IMPACT COMPLIANCE & TESTING

Executive Summary

ENERGY DEVELOPMENTS WATERVLIET, LLC AT THE ORCHARD HILLS LANDFILL
CAT® G3516 LANDFILL GAS FUELED IC ENGINE EMISSIONS TEST RESULTS

Energy Developments Watervliet, LLC (EDL) contracted Impact Compliance and Testing, Inc., to conduct a performance demonstration for the determination of formaldehyde (CH_2O) concentrations and emission rates from one (1) CAT® Model G3516 (Engine No. 3) landfill gas-fired reciprocating internal combustion engines and electricity generator sets operated at the EDL facility in Watervliet, Michigan.

Michigan Department of Environment, Great Lakes and Energy (EGLE) Air Quality Division (AQD) Permit to Install No. (PTI) 25-18 requires that CH_2O testing of the CAT® G3516 engine is required within 180 days of startup and within every five (5) years of completion of the previous stack test. The initial performance testing was conducted on October 22, 2019. The following tables presents the emissions results and operating data from the performance demonstration.

Emission Unit	Generator Output (kW)	LFG CH_4 Content (%)	CH_2O Emission Rate (lb/hr)
Engine No. 3	785	52.8	0.56
Permit Limit	-	-	*0.75*

kW=kilowatt, lb/hr = pounds per hour

The data above indicate that Engine No. 3 was tested while the unit operated within 10% of its maximum capacity (800 kW) and is in compliance with the emission standards specified in PTI No. 25-18.

IMPACT COMPLIANCE & TESTING

AIR EMISSION TEST REPORT

Title	AIR EMISSION TEST REPORT FOR THE VERIFICATION OF AIR POLLUTANT EMISSIONS FROM A LANDFILL GAS FUELED INTERNAL COMBUSTION ENGINE
Report Date	November 7, 2019
Test Dates	October 22, 2019

Facility Information	
Name	Energy Developments Watervliet, LLC
Street Address	3563 Hennesey Rd.
City, County	Watervliet, Berrien

Facility Permit Information			
PTI No.:	25-18	Facility SRN :	N5719

Testing Contractor	
Company	Impact Compliance and Testing, Inc.
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Project No.	1900205

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ENERGY DEVELOPMENTS WATERVLIET, LLC

1.0 INTRODUCTION

Energy Developments Watervliet, LLC (EDL) (Facility SRN: N5719) owns and operates one (1) Caterpillar (CAT®) Model No. G3516 landfill gas (LFG) fueled reciprocating internal combustion engines (RICE) and two (2) CAT® Model No. G3520C LFG fueled RICE at the Orchard Hill Sanitary Landfill in Watervliet, Berrien County, Michigan. The CAT® Model No. G3516 engine is identified as Emission Unit ID: EUICEENGINE3 in Permit to Install (PTI) No. 25-18. EUICEENGINE3 is also referred to as Engine No. 3 in this report and by facility representatives.

Air emission compliance testing was performed to satisfy the following requirements contained in PTI No. 25-18:

- Test EUICEENGINE3 for emissions of formaldehyde within 180 days of initial startup.

The compliance testing was performed by Impact Compliance and Testing, Inc., a Michigan-based environmental consulting and testing company. Impact Compliance and Testing, Inc. representatives Jory VanEss and Andrew Rusnak performed the field sampling and measurements October 22, 2019.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated August 22, 2019 that was reviewed and approved by the Michigan Department of Environment, Great Lakes and Energy (EGLE). EGLE representative Mr. Tom Gasloli observed the testing project.

Questions regarding this emission test report should be directed to:

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Report Certification

This test report was prepared by Impact Compliance and Testing, Inc. based on field sampling data collected by Impact Compliance and Testing, Inc.. Facility process data were collected and provided by EDL employees or representatives. This test report has been reviewed by EDL representatives and approved for submittal to the EGLE.

I certify that the testing was conducted in accordance with the specified test methods and submitted test plan unless otherwise specified in this report. I believe the information provided in this report and its attachments are true, accurate, and complete.

Report Prepared By:

Andy Rusnak, QSTI
Technical Manager
Impact Compliance and Testing, Inc.

2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 General Process Description

Landfill gas (LFG) containing methane is generated in the Orchard Hill Sanitary Landfill from the anaerobic decomposition of disposed waste materials. The LFG is collected from both active and capped landfill cells using a system of wells (gas collection system). The collected LFG is transferred to the EDL LFG power station facility where it is treated and used as fuel for the three (3) RICE. Each RICE is connected to an electricity generator that produces electricity that is transferred to the local utility.

