CA INTEGRATED WASTE MANAGEMENT BOARD

Landfill Gas Standardized Procedures

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I. Introduction

A. PURPOSE OF THIS DOCUMENT

The purpose of this document is to provide standardized procedures for California Integrated Waste Management Board (Board) inspectors to use when performing landfill gas (LFG) screening monitoring* during routine disposal site inspections. The standardization and simplification of the field gas monitoring procedures are intended to create an acceptable level of sureness in a site's compliance status with respect to the State Minimum Standards (SMS) for LFG monitoring. The initial monitoring (screening monitoring) process will also provide a basis for determining whether it is necessary to conduct supplemental enhanced monitoring before making a determination of compliance with SMS. This document presumes that each inspector has already had some experience in conducting disposal site inspections, including LFG screening monitoring.

Disposal site inspectors need to sample for LFG in the ground at the permitted facility boundary and in the structures within the permitted boundaries of a disposal site while conducting eighteen month; closed, illegal and abandoned site; or pre-permit inspections. Title 27 California Code of Regulations (27 CCR) Section 20919.5 requires all municipal solid waste landfill operators to ensure that the concentration of methane gas generated from their landfill does not exceed 1.25 percent (by volume in air) in all on site enclosed structures, excluding LFG control structures, nor 5% (by volume in air) at the property boundary (down to the maximum depth of waste within 1000 feet of the monitoring point)

Title 27 CCR Section 20919 requires operators of disposal sites to conduct monitoring and implement control measures to limit LFG migration if either an EA, the Board, or a Local Fire Authority notifies them that there is cause to believe that a hazard or nuisance may be created by LFG. Sections 20919 and 20919.5 apply to municipal solid waste landfills. Section 20919.5 does not apply to disposal sites that are not municipal solid waste landfill units as defined in 27 CCR Section 20164.

* ***Please note that due to the variety of instruments in the field (Landtech, GMI, etc.) as well as different methods used by the technicians and inspectors, detected gas levels may differ between instruments.***

B. SCREENING MONITORING

<u>**Screening monitoring defined:** Routine expedient field monitoring to determine a LFG control violation, area of concern or if supplemental enhanced monitoring is required.</u>

LFG screening is routinely conducted during facility inspections to determine if there is a LFG migration that could constitute a violation, area of concern or to determine if it is necessary to conduct further monitoring to verify that such violation exists. This monitoring is conducted whether or not a monitoring system is in place, on-site. A monitoring system usually consists of a series of in ground LFG probes installed around the permitted facility boundary. The probes should not be connected to or be in the vicinity of any negative pressure (vacuum) source.

An example of a basic multilevel probe is shown in Diagram 1:

