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

Prepared for:

ENERGY DEVELOPMENTS Waterviiet, LLC SRN N5719

ICT Project No.: 2200009
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IMPACT COMPLIANCE & TESTING

Report Certification

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

Energy Developments Watervliet, LLC
Watervliet, Michigan

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

Impact Compliance and Testing, Inc.

Max Fierro
Environmental Consultant

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1.0 Introduction

Energy Developments Watervliet, LLC (EDL) owns and operates landfill gas (LFG) fueled reciprocating internal combustion engine and electricity generator sets (RICE gensets) at the Orchard Hill Stationary Landfill in Watervliet, Berrien County, Michigan. The RICE are fueled by LFG that is recovered from the landfill and treated prior to use.

The State of Michigan Department of Environment, Great Lakes and Energy – Air Quality Division (EGLE-AQD) has issued to EDL a Renewable Operating Permit (MI-ROP-N5719-2016a*) and Permit to Install (PTI) 36-22 for operation of the renewable electricity generation facility, which consists of:

- Two (2) Caterpillar (CAT®) Model No. G3520C RICE gensets identified as emission units EUICEENGINE1 and EUICEENGINE2 (Flexible Group ID: FGICEENGINES)
- One (1) Caterpillar (CAT®) Model No. G3516LE RICE genset identified as emission unit EUICEENGINE3

Air emission compliance testing was performed pursuant to PTI 36-22 which states: *Within 180 days after permit issuance, the permittee shall verify the SO2 emission rate from EUICEENGINE3-S2 by testing at the owner's expense, in accordance with Department requirements.*

The compliance testing presented in this report was performed by Impact Compliance & Testing, Inc. (ICT), a Michigan-based environmental consulting and testing company. ICT representatives Max Fierro and Clay Gaffey performed the field sampling and measurements September 7, 2022.

The engine emission performance tests consisted of triplicate, one-hour sampling periods for sulfur dioxide (SO_2). Exhaust gas velocity, moisture, oxygen (O_2) content, and carbon dioxide (CO_2) content were determined for each test period to calculate volumetric exhaust gas flowrate and pollutant mass emission rates.

The exhaust gas sampling and analysis was performed using procedures specified in the Stack Test Protocol dated June 14, 2022, that was reviewed and approved by EGLE-AQD.

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

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Note: Operating Permit No. MI-ROP-N5719-2016a expired December 22, 2021. A renewal application was submitted to EGLE-AQD June 17, 2021.

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2.0 Summary of Test Results and Operating Conditions

2.1 Purpose and Objective of the Tests

Conditions of PTI 36-22 require EDL to test EUICEENGINE3-S2 for SO_2 emissions within 180 days of permit issuance. Engine No. 3 (Emission Units EUICEENGINE3-S2) was tested during this compliance test event within the 180-day requirement.

2.2 Operating Conditions During the Compliance Tests

The testing was performed while the EDL engine/generator sets were operated at maximum operating conditions (within 10% of 800-kilowatt (kW) electricity output). EDL representatives monitored and recorded generated power output (kW), fuel use (scfm), fuel methane content (%), and inlet fuel pressure (psi) at 15-minute increments for each test period.

Appendix 2 provides operating records provided by EDL representatives for the test periods, including Dräger Tube readings.

Table 2.1 presents a summary of the average engine operating conditions during the test periods.

Average output, fuel consumption, fuel methane content, and air-to-fuel ratio for each RICE are presented in Table 2.1 and Table 6.1.

2.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled LFG fueled RICE (Engine No. 3 / EUICEENGINE3-S2) were sampled for three (3) one-hour test periods during the compliance testing performed September 7, 2022.

Table 2.2 presents the average measured SO_2 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	EUICEENGINE3-S2 CAT® G3516LE
Generator output (kW)	787
Engine LFG fuel use (scfm)	300
LFG methane content (%)	45.8
Exhaust temperature (°F)	692
Fuel inlet pressure (psi)	6

Table 2.2 Average measured emission rates for each engine (three-test average)

	SO_2
Emission Unit	**(lb/hr)**
EUICEENGINE1-S2	5.86
Permit Limit	***8.9***

3.0 Source and Sampling Location Description

3.1 General Process Description

EDL is permitted to operate three (3) RICE-generator sets at its facility; two (2) CAT® Model No. G3520C RICE and one (1) CAT® Model No. G3516 RICE. The units are fired exclusively with LFG that is recovered from the Orchard Hill Sanitary Landfill solid waste disposal facility and treated prior to use.

