Engine Test Report

Energy Developments, Inc.
Orchard Hill Sanitary Landfill
3290 Hennesey Road
Watervliet, Berrien County, Michigan

Sources Tested: Two (2) Landfill Gas Fueled
RICE-Generator Sets
(EUICEENGINE1-S2 & EUICEENGINE2-S2)
Test Date: February 6, 2019

AST Project No. 2019-0347

Prepared By
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Hiawatha, IA 52233

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Alliance SOURCE TESTING

TEST REPORT SUMMARY

Client Information / Test Location

Energy Developments, Inc.
Orchard Hill Sanitary Landfill
3290 Hennesey Road
Watervliet, Berrien County, Michigan

Source Information

Engine/Unit ID:	EUICEENGINE1-S2
Engine Make/Model:	Caterpillar/G3520C
Engine Serial Number:	GZJ00541
Engine Type:	Spark Ignition - 4SLB
Engine Date of Manufacture:	2011
Engine Rating:	2,263 hp / 1,600 kW

Regulatory Applicability
40 CFR 60, Subpart JJJJ
ROP Permit No. MI-ROP-N5719-2016, SRN – N5719

AST Project No.
2019-0347

Run No.	Run 1	Run 2	Run 3	Average
Date	2/6/19	2/6/19	2/6/19	--
Engine Load, % *	97	97	97	97
Nitrogen Oxides Data				
Concentration, ppmvd @ 15% O_2	26.9	26.4	26.0	26.4
NSPS JJJJ Limit, ppmvd @ 15% O_2	--	--	--	150
Percent of Limit, %	--	--	--	**18**
Emission Factor, g/hp-hr	0.38	0.38	0.36	0.37
Permit Limit, g/hp-hr	--	--	--	1.0
Percent of Limit, %	--	--	--	**37**
Emission Rate, lb/hr	1.8	1.8	1.7	1.8
Permit Limit, lb/hr	--	--	--	4.94
Percent of Limit, %	--	--	--	**37**
Carbon Monoxide Data				
Concentration, ppmvd @ 15% O_2	362.6	369.2	372.1	367.9
NSPS JJJJ Limit, ppmvd @ 15% O_2	--	--	--	610
Percent of Limit, %	--	--	--	**60**
Emission Factor, g/hp-hr	3.1	3.2	3.1	3.2
Permit Limit, g/hp-hr	--	--	--	3.5
Percent of Limit, %	--	--	--	**91**
Emission Rate, lb/hr	15.1	15.7	15.2	15.3
Permit Limit, lb/hr	--	--	--	17.3
Percent of Limit, %	--	--	--	**89**
Non- Methane HC Data				
Concentration, ppmvd @ 15% O_2	15.3	18.2	16.5	16.7
NSPS JJJJ Limit, ppmvd @ 15% O_2	--	--	--	80
Percent of Limit, %	--	--	--	**21**
Emission Factor, g/hp-hr	0.21	0.25	0.22	0.23
Permit Limit, g/hp-hr	--	--	--	1.0
Percent of Limit, %	--	--	--	**23**

* Performance testing was conducted while the engine was operating at the highest achievable load at current site conditions.

Alliance SOURCE TESTING

TEST REPORT SUMMARY

Client Information / Test Location

Energy Developments, Inc.
Orchard Hill Sanitary Landfill
3290 Hennesey Road
Watervliet, Berrien County, Michigan

Source Information

Engine/Unit ID:	EUICEENGINE2-S2
Engine Make/Model:	Caterpillar/G3520C
Engine Serial Number:	GZJ00540
Engine Type:	Spark Ignition - 4SLB
Engine Date of Manufacture:	2011
Engine Date of Reconstruct:	N/A
Engine Rating:	2,272 bhp / 1,600 kW

Regulatory Applicability
40 CFR 60, Subpart JJJJ
ROP Permit No. MI-ROP-N5719-2016, SRN – N5719