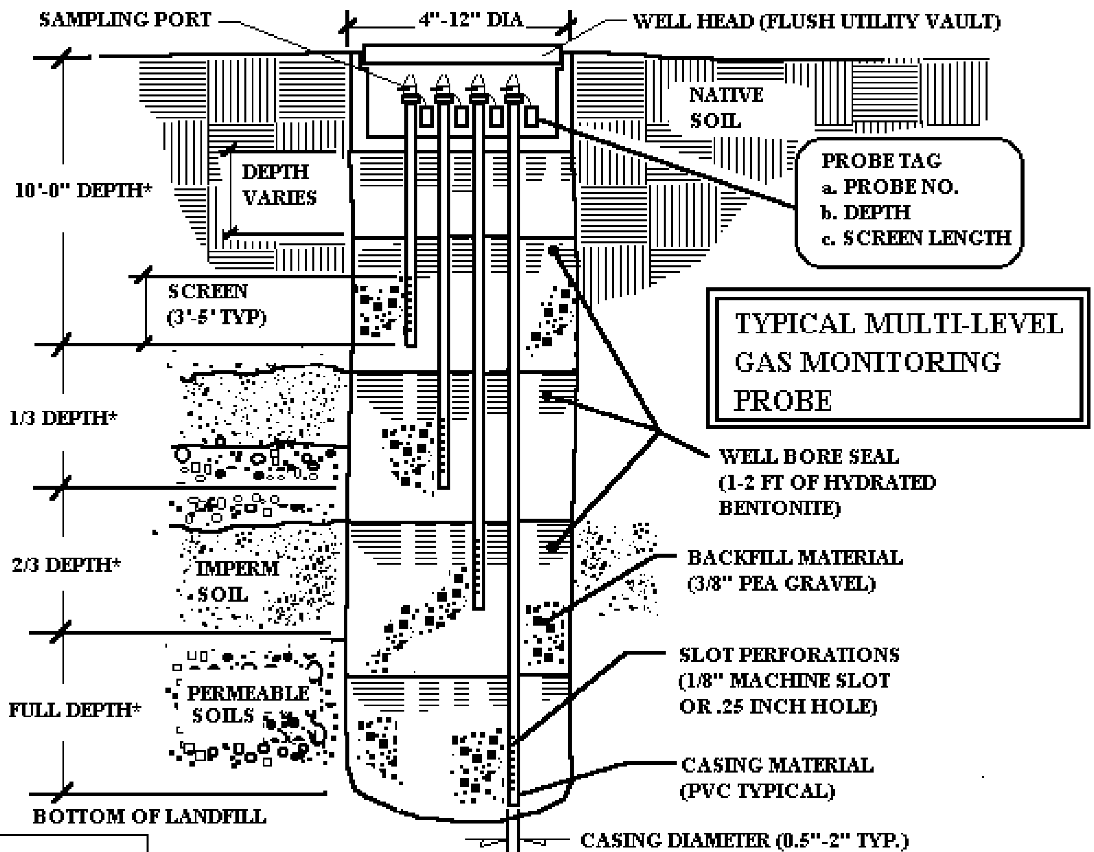


Diagram 1

II. Landfill Gas Screening Monitoring Procedures

A. Activities Performed in Screening Monitoring

Some or all of the following activities are performed during LFG screening monitoring:

(1) Monitoring in-place probes
(2) Constructing and monitoring bar hole probes
(3) Monitoring in on-site structures

B. Equipment to be used for Screening Monitoring

In order to conduct adequate screening monitoring for landfills with or without monitoring systems, the following equipment maybe needed:

- *Properly calibrated infrared detector, combustible gas indicator (CGI), flame ionization detector (FID) or an equivalent instrument, capable of detecting methane gas at concentrations of 0.5-100.0 percent by volume in air.*
- Bar hole punch with at least a three foot long clean rod and weighted sliding handle for driving the rod into the ground.
- Three foot long, one-and-one-quarter inch diameter, hand-driven, soil auger.

- Plastic tubing and assorted connectors for ensuring airtight connections when hooking up the monitoring instrument to probes.
- Auxiliary air pump (AP)
- Tedlar bags
- Durable work gloves for using bar hole punch or impact drilling rig.
- Nominal 1/2" plastic PVC pipe cut in 12-18 inch lengths with one end cut off at a 45-degree angle, for purposes of driving the pipe into the soil.
- Flow meter to measure pumping rate AP.
- Magnehilix

Note: Training for LFG screening monitoring and for using gas monitoring equipment will be given on annual basis by the **LFG Training Group** (please contact Mr. John Bell at (916) 341-6368 for more information). As a matter of practice, new EA inspectors should be trained in the proper procedures for screening monitoring of landfill gas upon being hired and before evaluating a disposal site for compliance with the SMS for landfill gas by themselves. Additionally, **Board and LEA Staff** should attend the annual refresher training on how to conduct LFG screening monitoring. All staff training should be documented. Maintenance and calibration is documented for each instrument as recommended by the manufacturer to satisfy quality assurance/quality control requirements.

C. MONITORING SYSTEM EVALUATION

1. Pre-inspection information gathering

Prior to the inspection, the inspector should obtain and review copies of LFG monitoring reports submitted to the Local Enforcement Agency (LEA) by the operator for at least one year prior to the inspection. For existing monitoring systems, the inspector should identify from the monitoring reports any particular probes that should be sampled as mentioned in the section on monitoring sites that have an adequate in-place monitoring system. Additionally, the inspector should obtain maps and as-built drawings for the monitoring system that indicate location, depth and number of perimeter probes, as well as location of any gas control system or energy extraction system wells. Any available gas control system drawings and specifications, well construction details and boring logs would also be useful. This information can help identify probes that should be sampled during the initial LFG monitoring. The inspector should also consult the LEA to determine (if applicable) what type of probe fitting/adapter may be used to connect the gas-monitoring instrument to the probes at a site.