3.2 Rated Capacities and Air Emission Controls

The CAT® G3516LE engine generator set has a rated design capacity of:

- Engine Power: 1,148 brake horsepower (bhp)
- Electricity Generation: 800 kW

The engine is equipped with an air-to-fuel ratio (AFR) controller that 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 are located after the muffler in the vertical exhaust stacks, with an inner diameter of 13.75 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location at least 0.5 duct diameters upstream and at least 2.0 duct diameters downstream from any flow disturbance.

All sample port locations satisfy the USEPA Method 1 criteria for a representative sample location. Individual traverse points were determined in accordance with USEPA Method 1.

Appendix 1 provides a diagram 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 the 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 were determined using paramagnetic and infrared instrumental analyzers, respectively.
USEPA Method 4	Exhaust gas moisture was determined based on the water weight gain in chilled impingers.
USEPA Method 6C	Exhaust gas SO_2 concentration was determined using a pulsed ultraviolet florescence instrumental analyzer.

Dräger Tube hydrogen sulfide sampling was performed on the landfill gas that fuels the engine once during the testing. H_2S content was determined to be 1750 ppm. Attachment 2 includes photo of Dräger Tube.

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 at the 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 was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a Servomex infrared gas analyzer. The O_2 content of the exhaust was monitored using a Servomex 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 Exhaust Gas Moisture Determination (USEPA Method 4)

Moisture content of the RICE exhaust gas was determined in accordance with USEPA Method 4 using a chilled impinger sampling train. Exhaust gas moisture content measurements were performed concurrently with the instrumental analyzer sampling periods. At the conclusion of each sampling period the moisture gain in the impingers was determined gravimetrically by weighing each impinger to determine net weight gain.

Appendix 3 provides moisture calculations and data sheets.

4.5 SO_2 Concentration Measurements (USEPA Method 6C)

The RICE exhaust gas SO_2 concentration measurements were performed using a Thermo Environmental Instruments, Inc. (TEI) Model 43i that uses pulsed ultraviolet fluorescence technology in accordance with USEPA Method 6C for the measurement of SO_2 concentration.

Appendix 4 provides SO_2 calculation sheets. Raw instrument response data are provided in Appendix 5.

5.0 QA/QC Activities

5.1 Flow Measurement Equipment

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

The absence of cyclonic flow for each sampling location was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each of the velocity traverse points 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).

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 SO_2, 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 SO_2,, 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. The SO_2 instrument was calibrated with USEPA Protocol 1 certified concentrations of SO_2 in air and zeroed using hydrocarbon-free air. 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 stack indicated that the measured O_2 and CO_2 concentrations did not vary by more than 5% of the mean across the 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 Meter Box Calibrations

The dry gas meter sampling console used for moisture testing was calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5. The metering console calibration exhibited no data outside the acceptable ranges presented in USEPA Method 5.

The digital pyrometer in the metering console was calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

Appendix 6 presents test equipment quality assurance data (NO_2 – NO conversion efficiency test data, instrument calibration and system bias check records, calibration gas certifications, interference test results, meter box calibration records, 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.

EUICEENGINE3-S2 has the following allowable emission limits specified for the engine in PTI 36-22:

- 8.9 lb/hr for SO_2

The measured air pollutant concentrations and emission rates for EUICEENGINE3-S2 are less than the allowable limits specified in PTI 36-22.

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 gensets were operated within 10% of maximum output (800 kW generator output for CAT® G3516LE RICE).