AST Project No.
2019-0347

Run No.	Run 1	Run 2	Run 3	Average
Date	**2/6/19**	**2/6/19**	**2/6/19**	**--**
Engine Load, % *	97	96	96	96
Nitrogen Oxides Data				
Concentration, ppmvd @ 15% O_2	26.5	26.1	26.0	26.2
NSPS JJJJ Limit, ppmvd @ 15% O_2	--	--	--	150
Percent of Limit, %	--	--	--	**17**
Emission Factor, g/hp-hr	0.35	0.36	0.36	0.36
Permit Limit, g/hp-hr	--	--	--	1.0
Percent of Limit, %	--	--	--	**36**
Emission Rate, lb/hr	1.7	1.7	1.7	1.7
Permit Limit, lb/hr	--	--	--	4.94
Percent of Limit, %	--	--	--	**35**
Carbon Monoxide Data				
Concentration, ppmvd @ 15% O_2	343.0	346.7	342.8	344.2
NSPS JJJJ Limit, ppmvd @ 15% O_2	--	--	--	610
Percent of Limit, %	--	--	--	**56**
Emission Factor, g/hp-hr	2.8	2.9	2.9	2.8
Permit Limit, g/hp-hr	--	--	--	3.5
Percent of Limit, %	--	--	--	**81**
Emission Rate, lb/hr	13.3	14.0	13.9	13.7
Permit Limit, lb/hr	--	--	--	17.3
Percent of Limit, %	--	--	--	**79**
Non- Methane HC Data				
Concentration, ppmvd @ 15% O_2	16.2	16.8	19.2	17.4
NSPS JJJJ Limit, ppmvd @ 15% O_2	--	--	--	80
Percent of Limit, %	--	--	--	**22**
Emission Factor, g/hp-hr	0.21	0.22	0.25	0.23
Permit Limit, g/hp-hr	--	--	--	1.0
Percent of Limit, %	--	--	--	**23**

* Performance testing was conducted while the engine was operating at the highest achievable load at current site conditions.

1.0 Introduction

Alliance Source Testing, LLC (AST) was retained by Energy Developments, Inc. (EDI) to conduct compliance emissions testing at the Orchard Hill Sanitary Landfill located in Watervliet, Berrien County, Michigan. The station operates under Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) No. MI-ROP-N5719-2019. Testing was conducted on two (2) Landfill Gas Fueled RICE-Generator Sets (EUICEENGINE1-S2 & EUICEENGINE2-S2) to demonstrate compliance with emission limits detailed in the facility's MDEQ air permit and 40 CFR 60, Subpart JJJJ.

Compliance testing was conducted to determine the emission rates of nitrogen oxides (NOx), carbon monoxide (CO) and non-methane hydrocarbons (NMHC). Testing consisted of three (3) 60-minute test runs for each source. Performance testing was conducted while the engines were operating at the highest achievable load at current site conditions. The Test Report Summary (TRS) provides the results from the compliance testing, including the three (3) run average, with comparisons to the applicable limits. Any difference between the summary results listed in the TRS and the detailed results contained in the appendices is due to rounding for presentation.

1.1 Facility and Process Description

EDI operates two (2) CAT® G3520C RICE gensets identified as emission units EUICEENGINE1-S2 and EUICEENGINE2-S2 (which are part of flexible emission unit FGICEENGINES-S2). The engines are fueled with landfill gas (LFG) that is generated at and collected by the Orchard Hill Sanitary Landfill.

1.2 Project Team

Personnel involved in this project are identified in the following table.

Table 1-1
Project Team

Facility Representative	Dan Zimmerman
AST Personnel	James Holder Alex Balke Will Leist

1.3 Instrument Information

The instruments used to conduct the compliance testing are summarized in the following table.

Table 1-2
Instrument Information

Pollutant	Manufacturer	Model	Serial Number
O_2 / CO_2	California Analytical	600	F05003-M
CO			
NOx	California Analytical	400CLD	U10068
VOC	California Analytical	300M	W01019

1.4 Test Protocol and Notification

Testing was conducted in accordance with the test protocol submitted to MDEQ by EDI.