2.2 Rated Capacities and Air Emission Controls

The CAT® Model No. G3516 RICE has a rated output of 1,148 brake-horsepower (bhp) and the connected generator has a rated electricity output of 800 kilowatts (kW). The engine is designed to fire low-pressure, lean fuel mixtures (e.g., LFG).

The engine/generator set is not equipped with add-on emission control devices. Air pollutant emissions are minimized through the proper operation of the gas treatment system and efficient fuel combustion in the engines.

The fuel consumption rate is regulated automatically to maintain the heat input rate required to support engine operations and is dependent on the fuel heat value (methane content) of the treated LFG.

2.3 Sampling Locations

The RICE exhaust gas is directed through mufflers and is released to the atmosphere through dedicated vertical exhaust stacks with vertical release points.

The exhaust stack sampling ports for the CAT® Model G3516 engine (Engine No. 3) are located in an individual exhaust stack with an inner diameter of 13.25 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location greater than 120 inches (>9.1 duct diameters) upstream and 96.0 inches (7.3 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

Individual traverse points were determined in accordance with USEPA Method 1.

Appendix 1 provides diagrams of the emission test sampling locations.

3.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

3.1 Purpose and Objective of the Tests

The conditions of PTI No. 25-18 require EDL to test Engine No. 3 for formaldehyde (CH_2O) within 180 days of startup and within five (5) years of the previous stack test. This test event represented the initial testing.

3.2 Operating Conditions During the Compliance Tests

The testing was performed while the EDL engine/generator set was operated at maximum operating conditions (800 kW electricity output +/- 10%). EDL representatives provided the kW output in 15-minute increments for each test period. The Engine No. 3 generator kW output ranged between 778 and 794 kW for each test period.

For the testing performed on Engine No. 3 fuel methane content was recorded by EDL representatives in 15-minute increments for each test period. The fuel methane content ranged between 51.7 and 53.0% during the test periods.

Appendix 2 provides operating records provided by EDL representatives for the test periods.

Table 3.1 presents a summary of the average engine operating conditions during the test periods.

3.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled LFG fueled RICE (Engine Nos. 3) were sampled for three (3) one-hour test periods during the compliance testing performed October 22, 2019.

Table 3.2 presents the average measured CH_2O emission rates for the engine (average of the three test periods).

Test results for each one hour sampling period and comparison to the permitted emission rates is presented in Section 6.0 of this report.

Table 3.1 Average engine operating conditions during the test periods

Engine Parameter	Engine No. 3
Generator output (kW)	785
LFG methane content (%)	52.8

Table 3.2 Average measured emission rates for Engine No. 3 (three-test average)

Emission Unit	CH_2O Emission Rate (lb/hr)
Engine No. 3	0.56
Permit Limit	0.75

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A test protocol for the air emission testing was reviewed and approved by the EGLE. This section provides a summary of the sampling and analytical procedures that were used during the EDL testing periods.

4.1 Summary of Sampling Methods

USEPA Method 1	Exhaust gas velocity measurement locations were determined based on the physical stack arrangement and requirements in USEPA Method 1
USEPA Method 2	Exhaust gas velocity pressure was determined using a Type-S Pitot tube connected to a red oil incline manometer; temperature was measured using a K-type thermocouple connected to the Pitot tube.
USEPA Method 3A	Exhaust gas O_2 content was determined using paramagnetic instrumental analyzer.
ASTM D6348	Exhaust gas formaldehyde concentration via Fourier transform infrared spectroscopy (FTIR)

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

The RICE exhaust stack gas velocities and volumetric flow rates were determined using USEPA Method 2 during each test. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure at each traverse point across the stack cross section. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were leak-checked prior to each traverse to verify the integrity of the measurement system.

The absence of significant cyclonic flow for the exhaust configuration was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each velocity traverse point with the planes of the face openings of the Pitot tube perpendicular to the stack cross-sectional plane. The Pitot tube was then rotated to determine the null angle (rotational angle as measured from the perpendicular, or reference, position at which the differential pressure is equal to zero).

Appendix 3 provides exhaust gas flowrate calculations and field data sheets.

4.3 Exhaust Gas Oxygen Content Determination (USEPA Method 3A)

O_2 content in the RICE exhaust gas stream was measured continuously throughout each test period in accordance with USEPA Method 3A. The O_2 content of the exhaust was monitored using a Servomex 1440D gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the IC engine exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzers; therefore, measurement of O_2 concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

Prior to, and at the conclusion of each test, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document). Sampling times were recorded on field data sheets.

Appendix 4 provides O_2 calculation sheets. Raw instrument response data are provided in Appendix 5.

