with collection of accurate gas readings. While it is possible to obtain a discrete sample from the open top of the probe by sealing the opening during monitoring, a permanent, valved, monitoring port to which the monitoring instrument can be connected provides the most accurate and reliable measurements. In general, probes extend to the maximum depth of the adjacent waste unit, and are slotted from the bottom to within

about five feet of the surface. In some cases two or three probes are slotted at multiple depths in the same location to monitor discrete permeable zones. The methane monitoring plan should include the boring logs and construction diagrams for all of the soil gas probes at the facility.

Frequency of Monitoring
As required by ARM 17.50.1106(3), monitoring at landfills is conducted at least quarterly. Monthly monitoring is suggested, and may be required, for larger facilities which produce more gas, facilities in populated areas or where potential receptors are located nearby, facilities with a history of methane standard exceedances, and facilities with active gas extraction systems. The methane monitoring plan should describe the frequency of monitoring, including any procedures for follow up monitoring in the case of a methane standard exceedance.

Monitoring Procedures
The methane monitoring plan should describe the standard operating procedures for methane monitoring. This should include the type of instrument which will typically be used in monitoring, and list the chemical parameters it detects and the detection ranges for those parameters. As described above, many types of instruments can be used to monitor various landfill gas components. Instruments which measure on the LEL scale typically only detect up to 100% of the LEL (5% methane by volume) and often do not work in low oxygen atmospheres, making them less useful for many facilities where landfill gas is routinely detected in soil gas probes. The DEQ recommends using an instrument which measures methane by volume up to 100% to give more complete information when methane concentrations exceed the 100% of the LEL.

Monitoring in facility structures is simply a matter of taking methane readings in the structure. Sometimes measurements are also taken in crawlspaces, floor drains, or other areas where landfill gas may accumulate. Monitoring at a soil gas probe is typically conducted one of two ways. For probes with a monitoring port, the gas intake for the instrument is connected to the port and the port valve is opened. For probes without a monitoring port, the cap is opened and the intake for the instrument is inserted into the probe while the top of the probe is immediately sealed in some fashion. In both cases the pump on the instrument is then operated to purge the probe until the gas readings stabilize. The stabilized readings should be recorded, along with any other relevant information which may include length of purge, initial spikes in parameter concentrations which dissipated, weather information, and any issues with probe condition.

Reporting
The results of all methane monitoring events must be reported to the DEQ after the event. If a concentration of methane exceeding the standards for buildings or the property boundary is detected, ARM 17.50.1106(4) describes the necessary actions, which include immediate protection of human health, documentation of the exceedance in the operating record within 7 days, and preparation of a remediation plan within 60 days. Immediate notification of the DEQ is also required upon detection of any methane exceedances. A facility specific methane exceedance response plan should be included in the methane monitoring plan, describing the actions to be taken in the event a methane exceedance is detected.

Methane Remediation and Control
Detection of a methane exceedance in a building is rare, but is a serious human health threat and requires immediate action to evacuate and ventilate the building. Following the immediate response, a building methane control system can be implemented, typically by installing a positive pressure ventilation system and continuous monitoring devices with alarms. Some facilities include continuous monitoring devices in site buildings during facility design to ensure worker safety regardless if methane has ever been detected.

In most cases the initial response to a methane exceedance at the property boundary probes is a verification measurement within one month. The DEQ recommends and may require monthly monitoring to continue

until methane concentrations return to levels below the LEL. If the methane exceedance persists, additional soil gas probes may need to be installed to define the extent of the high methane concentrations. Monitoring may also be required in off-site buildings near probes which have shown a methane exceedance. Depending on the frequency, duration, and concentration of methane exceedances at a facility, some type of gas remediation may be necessary to maintain compliance with the LEL standard. Landfill gas remediation typically consists of attempting to limit the production of gas by reducing the moisture available in the waste, or installing a gas control system to remove the gas from the waste unit.

Limiting the production of gas by reducing the available moisture typically involves removing leachate or capping the landfill. Removing leachate can have limited effectiveness, since leachate levels are already required to be maintained at less than 30-cm depth over the liner. The majority of moisture in the landfill unit which contributes to methane generation is contained within the waste, and cannot be extracted through the leachate collection system. Capping the landfill can reduce infiltration into the waste, but also provides a barrier to vertical migration of gas out of the landfill, which may actually increase methane concentrations at the perimeter probes as the gas escapes from the landfill laterally instead of vertically. Landfill capping is most effective when combined with a gas control system as described below.

For smaller facilities or lower methane concentrations, passive gas vents are a simple, lower cost option which may effectively lower methane concentrations to safe levels. Passive gas vents typically consist of a slotted plastic pipe or flex tubing bedded in gravel within the upper portion or at the top of the waste, and connected to solid PVC risers. The slotted portions of the vents can be horizontal or vertical or both. The risers are typically capped with a wind turbine ventilator (whirlybird) which provides a small draw on the piping to extract the gas from the waste. Passive gas venting systems can be installed over the entire unit, or in only the locations where high levels of gas have been detected, and are easily expanded as conditions change or the facility expands. Passive gas vents can also be installed over the entire landfill unit at the time of closure as a preventative measure.

For more serious methane issues, larger facilities, or facilities in populated areas, an active gas extraction system may be necessary to maintain methane concentration below the LEL at the property boundary. Active gas extraction systems are complex and costly to design, build, and operate and will only be described briefly in this document. An active gas extraction system consists of slotted horizontal or vertical collector lines or wells, similar to a passive gas system, except that the collectors are located throughout the waste rather than only near the top of the waste. These collectors are connected to wellheads which extend above the surface of the waste. These wellheads typically contain a valve for adjusting gas flow, temperature and pressure meters or measuring ports, and a sampling port for monitoring gas composition. The wellheads are connected to HDPE gas collection header pipes using a flexible connection that will not break as the landfill settles. Because landfill gas is usually saturated with water, the header pipes are sloped so that condensate will flow to a collection tank for storage and disposal. Condensate is typically disposed of at a POTW, evaporated in a lined pond, or recirculated to a lined portion of the landfill (with DEQ approval). The gas collection header pipes are connected to a blower system which provides the suction to withdraw gas from the waste. After it is collected the landfill gas is typically burned in a flare to destroy the harmful chemicals it contains. Landfill gas can also be burned in an engine to generate electricity, or cleaned to pipeline quality for use as natural gas.