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

Prepared for:

Sumpter Energy Associates, LLC
SRN N5984

Test Date: December 6, 2023

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IMPACT
COMPLIANCE & TESTING

Report Certification

AIR EMISSION TEST REPORT
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FROM
LANDFILL GAS FIRED ENGINE – GENERATOR SETS

Sumpter Energy Associates, LLC
at the Pine Tree Acres Landfill
Lenox Township, MI

Report Certification

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

Impact Compliance & Testing, Inc.

Tyler J. Wilson
Senior Project Manager

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1.0 Introduction

Sumpter Energy Associates, LLC (SEA) operates landfill gas (LFG)-fired reciprocating internal combustion engine (RICE) and electricity generator sets (gensets) at the Pine Tree Acres (PTA) Landfill in Lenox Township, Macomb County, Michigan. The RICE are fueled by LFG that is recovered from the PTA 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 SEA a Renewable Operating Permit (MI-ROP-N5984-2019) for operation of the SEA-PTA Phase II renewable electricity generation facility, which consists of:

- Two (2) Caterpillar (CAT®) Model No. G3520C RICE gensets identified as emission units EU-ICENGINE8 and EU-ICENGINE9 (Flexible Group ID FG-ICENGINE2).

Air emission compliance testing was performed pursuant to MI-ROP-N5984-2019. Conditions of MI-ROP-N5984-2019 for FG-ICENGINE2 state:

> *Except as provided in 40 CFR 60.4243(b), the permittee shall conduct an initial performance test for each engine in FG-ICENGINE2 within one year after startup of the engine and every 8760 hours of operation (as determined through the use of a non-resettable hour meter) or three years, whichever occurs first, to demonstrate compliance with the emission limits in 40 CFR 60.4233(e)…*

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 Tyler Wilson, Renee Fromwiller, and Andrew Eisenberg performed the field sampling and measurements on December 6, 2023.

The engine emission performance tests consisted of triplicate, one-hour sampling periods for nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOC, as non-methane hydrocarbons (NMHC or NMOC)). 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 September 21, 2023, that was reviewed and approved by EGLE-AQD. Mr. Robert Joseph of EGLE-AQD observed portions of the compliance testing.

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

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2.0 Summary of Test Results and Operating Conditions

2.1 Purpose and Objective of the Tests

Conditions of MI-ROP-N5984-2019 and 40 CFR Part 60, Subpart JJJJ, Standards of Performance for New Stationary Sources for Stationary Spark Ignition Internal Combustion Engines require SEA to test each engine in FG-ICENGINE2 for CO, NOx, and VOC emissions. Engine Nos. 8 and 9 (EU-ICENGINE8 and EU-ICENGINE9, respectively) were tested during this compliance test event.

2.2 Operating Conditions During the Compliance Tests

The testing was performed while the SEA engine/generator sets were operated at maximum operating conditions (within 10% of 1,600-kilowatt (kW) electricity output). SEA representatives provided kW output in 15-minute increments for each test period.

Fuel flowrate (standard cubic feet per minute (scfm)), fuel methane (CH_4) content (%), and air-to-fuel ratio were also recorded by SEA representatives in 15-minute increments for each test period. In addition, SEA representatives monitored LFG hydrogen sulfide (H_2S) content once per RICE (during Test No. 2 for each RICE) using Draeger® tubes.

Appendix 2 provides operating records provided by SEA representatives for the test periods and photos of the H_2S Draeger® tubes.

Average generator output (kW), fuel consumption, fuel methane content, and air-to-fuel ratio for each RICE is presented in Table 2.1 and Tables 6.1-6.2.

2.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled LFG fueled RICE (Engine Nos. 8 and 9 / EU-ICENGINE8 and EU-ICENGINE9) were each sampled for three (3) one-hour test periods during the compliance testing performed December 6, 2023.

Table 2.2 presents the average measured CO, NO_X, and VOC 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

Emission Unit	Generator Output (kW)	LFG Fuel Use (scfm)	LFG CH_4 Content (%)	Air / Fuel Ratio
Engine No. 8	1,550	593	52.5	8.2
Engine No. 9	1,532	558	50.9	7.2

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

Emission Unit	CO		NOx		VOC	
	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)
Engine No. 8	15.6	3.26	1.17	0.25	0.86	0.18
Engine No. 9	13.7	2.89	1.46	0.31	0.64	0.14
Permit Limit	***16.3***	***3.3***	***3.0***	***0.6***	***1.0[1]***	***1.0***

1. 1.0 lb/hr VOC limit is only for EU-ICENGINE8 (is not specified in ROP No. MI-ROP-N5984-2019 for EU-ICENGINE9).

