Baro-Pneumatic Estimation of Landfill Gas Generation Rates

Hydro Geo Chem, Inc. has developed an alternative, direct-measurement LFG estimation method (patent pending), termed the baro-pneumatic method. This method is not only more accurate and technically defensible than other direct or indirect methods, but also is less expensive to perform.

Current State of LFG Measurement Technology

Accurate estimation of landfill gas (LFG) generation is required for successful design of LFG-to-energy projects, LFG collection and control systems, and for calculation of non-methane organic compound (NMOC) emissions under 40 CFR Part 60. However, currently available indirect methods commonly under- or over-predict LFG production by factors of 2 or more, and available direct measurement techniques are so inaccurate that they are of little value.

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Design of LFG-to-energy projects requires estimating LFG quantity and fuel quality. Projecting these estimates into the future allows the design goals of the gas collection system to be identified, capital needs to be accurately assessed, and the costs and revenue to be determined. Given the uncertainties in present measurement methods, these project parameters rely on little more than educated guesses to predict the costs or energy production of an LFG-to-energy project. The consequences of inaccurate LFG estimation are significant. Underestimation of LFG generation reduces revenue. Overestimation of LFG generation needlessly increases capital costs and will be especially costly if the actual rate proves to be inadequate to economically justify the LFG-to-energy system.

Requirements Under 40 CFR 60

40 CFR 60 requires a landfill owner to calculate NMOC emissions using a 3-tiered approach based on estimates or measurements of LFG generation and NMOC concentrations within the landfill. If NMOC emissions are found to exceed 50 megagrams per year (MG/yr), the landfill owner is required to install a LFG control System.

Tiers 1 and 2 rely on an empirical formula for estimating LFG generation that is uncalibrated and does not involve direct measurement. Because this indirect method is designed to be conservative, its estimates of LFG generation are likely to be higher than the actual rate, especially for landfills in arid environments where low refuse moisture content may limit LFG generation.

Tier 3 includes measurement of LFG generation using the 40 CFR 60 approved protocol, which is not only time consuming and expensive, but recently has been shown to be technically flawed and not capable of providing accurate estimates of either LFG production or NMOC emissions (Walter, 2002)*. Use of the Tier 3 method has been regarded as justifiable if it results in a low estimate of LFG production and NMOC emissions of less than 50 MG/yr, allowing the installation of an LFG collection system to be delayed or deferred altogether.

Overestimation of LFG generation, however, is costly to the landfill operator if estimated NMOC emissions are greater than 50 MG/yr, requiring the installation of an LFG control system. Additional costs are incurred if an LFG control (and flare) system is overdesigned based on an inflated estimate of LFG production.

The Baro-Pneumatic Method

The baro-pneumatic method consists of accurate measurement and analysis of the pressure response in the landfill to natural variations in barometric pressure. The methodology is based on sound gas flow principles and independent estimates of the gas permeability of the cover, refuse, and surrounding soil.

The baro-pneumatic method recognizes that the pressure distribution within a landfill depends on the rate of LFG production; the effective gas permeability and air-filled porosity of landfill refuse, underlying soil, and overlying cover materials; and the barometric pressure at the landfill boundaries. LFG pressures increase with landfill gas production rates and decreased gas permeability. The transient barometric pressure response is attenuated and delayed with depth as a function of the pneumatic diffusivity. Given a relatively constant rate of LFG generation during the test period, the only factors affecting gas pressures at fixed measuring points will be changes in boundary pressures related to changes in barometric pressure and the gas permeability. Thus, gas permeability and LFG generation rate both can be estimated by appropriately analyzing the transient pressure responses at various depths within

