NEBRASKA

DEPT. OF ENVIRONMENTAL QUALITY

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Landfill Gas Monitoring and Reporting

This guidance document is intended to describe several considerations expected in a landfill permit application and suggest methods of preventing or overcoming existing or future gas generation hazards and complications at a municipal solid waste landfill.

Landfill gas is created by the natural decomposition of organic materials by microorganisms in the landfill. The rate and quantity of landfill gas generation depends on many factors; the key ingredients are the type and quantity of organic materials and the moisture content. Landfill gas is typically composed of methane (50-55%), carbon dioxide (45-50%), and trace amounts of other gases such as oxygen, nitrogen, and hydrogen sulfide. At each landfill in the State, deposition methods, covering, and content of the waste will vary from other landfills in the State. There is no single gas monitoring strategy that will work at all landfills in the State. Each landfill should have a site-specific gas monitoring plan for landfill gas. The gas monitoring plan should also be specific to the gas measuring device, and the measuring device operating manual should be incorporated by reference into the site gas monitoring plan. Methane should be controlled because it can migrate away from a landfill and become an environmental and safety hazard.

Methane gas is a by-product of the decomposition of waste, but methane is not produced until the waste decomposition process has completely used up all the oxygen in the deposited waste. Methane by itself is dangerous when the concentration in air is between the lower and upper explosive limits and when ignited has caused burn injuries and death where it has accumulated in close quarters. Once landfill gases are produced under the landfill surface, they can move away from the landfill.

Landfill gases tend to expand and fill any available space, so that they move, or “migrate,” through the limited pore spaces within the refuse and soils covering the landfill. The natural tendency of landfill gases that are lighter than air, such as methane, is to move upward, usually through the landfill surface. Upward movement of landfill gas is restrained by densely compacted waste or landfill cover material (daily soil cover and caps). When upward movement is inhibited, the gas tends to migrate horizontally to other areas within the landfill or to areas outside the landfill, where it can resume its upward path. Basically, gas follows the path of least resistance. For these reasons, gas monitoring probes need only penetrate to the lowest level of waste or an impermeable strata.

It is difficult to predict the distance that landfill gas will travel because so many factors affect its ability to migrate underground, but travel distances greater than 1,500 feet (1/4 mile or more) have been verified. Barometric pressure changes caused by moving weather front systems can also have an effect on the confining pressure at a landfill. Barometric pressure changes can produce large variations in methane gas measurements during a given day as well as between the regulated monitoring periods.

Confining pressure variations and the randomness accompanying the variations give rise to one defensive design characteristic that must be a part of every landfill gas monitoring probe design. The probe must be sealed to prevent external air from entering the probe while the gas measurements in the probe are being taken. Gases migrating from a landfill may eventually reach buildings and homes. Foundation cracks and gaps, pressure differences between the inside and outside of the building or home, mechanical ventilation systems and leakage areas (utility entry points, construction joints, or floor drain systems) provide entry points for gases.
Buildings with basements generally provide the easiest access for gases migrating in the soil. The amount of gases let into a building depends on a number of factors, including construction and maintenance practices.

Methane Monitoring Requirements

Title 132 – Integrated Solid Waste Management Regulations, Chapter 3, §004.17C requires:

- Owners and operators of Municipal Solid Waste (MSW) landfills shall ensure that the concentration of methane gas generated by the facility does not exceed 25% of the lower explosive limit (LEL) methane in facility structures (excluding gas control or gas recovery components). Manholes and pumping stations in the leachate control system (LCS) are structures but are exempt from structure monitoring because they are expected to contain landfill gases. Owners and operators must also ensure that gas does not exceed the LEL for methane at the solid waste disposal area boundary.

- If methane concentrations exceed either of these limits, Title 132 requires the landfill owners/operators to take all necessary steps to ensure protection of human health and **notify the Department of Environmental Quality immediately**.

- Owners and operators of MSW landfills shall place in the operating record the methane gas levels detected and a description of the steps taken to protect human health within seven (7) days of exceeding either of these limits.

- Within 60 days of exceeding these limits, owners and operators of MSW landfills shall develop and implement a plan to correct the problem by describing its nature and extent along with a proposed remedy.