If there is no existing and/or functional LFG monitoring system, the inspector should review any available documents containing technical information such as the report of facility information (RFI), periodic site review (PSR), and any closure documents that may provide the information needed to establish the best locations for bar hole punch monitoring as described below.

2. CRITERIA FOR FIELD CHECKING OF IN-PLACE MONITORING SYSTEMS

Generally, the following should be verified:

- **Probe design:** Probe construction details should generally be included with the approved gas management plan for a site. A copy of the plan should be obtained from the LEA and placed in the facility file. When monitoring system plans are not available, consideration should be given to the types, quantity and depth of buried wastes, as well as to the proximity of sensitive receptors.

Note: Operators should consider the regular closure construction standards when designing and placing probes. (This is suggested because all landfills will have to eventually meet these standards at closure and it is usually more cost effective to meet them sooner rather than later)

- **Probe Functionality.** Probes may become plugged up for a variety of reasons. Make sure probes are not damaged, partially or fully filled with water, covered with dirt or mud, or otherwise destroyed or contaminated. Additionally, probes should be clearly marked and include shut off valves and/or terminating caps securely attached to them. Probes in vaults are less likely to be damaged or plugged, however, they are more susceptible to flooding). An obstructed probe will result in the LFG monitor pump laboring noticeably, or even shutting down completely. Checking the latest monitoring records should help in determining what probes, if any, may not be fully functional. Adequate care should be taken to insure water or excessive water vapors ~~is~~ are not drawn into the monitoring instrument. A hydrophobic filter should always be used. Additionally, a comparison with the existing gas monitoring records may show a change from previously recorded consistent levels of gas to a string of consecutive extremely low or zero readings.

- Please note that not all of the landfill gas issues may be resolved employing the screening process during an initial inspection. If necessary, upon return from the inspection, EA inspector may consider consulting the appropriate technical staff at the Board for further assistance in determining the functionality of plugged probes and to discuss the need for supplemental enhanced monitoring.

- **Generally probes are adequately placed if they are:** At (within 2 ft. of the permitted boundary of the disposal facility) or facility property boundary if the landfill has no permit. If the operator has chosen to install a probe inside the permitted facility boundary closer to waste, and the inspector finds more than 5 percent LFG in the probe, then the operator will have to either install another probe closer to the permitted facility boundary, or control LFG at that point to a level below 5 percent. A point of compliance may be chosen at any monitoring probe designated by the operator to meet **27 CCR Section 20919.5**. If a methane concentration above 5 percent is found in a compliance probe located toward the interior of a disposal site, this would indicate the need for further monitoring closer to the boundary. In such a case, a violation can also be given for an inadequate monitoring system.

- Placed outside of the zone of influence of an active LFG control system outer gas extraction wells. Probes placed directly opposite of extraction wells generally tend to have lower LFG readings than wells placed between extraction wells, however, this should be verified through direct probe measurements using a vacuum gauge.

- Placed every 1,000 feet or less, or at least one for each linear side of the facility perimeter boundary, (whichever can provide more coverage), for landfills that are subject to **27 CCR 20919.5**. In some cases, exceptions from these guidelines may be allowed. (Additional probes may be required if there is a significant amount of landfill gas being generated within the site and there are no natural barriers to prevent off site LFG migration).
- Placed adjacent to receptors (structures, orchards, crops, etc.) that are within 1,000 feet of the site regulatory boundary.

Note: If possible, conduct a visual inspection to compare the system layout indicated in the available construction plans with the current field situation.

Note: The above recommendations and guidelines are not intended as absolute criteria in evaluating the adequacy of the LFG monitoring system and program implemented by the operator but are rather designed to assist the inspector in determining whether to monitor and, if necessary, where to conduct additional monitoring by employing bar hole probes.

3. Results of field checking

Monitoring system evaluation will result in one of the following conclusions:

a. **Monitoring system is adequate**
    i. Based upon determination by inspector
    ii. Based upon verification of in-place monitoring system constructed according to approved design.

b. **There is no monitoring system in place**

c. **The monitoring system is inadequate**
    i. Determined by inspector with or without approved plan
    ii. Determined by review of plans by appropriate technical staff prior to field inspection and verified by inspector.
    iii. Based on key probes being partially or fully nonfunctional during screening monitoring.