4.4 Determination of Formaldehyde Emissions (ASTM D6348)

Formaldehyde, moisture and carbon dioxide concentration in the RICE exhaust gas streams was determined using a MKS Multi-Gas 2030 Fourier transform infrared (FTIR) spectrometer.

Samples of the exhaust gas were delivered directly to the instrumental analyzer using a Teflon® heated sample line, heated head pump and heated filter to prevent condensation. The sample to the FTIR analyzer was not conditioned to remove moisture. Therefore, formaldehyde measurements correspond to standard conditions with no moisture correction (wet basis).

A calibration transfer standard (CTS), ethylene standard, and nitrogen zero gas were analyzed before and after each test run. Analyte spiking, of each engine, with acetaldehyde and sulfur hexafluoride was performed to verify the ability of the sampling system to quantitatively deliver a sample containing the compound of interest from the base of the probe to the FTIR. Data was collected at 0.5 cm^{-1} resolution. Instrument response was recorded using MKS data acquisition software.

Appendix 4 provides formaldehyde calculation sheets. Instrument response data for the FTIR is provided in Appendix 6.

5.0 QA/QC ACTIVITIES

5.1 Instrumental Analyzer Interference Check

The instrumental analyzer used to measure O_2 has had an interference response test preformed prior to their use in the field (June 12, 2014), pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e., gases that would be encountered in the exhaust gas stream) were introduced into the analyzer, separately and as a mixture with the analyte that the analyzer is designed to measure. The analyzer exhibited a composite deviation of less than 2.5% of the span for all measured interferent gases. No major analytical components of the analyzer have been replaced since performing the original interference tests.

5.2 Instrument Calibration and System Bias Checks

At the beginning of each day of the testing program, initial three-point instrument calibrations were performed for the O_2 analyzer by injecting calibration gas directly into the inlet sample port for the instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and determining the instrument response against the initial instrument calibration readings.

The instrument was calibrated with USEPA Protocol 1 certified concentrations of O_2 in nitrogen and zeroed using hydrocarbon free nitrogen.

5.3 FTIR QA/QC Activities

At the beginning of the day a calibration transfer standard (CTS, ethylene gas), analyte of interest (acetaldehyde) and nitrogen calibration gas were directly injected into the FTIR to evaluate the unit response.

Prior to and after each test run the CTS was analyzed. The ethylene was passed through the entire system (system purge) to verify the sampling system response and to ensure that the sampling system remained leak-free at the stack location. Nitrogen was also passed through the sampling system to ensure the system is free of contaminants.

Analyte spiking, of each emission unit, prior to and after sampling, with acetaldehyde was performed to verify the ability of the sampling system to quantitatively deliver a sample containing the compound of interest from the base of the probe to the FTIR and assured the ability of the FTIR to quantify that compound in the presence of effluent gas. The spike target dilution ratio was 1:10 (1 part cal gas; 9 parts stack gas).

As part of the data validation procedure, reference spectra were manually fit to that of the sample spectra (two spectra from each test period) and a concentration was determined. Concentration data was manually validated using the MKS MG2000 method analyzer software.

The software used multi-point calibration curves to quantify each spectrum. The software-calculated results were then compared with the measured concentrations to ensure the quality of the data.

Appendix 7 presents test equipment quality assurance data (instrument calibration and system bias check records, calibration gas certifications, interference test results, Pitot tube calibration records and FTIR QA/QC data).

6.0 RESULTS

6.1 Test Results and Allowable Emission Limits

Engine operating data and air pollutant emission measurement results for each one-hour test period are presented in Tables 6.1.

The measured air pollutant concentrations and emission rates for Engine No. 3 are less than the allowable limits specified in Permit to Install No. 25-18 for Emission Unit No. EUICEENGINE3:

- 0.75 lb/hr for CH_2O.

6.2 Variations from Normal Sampling Procedures or Operating Conditions

The testing for all pollutants was performed in accordance with USEPA and ASTM methods and the approved test protocol. The engine-generator sets were operated within 10% of maximum output (800 kW generator output) and no variations from normal operating conditions occurred during the engine test periods.