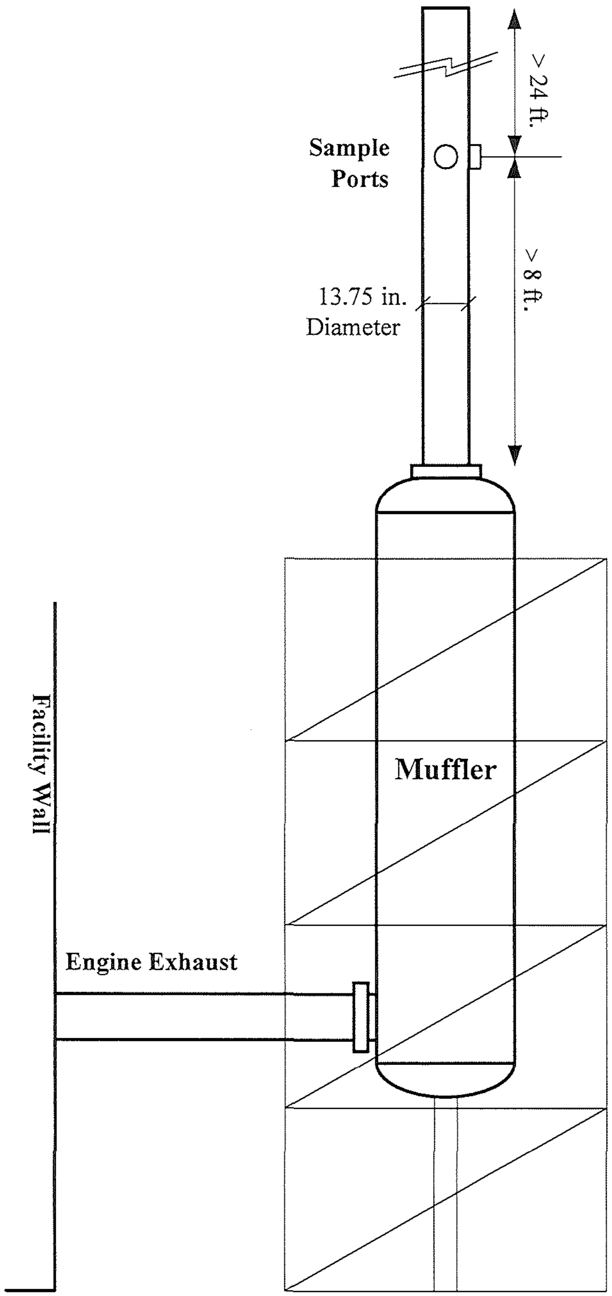
There were no variations from normal sampling procedures for any other pollutant or test periods.

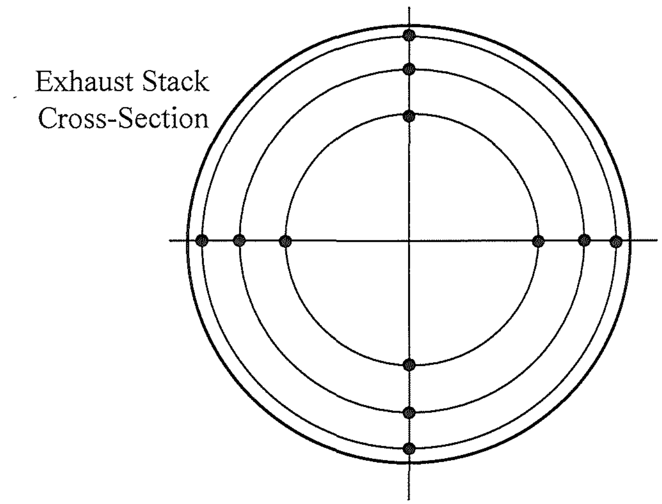
Table 6.1 Measured exhaust gas conditions and air pollutant emission rates for Engine No. 3 (EUICEENGINE3-S2)

Test No. Test date Test period (24-hr clock)	1 09/07/2022 0829-0929	2 09/07/2022 0959-1059	3 09/07/2022 1123-1223	Three Test Average
Fuel flowrate (scfm)	301	300	300	300
Generator output (kW)	779	787	796	787
LFG methane content (%)	45.7	45.8	45.8	45.8
Fuel inlet pressure (psi)	6	6	6	6
Exhaust Gas Composition				
CO_2 content (% vol)	11.3	11.4	11.5	11.4
O_2 content (% vol)	8.57	8.44	8.29	8.43
Moisture (% vol)	12.4	12.2	12.0	12.2
Exhaust gas temperature (°F)	698	694	684	762
Exhaust gas flowrate (dscfm)	2,667	2,668	2,667	2,667
Exhaust gas flowrate (scfm)	3,045	3,038	3,032	3,038
Sulfur Dioxide				
SO_2 conc. (ppmv)	225	219	216	220
SO_2 emissions (lb/hr)	5.99	5.84	5.76	5.86

APPENDIX 1

- RICE Engine Sample Port Diagram





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	13.14

09/14/22

EDL - Watervliet
Sampling Location - CAT 3516 Engine

Scale
None

Sheet
1 of 1

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