D. SELECTION OF WHICH PROBES TO MONITOR AND/OR PLACEMENT OF CONSTRUCTED (BARHOLE) PROBES

The following sections show where and how screening monitoring should be conducted for facilities that have (1) an adequate monitoring system, (2) no monitoring system, or (3) an inadequate monitoring system. After evaluating the monitoring system using the criteria in the previous section:

1. If the monitoring system is adequate:

Monitor selected in-place perimeter probes.
Probes that have one or more of the following characteristics should be selected for monitoring:

- Probe has a documented history of elevated readings

- Probe at the perimeter of a waste unit without an active control system, or that has a control system that is malfunctioning, disconnected, or has a recent history of unreliable operation.

- Probe is close to off-site receptors (within 1,000 ft.)- Receptors include buildings, agricultural crops and public gathering locations, such as schools, playgrounds, parks and golf courses. If multi-depth probes meet any one of the above criteria, all depths should be monitored.

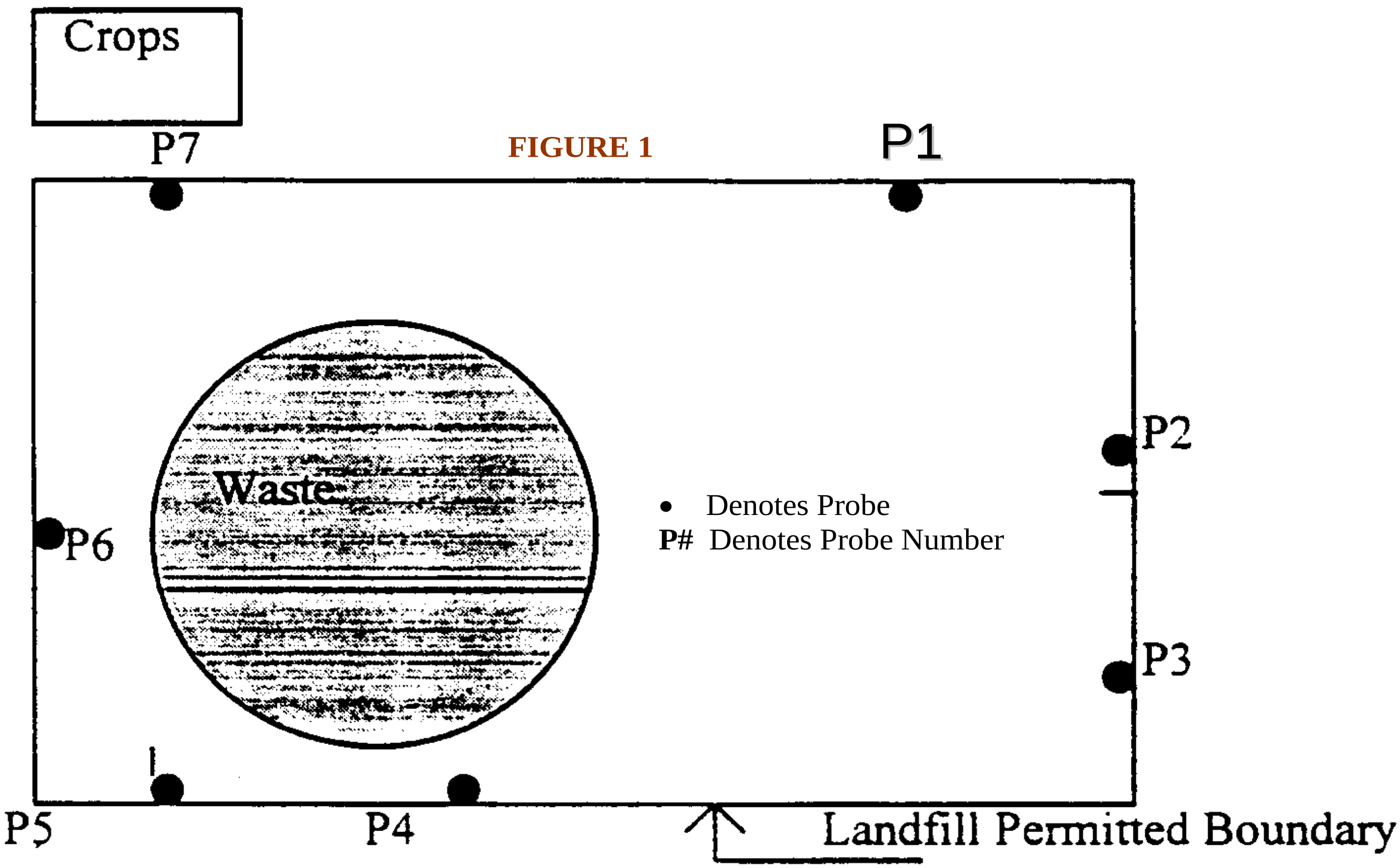
2. If there is no monitoring system:

Conduct screening monitoring using a bar-hole punch. Bar holes should be placed at appropriate locations on the perimeter of a site based upon the following criteria:

- **Soils -** porous soils, such as sands and sandy loams are the soils that may potentially yield the highest readings for LFG. If the soil appears to collapse in the hole as the punch is removed, then the monitoring point should be constructed by slipping a piece of PVC pipe over the rod and pounding the pipe into the ground.

- **<u>Geomorphology</u>** - Review available plans and geological and hydrogeological records that may indicate the most probable pathways for LFG to migrate. Consult with appropriate Board technical staff for sites where no landfill gas monitoring plan has been reviewed, or there is some reason to believe some special condition may exist at the site.

- **<u>Proximity of waste and receptors to permitted boundary</u>** - Bar hole monitoring is site specific should be done at or near the boundary, at points, which are closest to the waste or nearby receptors. See Figure 1 below.



Probes in Figure 1 above **P1, P4, P5, P6 and P7** should definitely be screened. Either one of probes 2 and 3 are optional, unless they have had a recent history of readings above 5% methane, or they have not been monitored in the past.

If the result of monitoring the bar hole probe indicates that LFG is migrating at a level of 0.5-5%, the operator should be encouraged to conduct further monitoring to determine if LFG is migrating at levels deeper then 3 feet pursuant to 27 CCR Section 20919.

At arid, rural landfills (ARLs), with no receptors nearby, only one bar hole location may be needed, because these sites typically generate little or no LFG. ARLs are those that usually receive less than 10 inches of precipitation per year, and take less than 20 tons of refuse per day. Moreover, the amount of moisture that returns to the atmosphere through evaporation will exceed the amount of moisture that penetrates into the ground. The result is a net loss of moisture at small dry landfills on an annual basis.

- Proximity to receptors - bar hole probes should be used as close as possible to receptors while still being at or near the boundary of the site.

<u>**Disclaimer:** The above guidelines for placement and monitoring of probes are used for screening monitoring and are not intended to be used by operators as absolute indicators of compliance with Subtitle D or other monitoring requirements.</u>

Note: If bar hole monitoring results are inconclusive, Board staff may conduct additional monitoring using the SGVIP unit, in order to assess the risk posed by the site to the public and the environment.

3. If monitoring system is inadequate:

A monitoring system is inadequate if it is significantly different from an approved monitoring plan or if it has not been approved by the LEA and/or the Board. The operator should be required to submit a work plan to correct the inadequacies. A violation or area of concern can be given if a monitoring system is inadequate and differs from what was specified by the LEA, local fire control authority or the Board.

An inspector can still use the guidance in 1 and 2 above to conduct Screening Monitoring. If a violation or area of concern for an inadequate monitoring system is given, the inspector should note all inconsistencies or system problems that led to the finding.

E. WHEN TO MONITOR

The best time of the day to monitor **bar hole probes** is when the barometric pressure is lowest. Depending on the weather, this may be late in the morning, or early in the afternoon. When the atmospheric pressure is at its lowest, gas can move out of the fill through convective forces caused by differences between the pressures inside the landfill and the atmospheric pressure above ground. The rate of LFG migration will be maximum when the difference in pressure between the fill and the ground surface is maximum. At depths greater than 10 feet, the difference in pressure will have a negligible effect on the concentration of LFG present in the probe.