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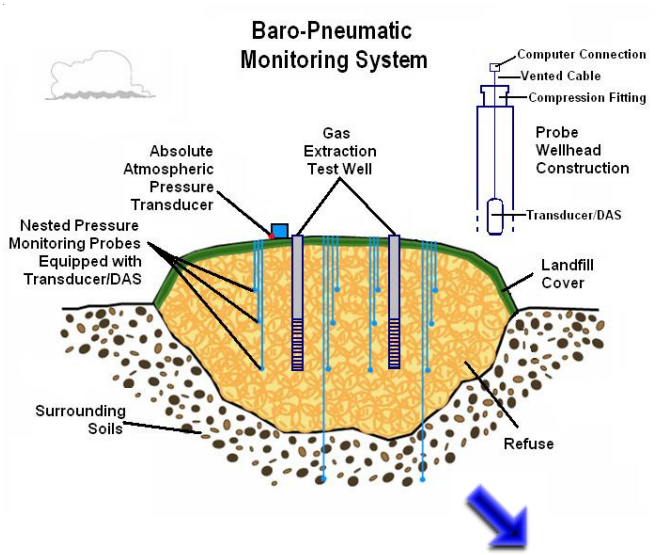
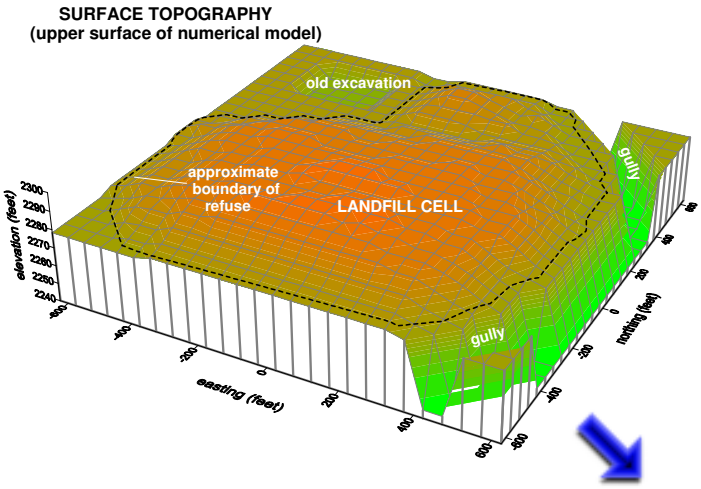
and beneath the landfill. In the case of an unlined landfill, gas movement through the sides of the landfill below grade and through the base of the landfill must also be considered in estimating gas generation rates.



Field Data Collection

The baro-pneumatic method relies on very accurate and sensitive pressure transducers installed at various locations in the landfill. The transducers can be deployed in borings and cone penetometer installations, or the existing LFG collection system wells can be employed to measure barometric responses. Landfill pressure is measured for several days using a computerized data acquisition system to store the data.



Data Analysis

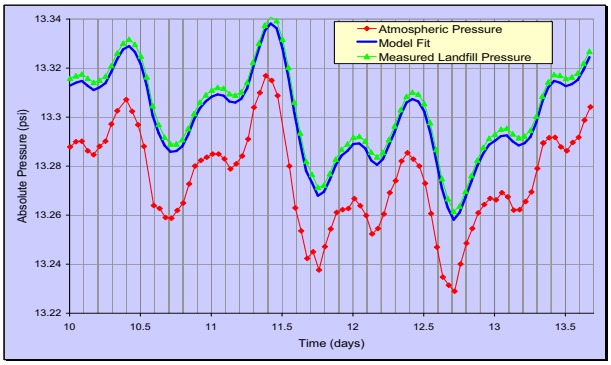
The pressures are analyzed by a numerical pneumatic model based on Darcy's law and the continuity equation. The model automatically satisfies mass balance and is designed to account for landfill geometry, cover conditions, and other realistic conditions. The observed barometric pressures are imposed as boundary conditions on the model, and the LFG generation rates and gas permeability are varied to provide model matches of the observed pressure responses in the landfill. A significant, additional benefit is that the calibrated model can be utilized to design an efficient LFG collection or control system.

Field Example

A lined, clay covered 77 acre landfill cell near Memphis, Tennessee was evaluated as methane feedstock for a major chemical company. Barometric pressures were measured at the surface and in shut-down collection wells of the operating LFG collection system. The best model fit to the barometric responses was an LFG generation rate of 4,130 scfm, obtained by adjusting gas permeability and LFG generation rates in a numerical gas flow model that included both the 77 acre cell and a smaller cell that had not been equipped with monitoring points. The subsequent buildout of the LFG collection system to include both cells resulted in an LFG capture of 3,400 scfm, indicating a reasonable LFG collection efficiency of 82%. Conversely, two LFG generation estimates by another engineering firm were, respectively, 2,730 and 1,700 scfm, both less than the LFG recovered and both yielding collection efficiencies impossibly higher than 100%.

What's Next?

The level of testing necessary will depend on specific site conditions and the results of initial barometric tests on the landfill itself. Most Subtitle D landfills that have liners and low permeability covers will require only barometric tests, as will unlined landfills completed in low permeability native soils. In the case where the cover permeability is nearly the same as the landfill permeability, additional gas-extraction tests may be required to refine estimates of cover and landfill permeability.



*Walter, Gary. 2002. "Fatal Flaws in Measuring Landfill Gas Generation Rates by Empirical Well Testing", Journal of the Air and Waste Management Association. April 2003.

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