- Any proposed remedy must protect human health and the environment.

- A copy of the plan shall be placed in the operating record and the owner or operator shall notify NDEQ that the plan has been implemented.

Generally, the frequency of monitoring should be sufficient to detect landfill gas migration based on subsurface conditions and changing landfill physical conditions. Some changing conditions may include but are not limited to partial or complete capping, landfill expansion, construction of new or replacement structures, and changes in landscaping or land use practices. In no case shall the monitoring be less than quarterly. Gas monitoring is required during the active life of the landfill and through the 30-year post-closure period.

Title 132, Chapter 2, §007.05 requires that copies of the gas monitoring results be submitted to the department within **30 days** of the end of each calendar quarter.

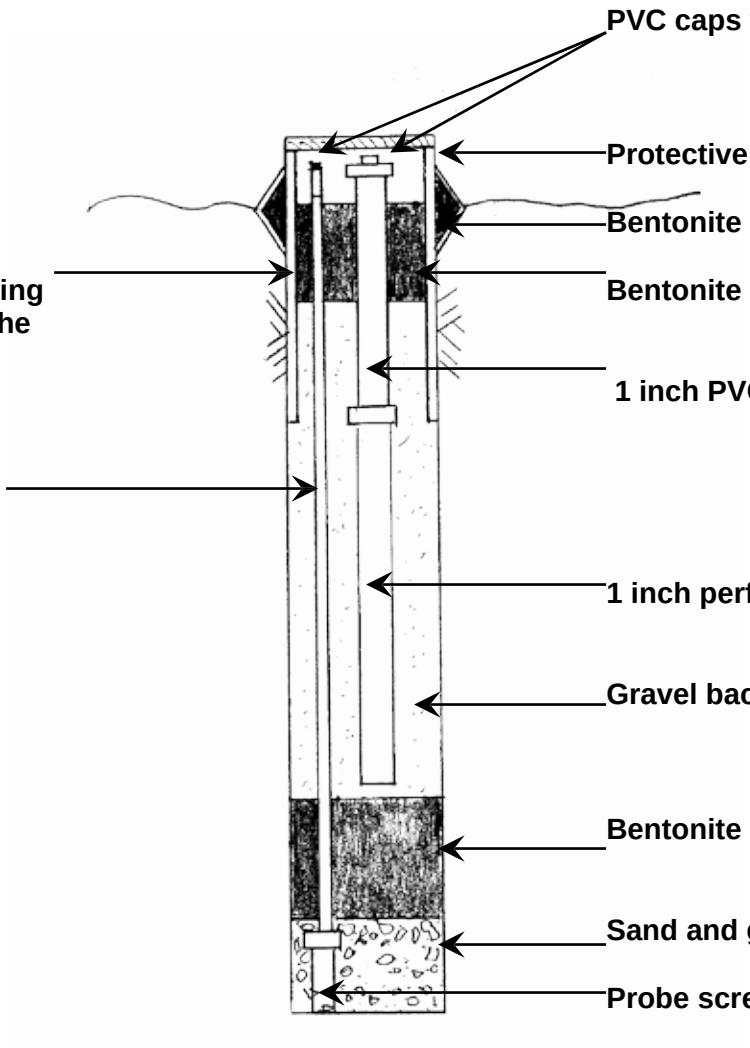
Gas Probe Siting

Since Title 132 requires methane gas monitoring specifically, it is understood that the monitoring must be accurate. To achieve accuracy, the monitoring probes should be sited at the solid waste disposal area boundary in a position to intercept any migrating methane gas. In order to beneficially place the probes, the site suitability geotechnical investigation must be sufficiently detailed so that it defines the soil formation(s) of the landfill site, both vertically and horizontally; and shows that if methane gas is migrating from any waste location within a landfill it will be detected by the monitoring probe system. The person responsible for the site investigation must be informed of this sufficiency. Nebraska regulations do not specify a spacing interval for gas monitoring probes, but the spacing must insure that any migrating gas will be detected.