F. HOW TO PERFORM SCREENING MONITORING

1. At existing probes:

a. Check probes condition and structural integrity and suitability for monitoring. Be sure each inspected probe is not subject to excessive negative pressure generated by nearby vacuum surces. A simple way to check for negative pressure is to hold a sheet of paper just above the opening of the probe and see if the paper is sucked to the opening. If the paper is sucked to the probe opening, the probe is more than likely influenced by negative pressure. A magnehelix, if available, should be used to determine whether or not a probe is under the influence of excessive negative pressure. The magnehelix is a device that measures pressure in terms of inches of water. If the probe is influenced by negative pressure, then it should not be sampled because attempting to overcome the negative pressure could damage the instrument, and it may not detect gas at the correct concentration. Probes should also be checked for presence of water prior to monitoring. Since water vapor can damage the instrument, if water is observed in any of the compliance probes, water traps should be used in order not to allow water from entering the instrument. Probes that are damaged or are under negative pressure are considered inadequate for use.

b. Use a gas monitoring instrument that is properly calibrated and warmed up. Open the petcock or otherwise ready the probe for sampling, and connect the flexible intake tube assembly to the probe, making sure that there is a tight seal. ***<u>(Note: Prior to taking any reading allow the CGI to warm-up at least 5 minutes. This will stabilize the instrument and any internal gas-measurement detectors.)</u>***

2. For bar hole probes:

a. Construct bar holes as follows:

1. Using the bar hole punch tool, drive the 1/2 inch diameter rod approximately 2.5-3 feet into the soil.
2. Use the bar hole punch only in soil in which the rod can be driven and extracted with a reasonable amount of effort so as to avoid injury to the individual doing the punching.

Notes to consider when constructing bar holes: You will be using the bar hole punch to drive a nominal ½" plastic PVC pipe cut in 12-18 inch lengths with one end cut off at a 45 degree angle into the soil. This pipe should prevent soil from falling into the hole. You will be inserting a cork or other gas-tight connection to the instrument sample tubing, which will seal the hole from ambient air. Gas can be then sampled from the probe anytime thereafter during the inspection. Gas is sampled with the instrument directly from the soil matrix that lies below the pipe.

Note: *Soils conducive to bar hole punching include sands and sandy loams and some silty soils. Soils not conducive to bar hole punching are those with significant amounts (> 30%) of clay and hard rock.*

<u>CAUTION: Check with the operator for the location of any buried utility lines (gas, water, electrical) at, or near the property boundary.</u>

b. Withdraw the bar hole rod from the hole that was made and do either of the following:

1. Place the sampling tip of the gas monitoring instrument into the hole as soon as the rod is removed. Make a seal around the hole by slipping an appropriately sized rubber stopper over the gas sampling tip.

OR:

2. Slip a section of PVC pipe as described in the equipment list onto the bar hole rod, and carefully drive it with the punch into the hole, leaving three to six inches of the pipe exposed, and extract the rod, while leaving the PVC pipe in place. Place a solid rubber stopper or a connector with a closeable sampling port in the exposed end of the PVC pipe.

Note: When creating temporary probes with the bar hole punch do the following to limit the chances of injury:

- ➢ *Let the weighted head of the bar hole tool drive the bar into the soil. Do not excessively force the bar into the soil. If the force of the weighted head cannot readily drive the bar into the soil, then bar hole monitoring should be attempted at a different point.*

- ➢ *Tuck the pelvis in, while bending the knees slightly, and use your legs and arms when extracting the bar hole tool from the soil to limit back strain and possible injury. The back should remain straight, while bending the knees slightly (**do not lock the knees)**, when using the bar hole punch.*

- ➢ *If more than one bar hole is made, alternate pounding and extracting the bar hole tool with your "buddy". A "buddy" could be an accompanying LEA inspector or an operator or a fellow Board inspector. Do not do all of the pounding and extracting yourself.*

3. Soil Gas Vapor Impact Probes (SGVIP) probes:

Instructions for placing SGVIP probes may be obtained from your supervisor or the Board LFG Training group. The following circumstances may warrant the use of the SGVIP unit for purposes of conducting screening monitoring:

- **When bar hole probe readings are between 0.5 - 5% LFG by volume.**
- **When soil is too hard for bar hole punching and a LFG problem is suspected Note:** The SGVIP unit may also be used for specialized monitoring (details for specialized monitoring will be developed later by the Closure and Remediation Branch)

CAUTION: Consult with the operator and call Underground Service Alert (USA) at 1-800-227-2600 at least 2 days prior to installation of probes to assure no interference with any underground transmission systems while conducting ground penetration.