3.0 Source and Sampling Location Description

3.1 General Process Description

SEA is permitted to operate two (2) RICE-generator sets (CAT® Model No. G3520C) at its SEA-PTA Phase II facility. The units are fired exclusively with LFG that is recovered from the PTA Landfill and treated prior to use.

Table 3.1 Engine Identification

Emission Unit	ROP Identification	Serial Number
Engine No. 8	EU-ICENGINE8	GZJ00189
Engine No. 9	EU-ICENGINE9	GZJ00609

3.2 Rated Capacities and Air Emission Controls

The CAT® G3520C engine generator sets each have a rated design capacity of:

- Engine Power: 2,233 brake horsepower (bhp)
- Electricity Generation: 1,600 kW

Each 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 are 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 for each engine.

3.3 Sampling Locations

Each 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 stacks for Engine Nos. 8 and 9 / EU-ICENGINE8 and EU-ICENGINE9 are identical. The exhaust stack sampling ports are located in individual vertical exhaust ducts, located before each engine muffler, with an inner diameter of 15.0 inches. Each 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 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 4	Exhaust gas moisture was determined based on the water weight gain in chilled impingers.
USEPA Method 3A	Exhaust gas O_2 and CO_2 content was determined using paramagnetic and infrared instrumental analyzers, respectively.
USEPA Method 7E	Exhaust gas NOx concentration was determined using chemiluminescence instrumental analyzers.
USEPA Method 10	Exhaust gas CO concentration was measured using an infrared instrumental analyzer.
USEPA Method 25A / ALT-096	Exhaust gas VOC (as NMHC) concentration was determined using a flame ionization analyzer equipped with methane separation column.

ionization detector in accordance with USEPA Method 25A.

The USEPA Office of Air Quality Planning and Standards (OAQPS) has issued an alternate test method approving the use of the TEI 55i-series analyzer as an effective instrument for measuring NMOC from gas-fueled RICE (ALT-096).

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

Prior to, and at the conclusion of each test, the instrument was calibrated using mid-range calibration (propane) and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document).

Appendix 4 provides VOC calculation sheets. Raw instrument response data for the NMHC analyzer is provided in Appendix 5.

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 1440D infrared gas analyzer. 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 RICE exhaust gas stream was extracted from the stack using a stainless-steel probe connected to a Teflon® heated

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 and 6.2.

Engine Nos. 8 and 9 / EU-ICENGINE8 and EU-ICENGINE9 each have the following allowable emission limits specified in MI-ROP-N5984-2019:

- 16.3 pounds per hour (lb/hr) and 3.3 grams per brake horsepower hour (g/bhp-hr) for CO;
- 3.0 lb/hr and 0.6 g/bhp-hr for NOx; and
- 1.0 lb/hr and 1.0 g/bhp-hr for VOC.
    - 1.0 lb/hr VOC limit is only for EU-ICENGINE8 (is not specified in ROP No. MI-ROP-N5984-2019 for EU-ICENGINE9).

The measured air pollutant concentrations and emission rates for Engine Nos. 8 and 9 / EU-ICENGINE8 and EU-ICENGINE9 are less than the allowable limits specified in MI-ROP-N5984-2019 and 40 CFR Part 60, Subpart JJJJ, Standards of Performance for New Stationary Sources for Stationary Spark Ignition Internal Combustion Engines.

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 engine-generator sets were operated within 10% of maximum output (1,600 kW generator output for CAT® G3520C RICE) during the engine test periods.

Test No. 3 for Engine No. 8 / EU-ICENGINE8 was paused for 11-minutes, due to the RICE genset unexpectedly shutting down. The Engine No. 8 / EU-ICENGINE8 bypass got stuck, causing the RICE genset to shut down. SEA representatives restarted the RICE genset and testing resumed once the RICE genset achieved maximum output (within 10% of 1,600-kW electricity output), and once the air pollutant sampling probe had been in the exhaust stack for at least twice the greatest system response time. Testing continued until at least 60-minutes of air pollutant concentration data was logged.

