Turnable Diode Laser Absorption Spectroscopy (TDLAS) Analysis of Landfill Gas Measurements

Landfill gas is a natural byproduct of the decomposition of organic material in anaerobic conditions. Landfill gas contains 45% to 60% methane and 40% to 60% carbon dioxide. In addition, landfill gas contains small amounts of nitrogen, oxygen, ammonia, sulfides, hydrogen, carbon monoxide, and non-methane organic compounds such as trichloroethylene, benzene, and vinyl chloride.

Methane is a potent greenhouse gas with a global warming potential that is 25 times greater than CO_2. Rather than releasing landfill methane into the atmosphere or flaring it, methane can be collected, converted and used as an energy source. The collected methane can be burned to generate thermal energy for heating applications. It can also be burned to create steam, which can be used to drive turbines that generate electricity. The landfill gas can also be sold off site and sent into natural gas pipelines after further purification. Pressure Swing Adsorption or membranes technique can increase the methane content up to 90 percent and this can easily be incorporated into existing energy gas pipelines.

According to the Environmental Protection Agency more than 950 municipal solid waste landfills are operating in the United States as of 2014. In 2016, 652 landfill gas energy projects were operating in 48 states and 1 U.S. territory. Three quarters of these projects generate electricity while the remainder are either direct-use projects where the landfill gas was used for its thermal capacity or upgraded projects where the gas was cleaned to a level similar to natural gas.

Operators of landfill gas plants need to continuously evaluate the percentage of methane in their product because this determines the end use of the gas and the pricing. This quality is either determined by measuring the actual methane content or by determining the BTU values. Direct measurements of methane are always preferable because they provide real time information. The environment (i.e. physical conditions like temperature and moisture content), as well as the makeup of the waste materials can determine the level of methane. Operation in a landfill plant requires analyzers that can give fast, accurate and real time methane information.

A simplified flow diagram of the landfill gas plant is shown in Figure 1 and includes landfill gas collection, an extensive treatment system and a processed gas delivery system for further use.

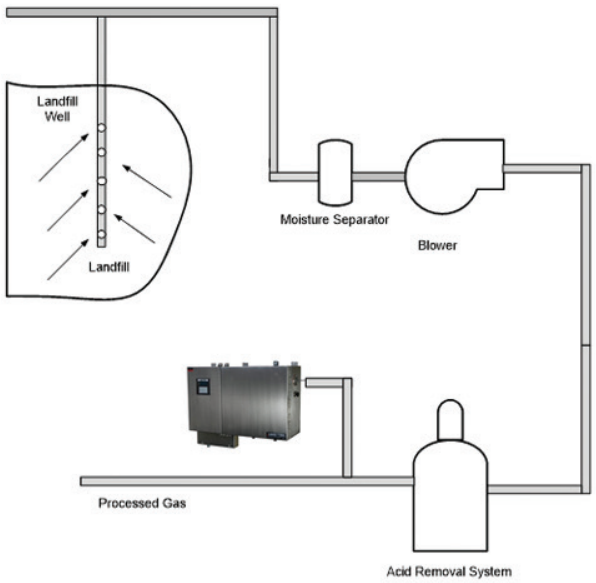

Figure 1: Landfill Gas System

Methane is extremely flammable and may form explosive mixtures with air. It is an important option for operators to run measurements of methane in parallel with oxygen measurements in landfill gas. A Tunable Diode Laser Absorption Spectroscopy (TDLAS) analyzer is a good choice for such a task. Traditionally gas chromatography and mass spectrometry are used to provide methane monitoring in the process of landfill gas production. Gas chromatography offers high sensitivity, but it has the disadvantage of a slow response time. A TDLAS analyzer provides real time monitoring with a data acquisition rate of 2 seconds. The AMETEK 5100 (TDLAS) series of analyzers are significantly less expensive than both gas chromatographs or mass spectrometers.

TDLAS is a non-contact analysis technique with long-term stability, high specificity and selectivity. A laser based methane and oxygen sensor offers the advantage of faster response time, large dynamic range and low drift in comparison with conventional techniques such as gas chromatography. In applications such as monitoring the methane and oxygen levels at the outlet of the landfill gas plant, the above mentioned attributes help to meet the optimal requirements of the plant operation better.