4. For on-site structures

All on-site structures, except for gas control facilities, should be checked for the presence of landfill gas. On site structures may include a scale house (fee booth), maintenance shed, operator's office, etc. Prior to entering a building to sample for LFG get permission to do so from the site operator. Sample with the Scout or GMI CGI in areas where cracks in the floor are apparent, as well as behind large objects and in corners. If gas exceeds 1.25% by volume at any point in any building within the permitted facility boundary, excluding actual gas control structures, then 27 CCR 20919.5 is being violated, and the operator must plan and institute controls to bring the level below 1.25% in the structure.

It is suggested that for the purposes of documenting the results of monitoring, log or record be kept to record the readings. Site location, probe number, sampling date, time, weather conditions, name of inspector, equipment model and serial numbers, calibration information, and readings taken should be recorded. A copy of the log or record should be placed in the facility file with the final approved inspection report.

G. WHEN SCREENING MONITORING IS COMPLETED

Screening monitoring is completed once you have sampled:

- ➢ probes and points at or near the permitted boundary that are close to sensitive receptors,

- probes and points at or near the permitted boundary that may be susceptible to LFG migrating from areas of fill, and
- all on-site enclosed structures, excluding any actual gas control system facilities not occupied by personnel on a regular basis.

Once a violation has been detected, it is up to the inspector to decide if additional probes should be monitored in the course of the inspection. Upon receiving a violation, the operator must conduct complete monitoring of the entire site as required by 14 CCR 20919, as well as remediate any violation of the gas control standards as required by 14 CCR 20919 and 14 CCR 20919.5.

Appendix

Gas Monitors

The selection of effective portable field gas monitoring equipment for the screening monitoring will depend on whether the screening monitoring is being performed in ambient air or if the gas is being pulled from a migration probe / bar hole. Screening for surface emissions from cracks in the soil surface near the boundary is performed under ambient oxygen concentrations, while sampling for methane migration is often done in oxygen-deficient probes. In addition, selection of equipment will depend on the concentration range of the gas to be sampled. The volatile organic gases typically are in the parts per billion (PPB) or parts per million (PPM) range and will require more sensitive equipment and different sampling methodologies than methane and carbon dioxide which are found in much larger concentrations.

Combustible Gas Indicator (Catalytic Oxidation Method)

Combustible Gas Indicators (CGIs) were originally developed for the natural gas and mine industries and operate under two different principles, catalytic oxidation and thermal conductivity. Some CGIs operate by both methods, but the discussion on surface emission sampling will focus on the catalytic oxidation method, as the thermal conductivity detection method is used primarily for volume gas measurements in migration probes. By the catalytic oxidation method, the CGI measures the concentration of a combustible gas in air, indicating the results in parts per million or in percent of the LEL. Often these readings are taken in conjunction with oxygen readings. These instruments use a platinum filament that heats up during the combustion of the sampled gas. Any changes in the combustion temperature will affect the resistance of the filament, which results in an imbalance of the resistor circuit called the "Wheatstone Bridge". This imbalance is measured via the analog or digital scale of the unit. Some CGIS have two scales, one measuring in parts per million by volume (ppmv) and the other in percent of the LEL.

Limitations of CGIs include:

1. The reaction is temperature dependent and is therefore only as accurate as the incremental difference between calibration and ambient sampling temperatures;

2. Sensitivity is a function of the physical and chemical properties of the calibration gas therefore methane should be used as the calibration standard;

3. The unit will not work well in oxygen deficient or oxygen enriched atmospheres (it will give false negative readings in oxygen deficient environments); and

4. The filament can be damaged by certain compounds such as leaded gas, halogens, and sulfur compounds and silicone will destroy the platinum filament. Since LFG contains some halogenated (chlorinated) hydrocarbons, the meter should be calibrated often to methane (the target constituent) and serviced yearly if it used on a routine basis to monitor methane surface emissions. In addition, if the meter contains an oxygen cell, this cell can be fouled by the carbon dioxide found in LFG and replacement of the cell may be required frequently. Advantages to the CGI are that they are small and portable, self-contained for field use, have an internal battery, are easy to use and typically are intrinsically safe.