Gas Monitoring Probe Design

Permanent gas probes should be installed to the depth of the bottom of the waste in the landfill or to an impermeable barrier. Since water is a barrier to methane, gas monitoring probes should never be installed to depths below the water table. Gas probes penetrating the water table must be registered as wells. Monitoring for gas migration should be within the more permeable soil strata. Multiple or nested probes are useful in defining the vertical configuration of the migration pathway. Monitoring separate soil strata in one well is possible. Vertical separation of gas samples may be accomplished by partitioning the well bore hole with appropriate impermeable (bentonite, cement) barriers in the aggregates in the bore hole.

See the drawing “Example Partitioned Gas Monitoring Well” below. Utilizing gas pickup tubes in a cased probe must also provide the same partitioning inside the casing as on the outside of the casing. The cased probe tube caps must be air tight and be equipped with a valve and hose barb that will prevent air intrusion while sampling is in progress. A gas monitoring probe must be designed to be air tight in order to prevent ambient air entering through the monitoring well appurtenances and causing false readings by the gas meter. In addition, if oxygen is present in a methane monitoring probe, its origin and effect on the accuracy of the measuring meter must be evaluated and documented.



Source: Warzyn Inc.
Example of Partitioned Gas Monitoring Probe

Notice that the low probe is completely isolated within the borehole and the upper probe is completely isolated from the lower monitoring zone.

Gas Monitoring Devices

There are several types of meters available for gas monitoring.

- Meters that utilize infra-red (IR) technology have the ability to measure LEL percentage in air-tight monitoring wells accurately, if properly calibrated. IR meters work from the principle that when the gas interacts with IR radiation, it absorbs a portion of the IR energy. IR absorbance by a gas over a given path length is proportional to its concentration. Some IR meters used to analyze for landfill gas have fixed path lengths to detect methane and carbon dioxide. The advantage of IR meters is that the high carbon dioxide levels found in landfills will not affect methane readings and they accurately measure in ambient air. Infra-red type meters should be examined, tested, and certified safe for use in explosive atmospheres by a standard method. The International Electrotechnical Commission (IEC) does have such a standard and results in a classification that the meter is "Intrinsically Safe" for use above ground in explosive atmospheres. There are portable IR meters available for use that measure up to 100% by volume methane and carbon dioxide. The

concentrations of these gases are detected by IR absorption. For oxygen detection, gas is measured by an electrochemical cell. The calibration gas used should be as recommended by the meter manufacturer.

- Some CGI test sensors are combined with a thermal conductivity (TC) sensor in a single meter. The CGI/TC meter uses a catalytic oxidation sensor to detect concentrations less than 100% LEL and a TC sensor to measure concentrations above 100% LEL. Meters using a TC sensor do not require oxygen for a valid reading, as combustion of the gas is not required. Depending on the combination of different gases (e.g. carbon dioxide) and their concentrations, values shown on the CGI/TC meter may vary from the actual concentration.

- One type is a Flame Ionization Detector (FID). However, this type of meter does not report in percent of LEL and only indicates that methane is present. This type of meter is not accurate in temperatures below 400 F and would have doubtful utility during Nebraska winter months.

- Another type of meter is the Photo-ionization Detector (PID). This meter ionizes gas molecules using UV (ultra violet) radiation that produces a current proportional to the number of ions created. But, this type of meter cannot detect methane and is not acceptable for landfill gas monitoring.

- A third type of meter is the Combustible Gas Indicator (CGI). The meter operates through a “hot wire” filament and measures and reports in terms of the percentage of LEL. The meter must be calibrated against known gas concentrations. This type meter will not measure methane in oxygen deficient atmospheres. CGI meters are not capable of measurements above 100% LEL and will provide erroneous readings when exposed to gas concentrations above 100% LEL. The hotwire filament is sensitive to certain compounds that may be present in landfill gas and can be damaged by them.

Permit applications should identify the type of meter to be used for monitoring gas wells and all limitations the meter may have in detection and accuracy. The gas monitoring report submitted to the NDEQ should also include the manufacturer of the meter used.