AMETEK model 5100 HD is an extractive type analyzer designed for hot/wet sample analysis. There is no sample conditioning for the analyzer system, just a fully integrated sample handling to transport the sample. The model 5100 HD uses a sealed reference cell for continuous on-line analyzer verification and offers high specificity, and sensitivity. The analyzer uses a digital implementation of the Wavelength Modulation Spectroscopy (WMS), so changing the experimental protocol is simply a matter of uploading a file. The Model 5100 HD is the choice of many customers to replace gas chromatographs for monitoring methane and oxygen. The Model 5100 HD analyzer can be built with two lasers and two sample cells in one enclosure to provide simultaneous measurements of both oxygen and methane.

The data shown in Figure 2 represent the response of the instrument to a series of methane challenges in the concentration range of 40-60%. Zero base line, which was represented by air saturated with water was also evaluated in this test. The data acquisition rate was 2 seconds/measurement.

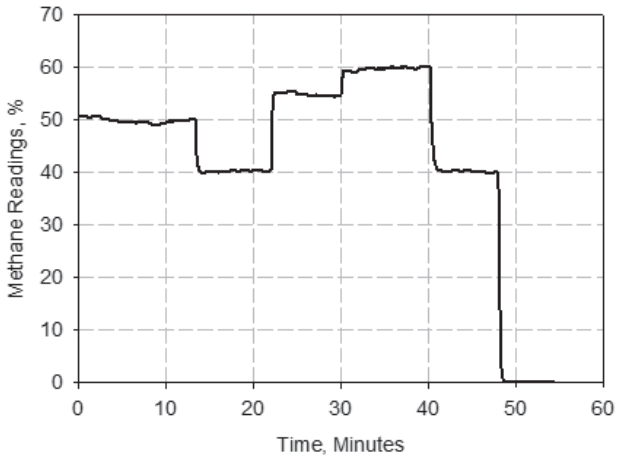

Figure 2: Response of the analyzer to a series of methane challenges

Validation test for the analyzer resulted in maximal error value of 0.3 volume percent evaluated for methane measurements in the concentration range 40 - 60%. This error was calculated as a difference between set value and averaged over the measurement time reading for each selected concentration level. Repeatability as a degree of agreement between replicate measurements of the same quality was expressed in terms of standard deviation of the measurement results. Standard deviation of the methane readings on each (with except of 10%) of the selected concentration challenges was less than 0.2% and repeatability at the methane level of 55% was 0.3%. The speed of the response T90 time was 34 seconds under flow rate of 2L/min.

The data shown on Figure 3 represent the response of the instrument to a series of oxygen challenges in the concentration range of interest. The duration of each of the challenges was 60 minutes or more with return to the 0% gas baseline value between challenges. The speed of the response T90

time was 20 seconds and was determined by the propagation of the gas in the sampling system with a flow rate of 2L/min.

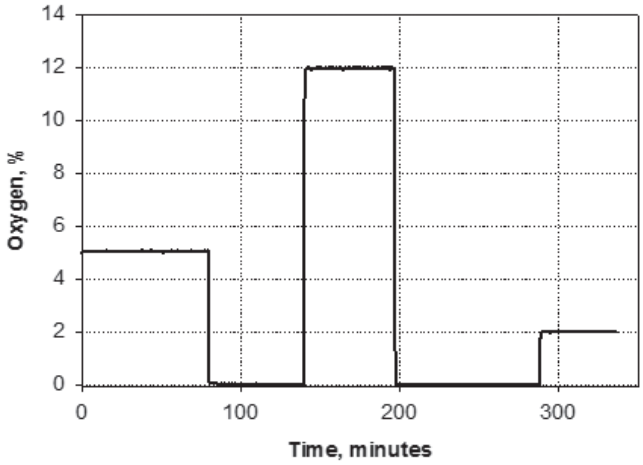

Figure 3: Response of the analyzer to a series of oxygen challenges.

Repeatability as a degree of agreement between replicate measurements of the same quality was expressed in terms of standard deviation of the measurement results. Standard deviation of the reading on each of the challenges was between 0.03% and 0.04% of the oxygen concentration. The value of the accuracy evaluated at the levels of 2% and 5% of oxygen was 0.1% oxygen.

Figure 2: The AMETEK 5100 HD TDLAS.

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