Combustible Gas Indicator/Thermal Conductivity Method

High concentrations of methane (greater than 100% of the LEL or 5% methane) are measured with a % GAS instrument using a thermal conductivity (TC) sensor. This type of sensor is often used with a catalytic oxidation sensor in the same instrument. The catalytic sensor is used to detect concentrations less than 100% of the LEL and at higher concentrations, the TC sensor is used to measure up to 100% gas by volume. The TC sensor is composed of two separate filaments, heated to the same temperature. Combustible gases enter only the TC side of the filament; the other filament (compensating) maintains a steady heated temperature. Incoming gases cool the TC filament and as the filament temperature decreases, the resistance across the Wheatstone Bridge also decreases, resulting in a meter reading. Instruments using a TC sensor do not require oxygen for a valid reading, as burning of the gas is not involved. Combustible gases vary in their ability to cool the TC filament. Methane absorbs heat well and efficiently cools the filament and is the calibrant gas of choice when using the instrument to measure methane in landfill gas. However, since landfill gas is comprised of a combination of different gases, readings on the meter will vary depending on the concentration of the other gases in the sample. Gases that cool the filament more effectively than methane (as the calibrant gas), will display a higher % GAS reading than is actually present. The converse is also true, that gases, which are less effective in cooling the filament, will display a lower %GAS reading than is actually present. It is important to realize that certain gases can cool the filament and **not** be combustible. Carbon dioxide, typically found in landfill gas at high concentrations, absorbs heat readily and can produce a false positive reading. Meter sensitivity to carbon dioxide varies from manufacturer to manufacturer and one should be very familiar with the technical information supplied with the equipment. With some meters calibration with a methane/carbon dioxide mixture can help with the interference of carbon dioxide with the monitoring of methane in landfill gas.

Flame Ionization Detector (FID)/Organic Vapor Analyzer (OVA)

Flame Ionization Detectors (FIDs) measures many organic gases and vapors. Some FIDs are commonly referred to as Organic Vapor Analyzers or OVAs. FIDs operate by a sample being ionized in a detection chamber by a hydrogen flame. A current is produced in proportion to the number of carbon atoms present. There are two modes of operation, the survey mode and the gas chromatograph (GC) mode. For methane surface emissions, the survey mode is used if both are available on the instrument. Since the sensitivity of the instrument depends on the compound, methane should be used as the calibration standard. These instruments are less rugged in the field than the CGIs and require hydrogen gas cylinders for use. The advantages to the FIDs are fast response in the survey mode, wide sensitivity (1 to 100,000 ppm), and some models offer a telescopic probe with cup intake that minimizes operator exposure to LFG and minimizes windy conditions at the site. The "cup" probe design can also serve to reduce the near surface dilution effects of the wind by providing a small sampling chamber when the probe is held normal to the surface.

Infra-Red Analyzer

Most IR analyzers are single beam spectrophotometers. Chemicals have a vibration energy that is specific to that chemical (gas). When the gas interacts with IR radiation, it absorbs a portion of the IR energy. The **absorption spectrum** for that gas is the pattern of vibrations from the atoms/functional groups, along with the overall molecular configuration. Specific gases will demonstrate optimal absorption within a small IR range. Since absorption ranges have been classified for different gases, it is possible to filter out all but a small part of the spectrum and measure the gas known to be present. The instrument works by a sample being drawn into the sample cell, IR radiation travels through the cell for a specific pathlength before reaching the instrument's detector. IR absorbance by a gas over a given pathlength is proportional to its concentration. IR monitors used to analyze for landfill gas have fixed pathlengths to detect methane and carbon dioxide in monitoring probes and gas extraction systems within landfills. The advantage of IR analyzers is that the high carbon dioxide levels found in landfills will not affect methane readings. Portable IR meters available for the field are capable of measuring up to 100% by volume methane and carbon dioxide. The concentrations of these gases are detected by infrared absorption. Oxygen concentration gas is measured by an electrochemical cell. These meters are designed to measure large concentrations of methane and carbon dioxide and are not sensitive at concentrations less than 0.5%. Field calibrant gas should be used to verify the accuracy of the monitoring results. A combination gas of 15% methane and 15% carbon dioxide is a common mixture when using the equipment to test migration probes. Higher concentrations of calibrant gases should be used if monitoring levels in gas extraction wells.