AIR EMISSION TEST REPORT FOR THE VERIFICATION OF AIR POLLUTANT EMISSIONS FROM LANDFILL GAS FIRED ENGINE – GENERATOR SET

Prepared for:

Energy Developments Pinconning, LLC at the Whitefeather Landfill SRN N5985

ICT Project No.: 2300112
May 4, 2023

IMPACT COMPLIANCE & TESTING

Report Certification

AIR EMISSION TEST REPORT

FOR THE
VERIFICATION OF AIR POLLUTANT EMISSIONS
FROM
LANDFILL GAS FIRED ENGINE – GENERATOR SET

Energy Developments Pinconning, LLC
at the Whitefeather Landfill
Pinconning, MI

The material and data in this document were prepared and reviewed under the supervision of the undersigned.

Report Prepared By:
Andy Rusnak, QSTI Technical Manager Impact Compliance & Testing, Inc.

Executive Summary

ENERGY DEVELOPMENTS PINCONNING, LLC
AT THE WHITEFEATHER LANDFILL
LFG FUELED IC ENGINE
EMISSION TEST RESULTS

Energy Developments Pinconning, LLC (EDP) contracted Impact Compliance & Testing, Inc. (ICT) to conduct a performance demonstration for the determination of formaldehyde (HCOH) concentration and emission rate from one (1) Caterpillar (CAT®) Model No. G3520C gas-fired reciprocating internal combustion engine and electricity generator set (RICE genset) identified as EUICEENGINE2 operated at the EDP facility located in Pinconning, Bay County, Michigan. The RICE is fueled with landfill gas (LFG) that is produced at the Whitefeather Landfill.

Compliance testing was performed with regards to conditions specified in the Michigan Department of Environment, Great Lakes, and Energy - Air Quality Division (EGLE-AQD) Renewable Operating Permit (ROP) No. MI-ROP-N5985-2019. The performance testing was conducted April 26, 2023.

The following table presents the CAT® G3520C emissions results from the performance demonstration.

Emission Unit	HCOH (ppmv)	Exhaust Flow (scfm)	HCOH (lb/hr)
EUICEENGINE2	73.1	5,104	1.75
Permit Limit	-	-	*2.10*

The following table presents the operating data recorded during the performance demonstration.

Emission Unit	Generator Output (kW)	Engine Output (bhp)	LFG Fuel Use (scfm)	Fuel CH_4 Content (%)
EUICEENGINE2	1,603	2,237	512	51.5

The data presented above indicates that EUICEENGINE2 was tested while the unit operated within 10% of maximum capacity and is in compliance with the emission standards specified in the ROP.

TABLE OF CONTENTS

List of Tables

List of Appendices

1.0 Introduction

Energy Developments Pinconning, LLC (EDP) operates RICE gensets at the EDP facility located at the Whitefeather Landfill in Pinconning, Bay County, Michigan. The EGLE-AQD has issued EDP ROP No. MI-ROP-N5985-2019 for operation of the RICE gensets.

Air emission compliance testing was performed pursuant to conditions specified in ROP No. MI-ROP-N5985-2019. The compliance emission testing was performed on EUICEENGINE2 (Engine No. 2), which is part of flexible group FGICENGINES. At least one (1) engine of FGICENGINES is required to test for HCOH every five (5) years (previous testing was conducted 3/1/2018). This test event satisfies the five (5) year ROP testing requirement.

The compliance testing presented in this report was performed by ICT, a Michigan-based environmental consulting and testing company. ICT representatives Tyler Wilson and Andy Rusnak performed the field sampling and measurements April 26, 2023.

The emission performance tests consisted of triplicate, one-hour sampling periods for HCOH on Engine No. 2. Exhaust gas velocity, moisture, oxygen (O_2) content, and carbon dioxide (CO_2) content were determined for each test period to calculate pollutant mass emission rates.

The exhaust gas sampling and analysis was performed using procedures specified in the Stack Test Protocol dated March 16, 2023, that was reviewed and approved by EGLE-AQD.

Questions regarding this air emission test report should be directed to:

Andy Rusnak, QSTI
Technical Manager
Impact Compliance & Testing, Inc.
4180 Keller Rd., Ste. B
Holt, MI 48842
(517) 481-3283
andy.rusnak@impactcandt.com

Ms. Courtney Truett
Compliance Specialist
Energy Developments
P.O. Box 15217
Lansing, MI 48901
(615) 290-4553
courtney.truett@EDPenergy.com

2.0 Summary of Test Results and Operating Conditions

2.1 Purpose and Objective of the Tests

Conditions of ROP No. MI-ROP-N5985-2019 require EDP to test at least one (1) engine of FGICENGINES for HCOH emissions every five (5) years.