Table 6.1 Measured exhaust gas conditions and air pollutant emission rates for Engine No. 8 (EU-ICENGINE8)

Test No. Test date Test period (24-hr clock)	1 12/6/2023 1230-1330	2 12/6/2023 1355-1455	3 12/6/2023 1517-1545; 1557-1627	Three Test Average
Fuel flowrate (scfm)	593	593	592	593
Generator output (kW)	1,549	1,546	1,556	1,550
Engine output (bhp)	2,171	2,166	2,180	2,172
LFG methane content (%)	52.3	52.8	52.5	52.5
Air-to-fuel ratio	8.2	8.2	8.1	8.2
Exhaust Gas Composition				
CO_2 content (% vol)	11.6	11.6	11.7	11.7
O_2 content (% vol)	8.81	8.79	8.77	8.79
Moisture (% vol)	10.4	9.4	7.7	9.2
Exhaust gas temperature (°F)	910	909	910	910
Exhaust gas flowrate (dscfm)	4,489	4,689	4,694	4,624
Exhaust gas flowrate (scfm)	5,013	5,173	5,087	5,091
Nitrogen Oxides				
NO_X conc. (ppmvd)	34.8	35.7	35.8	35.4
NO_X emissions (lb/hr)	1.12	1.20	1.20	1.17
NO_X permit limit (lb/hr)	-	-	-	*3.0*
NO_X emissions (g/bhp-hr)	0.23	0.25	0.25	0.25
NO_X permit limit (g/bhp-hr)	-	-	-	*0.6*
Carbon Monoxide				
CO conc. (ppmvd)	765	782	771	773
CO emissions (lb/hr)	15.0	16.0	15.8	15.6
CO permit limit (lb/hr)	-	-	-	*16.3*
CO emissions (g/bhp-hr)	3.13	3.35	3.29	3.26
CO permit limit (g/bhp-hr)	-	-	-	*3.3*
Volatile Organic Compounds				
NMHC conc. (ppmv)	24.5	24.2	25.0	24.6
NMHC emissions (lb/hr)	0.85	0.86	0.87	0.86
NMHC permit limit (lb/hr)	-	-	-	*1.0*
NMHC emissions (g/bhp-hr)	0.18	0.18	0.18	0.18
NMHC permit limit (g/bhp-hr)	-	-	-	*1.0*

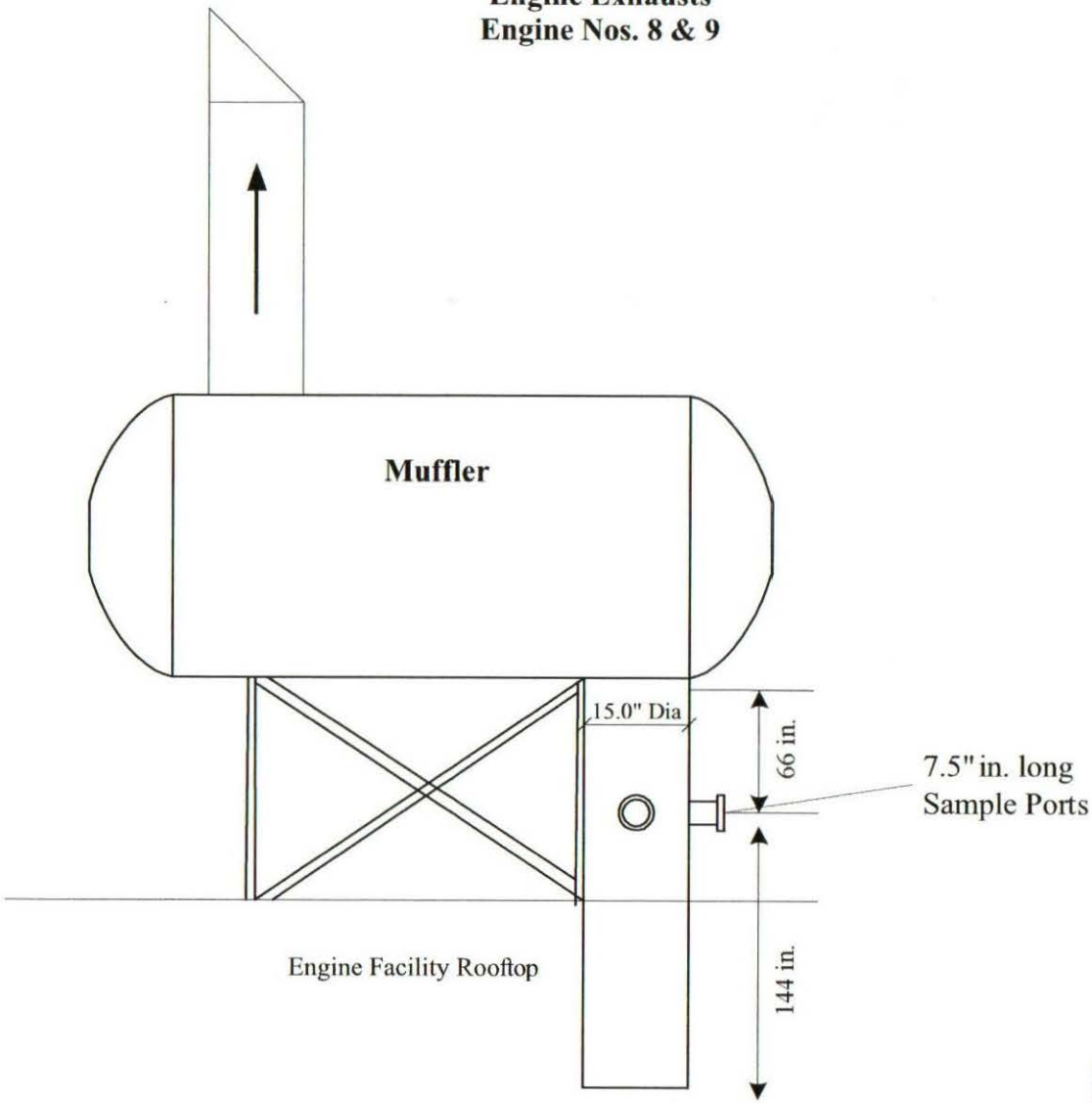
Table 6.2 Measured exhaust gas conditions and air pollutant emission rates for Engine No. 9 (EU-ICENGINE9)