1.5 Reporting Notes

MDEQ was notified testing was to be completed on February 7, 2019, however scheduling allowed for testing to be completed on February 6, 2019. This change was communicated with Mr. Tom Gasloli with the MDEQ and a copy of the correspondence is provided in Appendix F.

2.0 Testing Methodology

The emissions testing program was conducted in accordance with the U.S. EPA Reference Test Methods listed in Table 2-1. Method descriptions are provided below while quality assurance/quality control data is provided in Appendix C.

Table 2-1
Source Testing Methodology

Parameter	U.S. EPA Reference Test Methods	Notes/Remarks
Sample Point Determination	1	---
Volumetric Flow Rate	1 & 2	Full Velocity Traverses
Oxygen / Carbon Dioxide	3A	Instrumental Analysis
Moisture Content	4	Volumetric / Gravimetric Analysis
Nitrogen Oxides	7E	Instrumental Analysis
Carbon Monoxide	10	Instrumental Analysis
Non-Methane Hydrocarbons	25A	Instrumental Analysis
Gas Dilution System Certification	205	--

2.1 U.S. EPA Reference Test Method 1 – Sample Point Determination

The sampling location and number of traverse (sampling) points were selected in accordance with U.S. EPA Reference Test Method 1. To determine the minimum number of traverse points, the upstream and downstream distances were equated into equivalent diameters and compared to Figure 1-1 (for isokinetic sampling) and/or Figure 1-2 (measuring velocity alone) in U.S. EPA Reference Test Method 1.

2.2 U.S. EPA Reference Test Methods 1 & 2 – Volumetric Flow Rate

The sampling location and number of traverse (sampling) points were selected in accordance with U.S. EPA Reference Test Method 1. To determine the minimum number of traverse points, the upstream and downstream distances were equated into equivalent diameters and compared to Figure 1-1 (for isokinetic sampling) and/or Figure 1-2 (measuring velocity alone) in U.S. EPA Reference Test Method 1.

Full velocity traverses were conducted in accordance with U.S. EPA Reference Test Method 2 to determine the average stack gas velocity pressure, static pressure and temperature. The velocity and static pressure measurement system consisted of a pitot tube and inclined manometer. The stack gas temperature was measured with a K-type thermocouple and pyrometer.

2.3 U.S. EPA Reference Test Method 3A – Oxygen and Carbon Dioxide

The oxygen (O_2) and carbon dioxide (CO_2) testing was conducted in accordance with U.S. EPA Reference Test Method 3A. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless steel probe, Teflon sample line(s), gas conditioning system and the identified gas analyzer. The gas conditioning system was a non-contact condenser used to remove moisture from the stack gas. If an unheated Teflon sample line was used, then a portable non-contact condenser was placed in the system directly after the

probe. Otherwise, a heated Teflon sample line was used. Sampling was conducted at three traverse points passing through the centroidal area of the duct. The quality control measures are described in Section 2.9.

2.4 U.S. EPA Reference Test Method 4 – Moisture Content

The stack gas moisture content was determined in accordance with U.S. EPA Reference Test Method 4. The gas conditioning train consisted of a series of chilled impingers. The impingers were pre and post-measured to determine the amount of moisture condensed during each test run.

2.5 U.S. EPA Reference Test Method 7E – Nitrogen Oxides

The nitrogen oxides (NO_x) testing was conducted in accordance with U.S. EPA Reference Test Method 7E. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless steel probe, Teflon sample line(s), gas conditioning system and the identified gas analyzer. The gas conditioning system was a non-contact condenser used to remove moisture from the stack gas. If an unheated Teflon sample line was used, then a portable non-contact condenser was placed in the system directly after the probe. Otherwise, a heated Teflon sample line was used. Sampling was conducted at three traverse points passing through the centroidal area of the duct. The quality control measures are described in Section 2.9.