2.2 Operating Conditions During the Compliance Tests

The testing was performed while the EDP engine/generator set was operated at maximum operating conditions. EDP representatives provided kW output in 15-minute increments for each test period.

LFG fuel flowrate (pounds per hour, lb/hr) and fuel methane content (%) were also recorded by EDP representatives in 15-minute increments for each test period.

Engine output (bhp) cannot be measured directly and was calculated based on the recorded electricity output, the calculated CAT® Model G3520C generator efficiency (96.1%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp).

Engine output (bhp) = Electricity output (kW) / (0.961) / (0.7457 kW/hp)

The facility records fuel use rate in units of lb/hr. To convert to units of standard cubic feet of gas consumed per minute (scfm) the following equation was used:

Fuel Use (scfm) = Fuel Use (pph) / LFG MW (lb/lb-mol) * 385 scf LFG/lb-mol / 60 min/hr

A LFG MW of 30 lb/lb-mol was used.

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

Average output, fuel consumption and fuel methane content are presented in Table 2.1.

2.3 Summary of Air Pollutant Sampling Results

The gases exhausted from Engine No. 2 were sampled for three (3) one-hour test periods during the compliance testing performed April 26, 2023.

Table 2.2 presents the average measured O_2, CO_2 and HCOH emission rates for each engine (average of the three test periods).

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

Table 2.1 Average engine operating conditions during the test periods

Engine Parameter	Engine No. 2
Generator output (kW)	1,603
Engine output (bhp)	2,237
Engine LFG fuel use (scfm)	512
LFG methane content (%)	51.5

Table 2.2 Measured CAT® G3520C air pollutant emission rates (three-test average)

Emission Unit	O_2 (%)	CO_2 (%)	HCOH (lb/hr)
EUICEENGINE2	8.73	10.9	1.75
Permit Limit	-	-	***2.10***

3.0 Source and Sampling Location Description

3.1 General Process Description

LFG containing methane is produced in the Whitefeather Landfill from the anaerobic decomposition of waste materials. The gas is collected and directed to the EDP facility where it is used as fuel for the RICE gensets that produce electricity.

The gas-to-energy facility primarily consists of gas treatment equipment and two (2) CAT® Model No. G3520C RICE that are each connected an electricity generator.

3.2 Rated Capacities and Air Emission Controls

The CAT® G3520C engine generator set has a rated design capacity of 1,600 kW.

The engine is equipped with an air-to-fuel ratio (AFR) controller that automatically blends the appropriate ratio of combustion air and treated LFG fuel.

The RICE is not equipped with add-on emission control devices. The AFR controller maintains efficient fuel combustion, which minimizes air pollutant emissions. Exhaust gas is exhausted directly to atmosphere through a noise muffler and vertical exhaust stack.

3.3 Sampling Locations

The RICE exhaust gas is directed through a muffler and is released to the atmosphere through a dedicated vertical exhaust stack with a vertical release point.

The exhaust stack sampling ports for Engine No. 2 is located in an individual exhaust duct (horizontal section of the stack before the noise muffler) with an inner diameter of 13.75 inches. The duct is equipped with two (2) sample ports, opposed 90°, that provide a sampling location >120 inches (>8.7 duct diameters) upstream and 120 inches (8.7 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 with actual stack dimension measurements.

4.0 Sampling and Analytical Procedures

A Stack Test Protocol for the air emission testing was reviewed and approved by EGLE-AQD. This section provides a summary of the sampling and analytical procedures that were used during the 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 and CO_2 content was determined using paramagnetic and infrared instrumental analyzers, respectively.
ASTM D6348	Exhaust gas HCOH and moisture content were measured using a Fourier transform infrared spectroscopy (FTIR) instrumental analyzer.

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 once during each test period. 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 periodically throughout the test periods to verify the integrity of the measurement system.

The absence of significant cyclonic flow for each sampling location 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 Molecular Weight Determination (USEPA Method 3A)

CO_2 and O_2 content in the RICE exhaust gas stream were measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a M&C GenTwo infrared gas analyzer. The O_2 content of the exhaust was monitored using a M&C GenTwo gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the RICE 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 and CO_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 and CO_2 calculation sheets. Raw instrument response data are provided in Appendix 5.

4.4 Measurement of HCOH and Moisture Content via FTIR (ASTM D6348)

HCOH concentration and moisture content in the RICE exhaust gas stream were determined using an MKS Multi-Gas 2030 Fourier transform infrared (FTIR) spectrometer in accordance with test method ASTM D6348.