Sampling Procedures - Gas Probes

NDEQ recommends that instruments used to sample gas monitoring wells have an automatic pump that has the ability to withdraw enough volume from a gas probe to bring a fresh sample of soil gas into the meter. It is also beneficial if the instrument reads both oxygen and methane concentrations.

Some instruments have the ability to read barometric pressure, which is also desirable. The following steps should be considered as minimum criteria for a site gas monitoring plan.

Step 1 - Make sure the instrument is properly calibrated and follow the operating instructions provided by the manufacturer. Calibrate the instrument in the temperature and atmosphere of the location to be measured and away from vehicle exhaust fumes.

Step 2 - Connect the instrument to the probehead and begin collecting a sample. The type of connections may vary with the specific meter used to collect the sample, however an airtight seal *must* be maintained around the probehead to ensure air is not being drawn into the system.

Step 3 - Continue collecting the sample until the reading stabilizes. A stable reading does not vary more than 0.5 percent by volume or 10% of LEL on the meter’s scale.

Step 4 – When all probes have been measured, or at the end of the workday, recalibrate the meter to detect any deficiency in its operation. Have repairs for meters completed before the meter is used again.

Gas Monitoring - Facility Structures

Methane gas monitoring is required in structures that are located within the permitted boundary of the landfill. Buildings should be measured at the floor, ceiling, utility spaces; areas where below ground utilities enter the building, cracks, joints, small confined areas such as closets, bathrooms, etc. When monitoring inside a structure or around the floors of a structure (concrete cracks and joints), remember that meters do not process the gas sample instantaneously. Collect the gas sample at these individual sites for at least a time as long as it takes to fill the hose and probe with a fresh sample of gas. When actually sampling a joint or crack in a structure, it is necessary to stop and let the meter process a fresh sample before moving to the next sampling location.

Methane gas control or gas recovery system components are omitted from the facility structures monitoring required in Title 132, Chapter 3, §004.17C1(a). Leachate control systems (LCS) manholes and pump stations are presumed to have methane and a mixture of VOC's in the atmosphere within them. Gas sampling is therefore not necessary in those systems. However, every gas monitoring plan should contain a written confined space entry plan approved by NDEQ to be utilized in the event LCS components must be entered. *To clarify, specific confined space entry programs, permits, policies, and procedures need not be included as part of the gas monitoring plan, but must include written acknowledgement that the Occupational Safety and Health Agency (OSHA) standards will be followed in the event that entry to LCS components is necessary.*

Submittal of Gas Monitoring Data

- Each MSW landfill should submit one copy of the methane gas monitoring results to the Waste Management Compliance Unit Supervisor and one copy to the specific field office/waste management compliance unit staff person that performs compliance inspections at the landfill within 30 days of the end of each calendar quarter.

- Methane gas measurements are regulated in Title 132 by either the LEL at the property boundary or 25% of the LEL in facility structures. Therefore the gas metering results must be reported in terms of the LEL, not parts per million (ppm) or parts per billion (ppb) alone. Facilities may report O2 (percent by volume) or other items in addition to the methane monitoring data. An example of a reporting form is attached.

- The NDEQ recommends submitting the following items with the methane monitoring data:

    1. A generalized site drawing that illustrates the locations of all methane monitoring wells/probes locations;

    2. A list of all methane monitoring wells/probes locations for that specific facility and those wells/probes sampled during the monitoring event; and

    3. An explanation of the reason that any well/probe locations were not sampled during the monitoring event.

4. Additional information that NDEQ recommends is collection of data such as water presence and level, gas probe pressure, ambient temperature, and barometric pressure. This data provides useful information in assessing monitoring results. For example, rising barometric pressure may cause increased methane content in a well as gas is more readily pushed from the landfill.

Bar Hole Probe Monitoring

The department will not accept bar holes as the permanent gas monitoring system at a facility. A bar hole is uncased and usually formed by driving a sharpened rod or pipe device into the soil.
The act of driving the hole-making device into the soil smears the soil in contact with the device due to friction, and the gas permeability of that surrounding soil is reduced. The construction method makes sealing the annulus at the top of the bar against atmospheric pressure changes and maintaining the seal during measuring extremely difficult and unreliable. Measuring at depth is compromised because driving the hole-making device to depth is difficult in some soils and weather conditions. Bar-holes may be used in justifiable temporary locations with prior approval of NDEQ.