2.6 U.S. EPA Reference Test Method 10 – Carbon Monoxide

The carbon monoxide (CO) testing was conducted in accordance with U.S. EPA Reference Test Method 10. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless steel probe, Teflon sample line(s), gas conditioning system, and the identified gas analyzer. The gas conditioning system was a non-contact condenser used to remove moisture from the gas. If an unheated Teflon sample line was used, then a portable non-contact condenser was placed in the system directly after the probe. Otherwise, a heated Teflon sample line was used. Sampling was conducted at three traverse points passing through the centroidal area of the duct. The quality control measures are described in Section 2.9.

2.7 U.S. EPA Reference Test Method 25A – Non Methane Hydrocarbons

The non-methane hydrocarbon (NMHC) testing was conducted in accordance with U.S. EPA Reference Test Method 25A. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless steel probe, heated Teflon sample line(s) and the identified gas analyzer equipped with a non-methane cutter. The quality control measures are described in Section 2.10.

Methane determination was performed in the field using a heated flame-ionizing detector (HFID) equipped with a non-methane cutter that meets the specifications listed within 40 CFR, Part 1065. An integrated bag sample was procured during each instrumental test run, and at the conclusion of each run, the bag was analyzed with the non-methane cutter enabled. After the analyzer response was stable, the methane value was recorded. This procedure was repeated two (2) additional times per sample, and the average value was used to calculate a non-methane volatile organic compound (NMVOC) concentration using equation §1065.660-3.

2.8 U.S. EPA Reference Test Method 205 – Gas Dilution System Certification

A calibration gas dilution system field check was conducted in accordance with U.S. EPA Reference Method 205. Multiple dilution rates and total gas flow rates were utilized to force the dilution system to perform two dilutions on each mass flow controller. The diluted calibration gases were sent directly to the analyzer, and the analyzer response recorded in an electronic field data sheet. The analyzer response agreed within 2% of the actual diluted gas concentration. A second Protocol 1 calibration gas, with a cylinder concentration within 10% of one of the gas

divider settings described above, was introduced directly to the analyzer, and the analyzer response recorded in an electronic field data sheet. The cylinder concentration and the analyzer response agreed within 2%. These steps were repeated three (3) times. Copies of the Method 205 data can be found in the Quality Assurance/Quality Control Appendix.

2.9 Quality Assurance/Quality Control – U.S. EPA Reference Methods 3A, 7E and 10

Cylinder calibration gases used met EPA Protocol 1 (+/- 2%) standards. Copies of all calibration gas certificates can be found in the Quality Assurance/Quality Control Appendix.

Low Level gas was introduced directly to the analyzer. After adjusting the analyzer to the Low Level gas concentration and once the analyzer reading was stable, the analyzer value was recorded. This process was repeated for the Mid Level gas. Next, High Level gas was introduced directly to the analyzer, and the response recorded when it was stable. All values were within 2.0 percent of the Calibration Span or 0.5 ppmv absolute difference.

High or Mid Level gas (whichever was closer to the stack gas concentration) was introduced at the probe and the time required for the analyzer reading to reach 95 percent or 0.5 ppm (whichever was less restrictive) of the gas concentration was recorded. The analyzer reading was observed until it reached a stable value, and this value was recorded. Next, Low Level gas was introduced at the probe and the time required for the analyzer reading to decrease to a value within 5.0 percent or 0.5 ppm (whichever was less restrictive) was recorded. If the Low Level gas was zero gas, the response was 0.5 ppm or 5.0 percent of the upscale gas concentration (whichever was less restrictive). The analyzer reading was observed until it reached a stable value and this value was recorded. The measurement system response time and initial system bias were determined from these data. The System Bias was within 5.0 percent of the Calibration Span or 0.5 ppmv absolute difference

High or Mid Level gas (whichever was closer to the stack gas concentration) was introduced at the probe. After the analyzer response was stable, the value was recorded. Next, Low Level gas was introduced at the probe, and the analyzer value recorded once it reached a stable response. The System Bias was within 5.0 percent of the Calibration Span or 0.5 ppmv absolute difference or the data was invalidated and the Calibration Error Test and System Bias were repeated.