The USEPA New Source Performance Standard (NSPS) for landfill gas fired engines (Subpart JJJJ) specifies ASTM D6348 as an acceptable test method for moisture concentration determinations. Additionally, the USEPA National Emissions Standard for Hazardous Air Pollutants (NESHAP) for landfill gas fired engines (Subpart ZZZZ) specifies ASTM D6348 as an acceptable test method for moisture and formaldehyde concentration determinations.

Samples of the exhaust gas were delivered directly to the instrumental analyzer using a Teflon® heated sample line to prevent condensation. The sample to the FTIR analyzer was not conditioned to remove moisture. Therefore, 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 MG2000 data acquisition software.

Appendix 4 provides HCOH calculation sheets. Moisture content data is provided in the flowrate calculations presented in Appendix 3. Raw instrument response data for the FTIR analyzer is provided in Appendix 6.

5.0 QA/QC Activities

5.1 Flow Measurement Equipment

Prior to arriving onsite (or onsite prior to beginning compliance testing), the instruments used during the source test to measure exhaust gas properties and velocity (barometer and Pitot tube) were calibrated to specifications in the sampling methods.

5.2 Gas Divider Certification (USEPA Method 205)

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The ten-step STEC gas divider was NIST certified (within the last 12 months) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivered calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

5.3 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure O_2, and CO_2 have had an interference response test preformed prior to their use in the field, 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 each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 2.5% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

5.4 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 CO_2, and O_2 analyzers by injecting calibration gas directly into the inlet sample port for each 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 instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2 and O_2, in nitrogen and zeroed using hydrocarbon free nitrogen. A STEC Model SGD-710C ten-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

5.5 Determination of Exhaust Gas Stratification

A stratification test was performed for each RICE exhaust stack. The stainless-steel sample probe was positioned at sample points correlating to 16.7, 50.0 (centroid), and 83.3% of the stack diameter. Pollutant concentration data were recorded at each sample point for a minimum of twice the maximum system response time.

The recorded concentration data for the RICE exhaust stacks indicated that the measured O_2 and CO_2 concentrations did not vary by more than 5% of the mean across each stack diameter. Therefore, the RICE exhaust gas was considered to be unstratified and the compliance test sampling was performed at a single sampling location within the RICE exhaust stack.

5.6 System Response Time

The response time of the sampling system was determined prior to the compliance test program by introducing upscale gas and zero gas, in series, into the sampling system using a tee connection at the base of the sample probe. The elapsed time for the analyzer to display a reading of 95% of the expected concentration was determined using a stopwatch.

Sampling periods did not commence until the sampling probe had been in place for at least twice the greatest system response time.

5.7 FTIR QA/QC Activities

At the beginning of each day a calibration transfer standard (CTS, ethylene gas), analyte of interest (acetaldehyde and sulfur hexafluoride) and nitrogen calibration gas was 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 was free of contaminants.

Analyte spiking, of each emission unit, 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 assure the ability of the FTIR to quantify that compound in the presence of effluent 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 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 and gas divider certifications, interference test results, FTIR QA/QC data, stratification checks, and field equipment calibration records).

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.

Engine No. 2 has the following allowable emission limits specified in ROP No. MI-ROP-N5985-2019:

Emission Unit ID	HCOH Limits
EUICEENGINE2	2.10 lb/hr

The results of the Engine No. 2 performance testing demonstrate compliance with the emission limits specified in ROP No. MI-ROP-N5985-2019.