Test No. Test date Test period (24-hr clock)	1 12/6/2023 755-855	2 12/6/2023 935-1035	3 12/6/2023 1101-1201	Three Test Average
Fuel flowrate (scfm)	558	561	553	558
Generator output (kW)	1,532	1,529	1,535	1,532
Engine output (bhp)	2,146	2,142	2,151	2,147
LFG methane content (%)	50.8	50.8	51.1	50.9
Air-to-fuel ratio	7.2	7.2	7.2	7.2
Exhaust Gas Composition				
CO_2 content (% vol)	11.9	11.8	11.8	11.8
O_2 content (% vol)	8.54	8.56	8.57	8.56
Moisture (% vol)	11.7	12.1	11.6	11.8
Exhaust gas temperature (°F)	932	935	928	932
Exhaust gas flowrate (dscfm)	4,187	4,087	4,316	4,197
Exhaust gas flowrate (scfm)	4,743	4,651	4,884	4,760
Nitrogen Oxides				
NO_X conc. (ppmvd)	48.0	48.2	48.9	48.4
NO_X emissions (lb/hr)	1.44	1.41	1.51	1.46
NO_X permit limit (lb/hr)	-	-	-	*3.0*
NO_X emissions (g/bhp-hr)	0.30	0.30	0.32	0.31
NO_X permit limit (g/bhp-hr)	-	-	-	*0.6*
Carbon Monoxide				
CO conc. (ppmvd)	749	744	747	746
CO emissions (lb/hr)	13.7	13.3	14.1	13.7
CO permit limit (lb/hr)	-	-	-	*16.3*
CO emissions (g/bhp-hr)	2.89	2.81	2.97	2.89
CO permit limit (g/bhp-hr)	-	-	-	*3.3*
Volatile Organic Compounds				
NMHC conc. (ppmv)	19.3	19.5	20.1	19.6
NMHC emissions (lb/hr)	0.63	0.62	0.67	0.64
NMHC emissions (g/bhp-hr)	0.13	0.13	0.14	0.14
NMHC permit limit (g/bhp-hr)	-	-	-	*1.0*

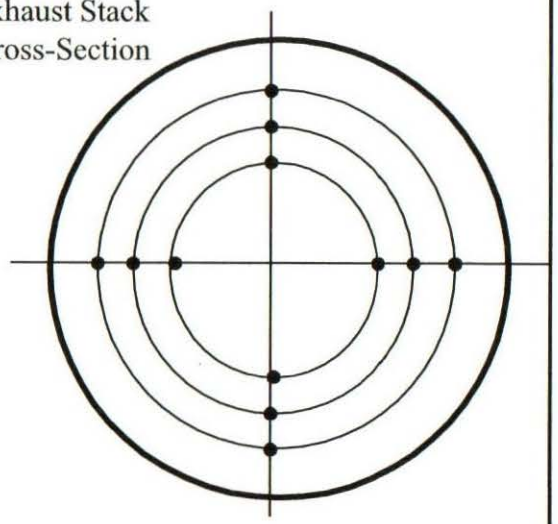
APPENDIX 1

- RICE Engine Sample Port Diagram

SEA-PTA Phase II
Engine Exhausts
Engine Nos. 8 & 9



Exhaust Stack
Cross-Section



Velocity Sample Location as Measured from Stack Wall

Sample Port	
Pt. #	in.
1	0.66
2	2.19
3	4.44
4	10.56
5	12.81
6	14.34

SEA-PTA Phase II Facility
Engine Exhaust Sample Locations

Scale	Sheet
None	1 of 1

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Appendix 2

- Facility Operating Records and Draeger® Tube Photos