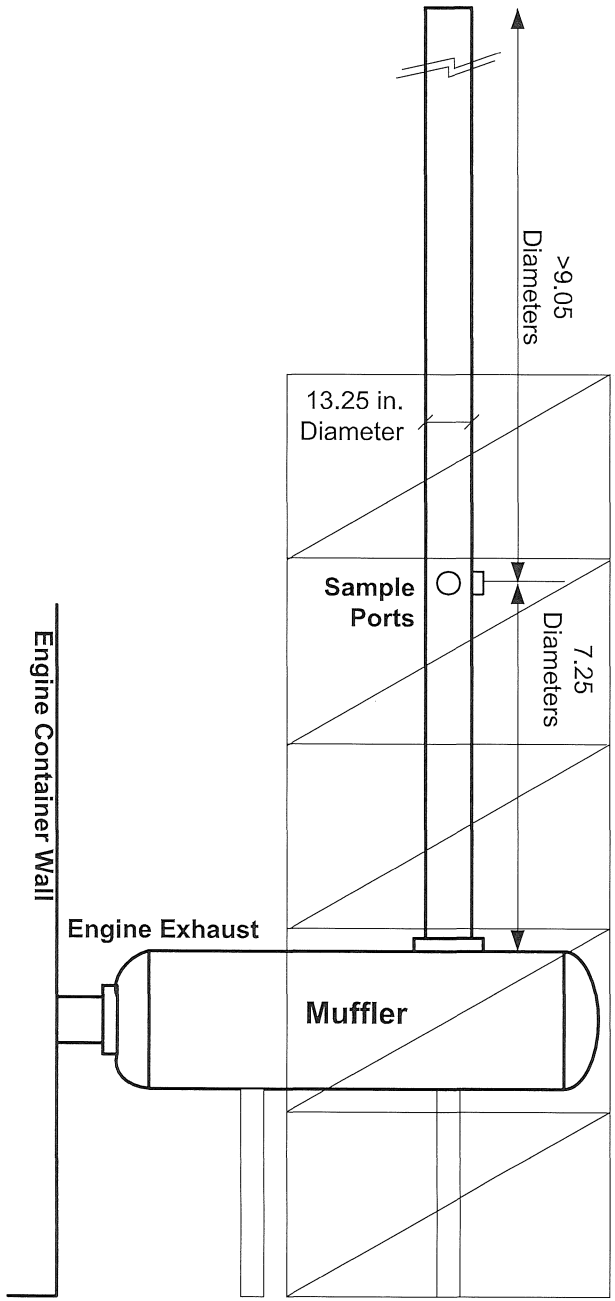
Table 6.1 Measured exhaust gas conditions and CH_2O air pollutant emission rates for Engine No. 3 (EUICEENGINE3)

Test No. Test date Test period (24-hr clock)	1 3/7/18 1232-1332	3 3/7/18 1500-1600	4 3/7/18 1619-1719	Three Test Average
Generator output (kW)	785	786	784	785
LFG methane content (%)	52.9	52.7	52.9	52.8
Exhaust Gas Composition				
CO_2 content (% vol)	12.4	12.3	12.4	12.4
O_2 content (% vol)	5.79	5.94	5.93	5.89
Moisture (% vol)	13.5	13.8	13.6	13.6
Exhaust gas temperature (°F)	688	688	685	687
Exhaust gas flowrate (scfm)	2,360	2,355	2,328	2,348
Formaldehyde				
CH_2O conc. (ppmv)	50.3	52.1	51.7	51.4
CH_2O emissions (lb/hr)	0.56	0.57	0.56	0.56
Permitted emissions (lb/hr)	-	-	-	0.75

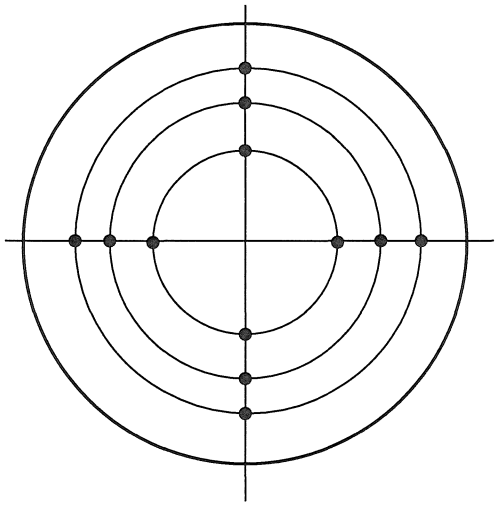
APPENDIX 1

- Figure 1 – IC Engine No. 3 Sample Port Diagram

Impact Compliance and Testing, Inc.



Exhaust Stack Cross-Section with Traverse Points



Velocity sample locations as measured from stack wall

Pt. #	% Dia.
1	0.58
2	1.93
3	3.92
4	9.33
5	11.32
6	12.66

12/18/19 ALR	**EDL Watervliet, LLC LFG Power Station Exhaust Sample Location, Engine No. 3**		
	Scale None	Sheet 1 of 1	ICT DWG No. EDL-Water-3