Gas Monitoring Plan Checklist

In order to ensure reliable and reproducible gas generation data; it will be necessary for all waste management facilities required to monitor for explosive gases to have an approved gas monitoring plan in their permit application. The gas monitoring plan in the permit application should be complete and contained in only one section of the permit application, and be a stand- alone section. The **attached checklist** will be used by the department to review and evaluate each site's gas-monitoring plan. Permit applications for facilities required to monitor for explosive gas should address all of the items in the checklist or explain why that item is not applicable to that particular landfill.

RESOURCES:

- NDEQ Home Page http://deq.ne.gov/

- ATSDR, Landfill Gas Primer – An Overview for Environmental Health Professionals, November 2001 – https://www.atsdr.cdc.gov/HAC/landfill/html/intro.html *

Contacts:

- NDEQ Waste Management Section (402) 471-4210
- NDEQ Toll Free Number (877) 253-2603
- NDEQ Hazardous Waste Compliance Assistant (402) 471-8308
- Email questions to: NDEQ.moreinfo@nebraska.gov

NDEQ Publications:

- Title 132 – Integrated Solid Waste Management Regulations
  Titles are available on the NDEQ Home Page under "Laws/Regs & EQC", "Rules & Regulations"

- EPA. 1993. "Solid Waste Disposal Facility Criteria – Technical Manual". Office of Solid Waste and Emergency Response. EPA530-R-93-017

- Missouri Department of Natural Resources, June 2007. "An Analysis of Landfill Gas Monitoring Well Design and Construction". Division of Environmental Quality, Solid Waste Management Program. https://clu-in.org/conf/itrc/directpush/prez/Missouri_Study.pdf
- Missouri Department of Natural Resources. Various Guidance Documents. "Design and Construction of Landfill Gas Monitoring Wells" (PUB002054, Jan 2007). "Sampling of Landfill Gas Monitoring" PUB002053 (June, 2006). "Procedure for Sampling Landfill Gas Inside Buildings" PUB002052 (September, 1999).
- California Natural Resources Agency (CNRA). "Landfill Gas Screening Procedures". Department of Resources Recycling and Recovery (CalRecycle). http://www.calrecycle.ca.gov/SWFacilities/Landfills/Gas/Monitoring/Screening/default.htm
- Indiana Department of Environmental Management. Non-Rule Policy Document (NPD). "Methane Monitoring Program". WASTE-0056-NPD. http://www.in.gov/idem/4694.htm
- North Carolina Department of Environment and Natural Resources. Guidance Document. "Methane Monitoring Guidance". Division of Waste Management. http://deq.nc.gov/about/divisions/waste-management/waste-management-permit-guidance/solid-waste-section/environmental-monitoring

Attachments:

- Example of a Landfill Gas Monitoring Report Form.
- Gas Monitoring Plan Review Checklist

*** This document contains links to non-NDEQ websites; these links will open in a new tab or window.**

Landfill Gas Monitoring Report

Date:

Facility Name:

Permit No.:

Sampling Personnel:

Instrument Used:

Date Instrument Calibrated and Standard Used:

Weather Conditions:

MONITORING WELL/PROBE	% LEL	% O_2	COMMENTS
FACILITY STRUCTURES	**% LEL**	**% O_2**	**COMMENTS**

List Wells/probes not sampled during this monitoring event:

GAS MONITORING PLAN
REVIEW CHECKLIST

A. Property Line Limits

Methane concentration cannot exceed 100 percent of the lower explosive limit (LEL) at the property boundary of a solid waste disposal area (Title 132- Chapter 3, §004.17C 1(b). *Note that a concentration which exceeds the lower explosive would occur when the presence of methane is greater than five percent (5%) as measured by percent (%) volume in air.*

I. MEASURING INSTRUMENTS.

A. Does the meter measure methane?
B. Does the meter report methane concentration as a percent of LEL?
C. Does the meter manufacturer supply a complete calibration procedure and is it a part of the application by reference?
   1. Is the meter calibrated before and after each monitoring event? This will indicate damage during the monitoring event.
   2. Is the meter calibrated in the same atmosphere as the feature being measured?
   3. Is the calibrating gas recommended by the manufacturer?
   4. Is the accuracy of the meter stated in the calibrating procedure for all methane calibrating gas concentrations?
   5. Will the meter measure accurately through all reasonable temperature ranges in Nebraska?
D. Is the calibration gas dated and within the manufacturers freshness period?
E. Is the pumping rate of the meter known?
F. Does the meter manufacturer require or recommend factory check ups to maintain meter accuracy?