6.2 Variations from Normal Sampling Procedures or Operating Conditions

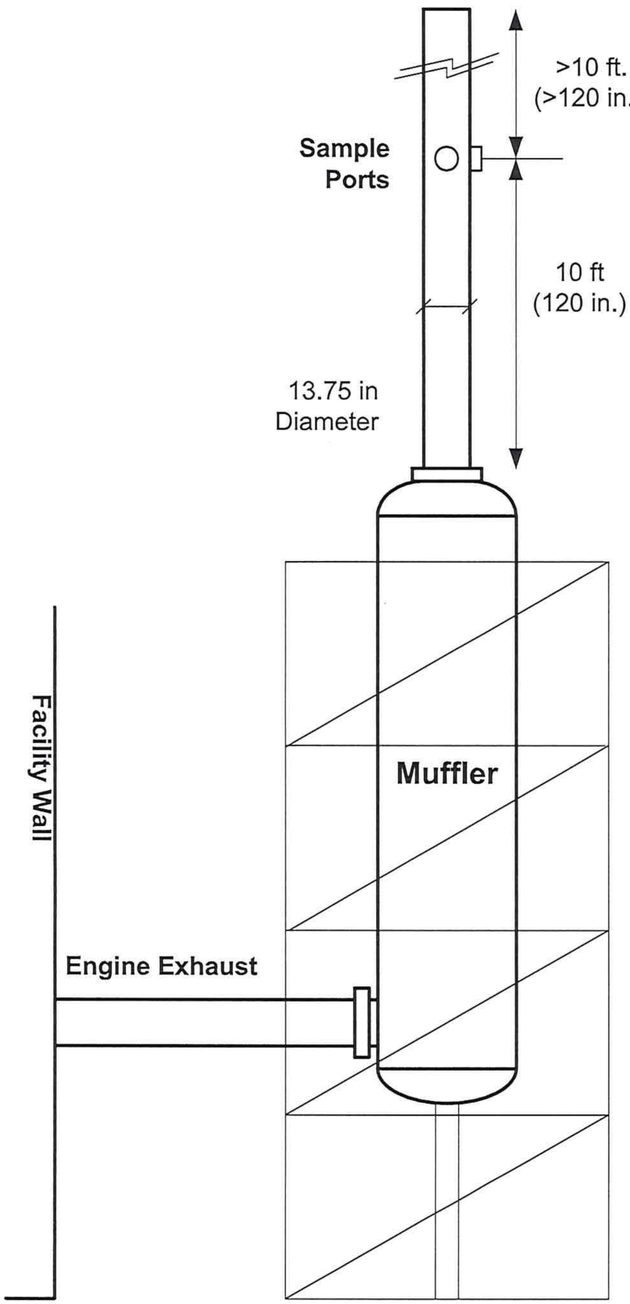
The testing for all pollutants was performed in accordance with USEPA methods and the approved Stack Test Protocol. The RICE-generator sets were operated within 10% of maximum output and no variations from normal operating conditions occurred during the engine test periods.

Table 6.1 Measured exhaust gas conditions and HCOH air pollutant emission rates for Engine No. 2 (EUICEENGINE2)

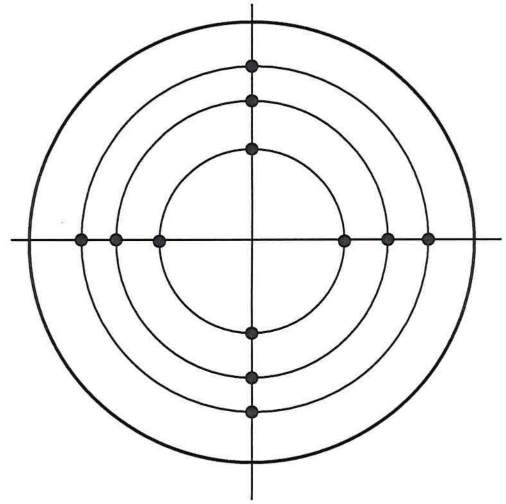
Test No. Test date Test period (24-hr clock)	1 4/26/2023 750-850	2 4/26/2023 905-1005	3 4/26/2023 1019-1119	Three Test Average
Generator output (kW)	1,606	1,600	1,604	1,603
Engine output (bhp)	2,241	2,233	2,238	2,237
LFG flowrate (lb/hr)	2,410	2,393	2,381	2,395
LFG flowrate (scfm)	516	512	509	512
LFG methane content (%)	51.0	51.5	52.0	51.5
<u>Exhaust Gas Composition</u>				
CO_2 content (% vol)	10.9	10.9	10.9	10.9
O_2 content (% vol)	8.68	8.74	8.76	8.73
Moisture (% vol)	11.5	11.5	11.6	11.5
Exhaust gas temperature (^oF)	774	772	774	773
Exhaust gas flowrate (scfm)	5,153	5,111	5,049	5,104
<u>Formaldehyde</u>				
HCOH conc. (ppmv)	72.1	73.2	74.0	73.1
HCOH emissions (lb/hr)	1.74	1.75	1.75	1.75
Permit limit (lb/hr)	-	-	-	*2.10*

APPENDIX 1

- RICE Engine Sample Port Diagram



Exhaust Stack Cross-Section with Traverse Points



Velocity sample locations as measured from stack wall

Pt. #	in.
1	0.61
2	2.01
3	4.07
4	9.68
5	11.74
6	13.15

4/10/15 TJW 4/27/23 ALR	**Energy Developments Pinconning, LLC** **Exhaust Sample Location, CAT® G3520C ICE**		
	Scale None	Sheet 1 of 1	ICT Dwg. No.: EDP-ENG