Drift between pre- and post-run System Bias was within 3% of the Calibration Span or 0.5 ppmv absolute difference. If the drift exceeded 3% or 0.5 ppmv, the Calibration Error Test and System Bias were repeated.

To determine the number of sampling points, a gas stratification check was conducted prior to initiating testing. The pollutant concentrations were measured at three points (16.7, 50.0 and 83.3 percent of the measurement line). Each traverse point was sampled for a minimum of twice the system response time.

If the pollutant concentration at each traverse point did not differ more than 5% or 0.5 ppm (whichever was less restrictive) of the average pollutant concentration, then single point sampling was conducted during the test runs. If the pollutant concentration did not meet these specifications but differed less than 10% or 1.0 ppm from the average concentration, then three (3) point sampling was conducted (stacks less than 7.8 feet in diameter - 16.7, 50.0 and 83.3 percent of the measurement line; stacks greater than 7.8 feet in diameter – 0.4, 1.0, and 2.0 meters from the stack wall). If the pollutant concentration differed by more than 10% or 1.0 ppm from the average concentration, then sampling was conducted at a minimum of twelve (12) traverse points. Copies of stratification check data can be found in the Quality Assurance/Quality Control Appendix.

An NO_2 – NO converter check was performed on the analyzer prior to initiating testing and at the completion of testing. An approximately 50 ppm nitrogen dioxide cylinder gas was introduced directly to the NOx analyzer and the instrument response was recorded in an electronic data sheet. The instrument response was within +/- 10 percent of the cylinder concentration.

A Data Acquisition System with battery backup was used to record the instrument response in one (1) minute averages. The data was continuously stored as a *.CSV file in Excel format on the hard drive of a computer. At the completion of testing, the data was also saved to the AST server. All data was reviewed by the Field Team Leader before leaving the facility. Once arriving at AST's office, all written and electronic data was relinquished to the report coordinator and then a final review was performed by the Project Manager.

2.10 Quality Assurance/Quality Control – U. S. EPA Reference Method 25A

Cylinder calibration gases used met EPA Protocol 1 (+/- 2%) standards. Copies of all calibration gas certificates can be found in the Quality Assurance/Quality Control Appendix.

Within two (2) hours prior to testing, zero gas was introduced through the sampling system to the analyzer. After adjusting the analyzer to the Zero gas concentration and once the analyzer reading was stable, the analyzer value was recorded. This process was repeated for the High Level gas, and the time required for the analyzer reading to reach 95 percent of the gas concentration was recorded to determine the response time. Next, Low and Mid Level gases were introduced through the sampling system to the analyzer, and the response was recorded when it was stable. All values were less than +/- 5 percent of the calibration gas concentrations.

Mid Level gas was introduced through the sampling system. After the analyzer response was stable, the value was recorded. Next, Zero gas was introduced through the sampling system, and the analyzer value recorded once it reached a stable response. The Analyzer Drift was less than +/- 3 percent of the span value.

The non-methane cutter used for methane determination during this test has been checked in accordance with the procedures detailed in §1065(e)(1)-(11). These procedures are described in the following. After the system was calibrated with propane gas in THC mode, the analyzer was placed in methane mode and ethane gas was introduced through the sample port. Thirty (30) seconds of data was recorded and averaged. With the analyzer back in THC mode, ethane gas was introduced through the sample port, and thirty (30) seconds of data was recorded and averaged. The ethane penetration fraction (EPF) was less than 0.02. Next, methane gas was introduced through the sample port, and the steps previously described for ethane gas were repeated. The methane penetration fraction (MPF) was greater than 0.95. At a minimum, the procedure is repeated for this instrument every 180 days.

A Data Acquisition System with battery backup was used to record the instrument response in one (1) minute averages. The data was continuously stored as a *.CSV file in Excel format on the hard drive of a computer. At the completion of testing, the data was also saved to the AST server. All data was reviewed by the Field Team Leader before leaving the facility. Once arriving at AST's office, all written and electronic data was relinquished to the report coordinator and then a final review was performed by the Project Manager.