II. GAS WELL DESIGN

A. Is the gas probe sealed with extremely low gas conductive material?
   1. At the top to eliminate atmospheric pressure change influence within the gas monitoring probe.
   2. If the gas probe is intended to measure multiple intervals, are the intervals sealed inside and outside the casing?
   3. Does the cap design allow meter access while disallowing air into the gas probe?
   4. If pickup tubes are utilized, do they extend to the screened depth and are the intervals sealed?
   5. Are all caps threaded to put positive compression on all gaskets?
B. Are bar holes being utilized?
   1. Bar holes cannot be the permanent measuring wells.
   2. Does the design of the bar hole provide isolation of the bar hole volume from all atmospheric pressure changes?
   3. Does the bar hole design provide a positive seal between the gas meter probe and the top of the bar hole.

III. MONITORING PROCEDURES AT THE MONITORING PROBES

A. Does the monitoring plan address safety issues to be followed during the measuring event?
B. Does the monitoring plan require calibration of the gas meter before and after each monitoring event (Event to mean all wells and buildings measured on same day)?
    1. Is the calibration completed at the temperature of the probes?
C. Does the monitoring plan require the operator to record measurements when the measurements stabilize? A stable reading does not vary more than 0.5 per cent by volume or 10% of LEL on the meters scale?
D. Does the monitoring plan explain how the connection to the probe is to be made?
    1. Is the connection airtight at all times?

B. Structure Limits

The concentration of methane gas generated by the facility cannot exceed twenty-five percent of the LEL for methane in facility structures (excluding gas control or recovery system components). LCS are also exempt because they are expected to accumulate landfill gas.

I. MONITORING PROCEDURES IN STRUCTURES AND BUILDINGS

A. Does the monitoring plan describe the actual places that will be measured for gas to insure the same place(s) are measured at each sampling event?
    1. The descriptions must be precise.
    2. Leachate collection system (LCS) manholes, as envisioned in Title 132, are expected to collect landfill gas and must be treated as confined spaces.
        a. Manholes and pump stations are entered only by strict adherence to confined space entry procedures.
B. Does the monitoring plan accurately describe the procedures for monitoring the locations enumerated in a. above?
C. Does the monitoring plan describe adequate monitoring procedures for cracks and joints in concrete floors and/or walls?
    1. Describe the period of time necessary to hold probe in place at separate building locations. (Considers gas meter pumping rates to insure a representative sample is collected).

C. Title 132 Requirements

If methane gas levels exceeding the lower explosive limit for methane at the solid waste disposal area boundary or 25% of the lower explosive limit in facility structures occur, the owner or operator shall immediately take all necessary steps to ensure protection of human health and immediately notify the Department. In addition, the owner or operator must, within 7 days, place in the operating record the methane levels detected and a description of the steps taken to protect human health. Then, within 60 days of detection of these limits, the owner or operator shall implement a remediation plan for the methane releases. The remediation plan must describe the nature and extent of the release problem and the proposed remedy. The plan should be reviewed by the Waste Management Section of the Department prior to implementation. Any proposed remedy must protect human health and the environment. The

remediation plan shall be placed in the operating record and the Department notified that the plan has been implemented.

II. Gas Monitoring Plan Organization

A. Should be located in one place in the application with no referrals to other locations for pertinent details. Must be a stand-alone section of the permit application.
B. Should include drawings of typical and special gas wells, maps showing locations of gas monitoring probes, tables showing depth and screen locations of all gas monitoring probes, and tables showing only those wells that are measured.
C. The application should contain a confined space entry plan.