IMPACT
COMPLIANCE & TESTING

Executive Summary

ENERGY DEVELOPMENTS BYRON CENTER, LLC
CAT® G3520C LANDFILL GAS FUELED IC ENGINE EMISSION RESULTS

Energy Developments of Byron Center, LLC (EDL) contracted Impact Compliance & Testing, Inc. (ICT) to perform air emission testing for nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compound (VOC) concentrations and emission rates for two (2) Caterpillar (CAT®) Model No. G3520C landfill gas-fired reciprocating internal combustion engines (RICE) that are operated at the South Kent Landfill in Byron Center, Kent County, Michigan.

The RICE are identified as emission units EUICEENGINE1 and 2 in Renewable Operating Permit No. MI-ROP-N1324-2018 issued by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Air Quality Division (AQD). Conditions of the permit require that emission testing be performed for the CAT® G3520C engines within 180 days of startup and every 8,760 hours of operation (or every three years) in accordance with the provisions of 40 CFR Part 60 Subpart JJJJ (NSPS for spark ignition internal combustion engines). The test results presented in this report are for test event that occurred on November 5, 2019.

The following table presents a summary of the air pollutant emission test results.

Emission Rates					
	NOx		CO		VOC
Emission Unit	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)	g/bhp-hr
EUICEENGINE1	2.13	0.43	13.51	2.7	0.19
EUICEENGINE2	2.67	0.54	12.68	2.6	0.15
Permit Limits	4.92	1.0	16.23	3.3	1.0

lb/hr = pounds per hour, g/bhp-hr = grams per brake horse power-hour

The following table presents the operating data recorded during the emission test periods.

Emission Unit	Generator Output (kW)	Engine Output (bhp)	LFG Fuel Use (lb/hr)	LFG CH_4 Content (%)	Exhaust Temp. (°F)
EUICEENGINE1	1,613	2,250	2,484	50.8	837
EUICEENGINE2	1,607	2,242	2,509	51.0	839

The data presented above indicate that EUICEENGINE1 and EUICEENGINE2 were tested while the units operated within 10% of maximum rated capacity (2,233 bhp and 1,600 kW) and are in compliance with the emission standards specified in 40 CFR 60.4233(e) and MI-ROP-N1324-2018.

IMPACT COMPLIANCE & TESTING

NSPS AIR EMISSION TEST REPORT

Title	AIR EMISSION TEST REPORT FOR LANDFILL GAS FUELED INTERNAL COMBUSTION ENGINES
Report Date	December 30, 2019
Test Dates	November 5, 2019

Facility Information	
Name	Energy Developments Byron Center, LLC
Street Address	10300 South Kent Drive SW
City, County	Byron Center, Kent
SRN	N1324

Emission Unit Information	
Permit No.	MI-ROP-N1324-2018
Emission Units	EUICEENGINE1, EUICEENGINE2

Testing Contractor	
Company	Impact Compliance & Testing, Inc.
Mailing Address	37660 Hills Tech Dr Farmington Hills, MI 48331
Phone	(734) 464-3880
Project No.	1900207

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AIR EMISSION TEST REPORT
FOR
LANDFILL GAS FUELED INTERNAL COMBUSTION ENGINES

ENERGY DEVELOPMENTS BYRON CENTER, LLC

1.0 INTRODUCTION

Energy Developments of Byron Center, LLC (EDL) operates two (2) Caterpillar (CAT®) Model No. G3520C gas fueled reciprocating internal combustion engines (RICE) and electricity generator sets (gensets) at the South Kent Landfill in Byron Center, Kent County, Michigan. The landfill gas (LFG) fueled RICE gensets are identified as emission units EUICEENGINE1 and EUICEENGINE2 (collectively flexible emission group FGICEENGINES) in Section 2 of Michigan Renewable Operating Permit MI-ROP-N1324-2018 issued by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Air Quality Division (AQD).

Air emission compliance testing was performed on November 5, 2019 to satisfy requirements to periodically test air pollutant emissions for EUICEENGINE1 and EUICEENGINE2 (Engine Nos. 1 and 2) in accordance with 40 CFR Part 60 Subpart JJJJ, the federal standards of performance for new stationary spark ignition engines (SI-RICE NSPS).

The compliance testing was performed by Impact Compliance & Testing, Inc. (ICT) representatives Tyler Wilson and Jory VanEss.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated October 25, 2019 that was reviewed and approved by the EGLE-AQD. Mr. David Patterson of the EGLE-AQD was onsite to observe portions of 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 & Testing, Inc. based on field sampling data collected by ICT. 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-AQD. A Responsible Official certification form (EQP 5736) accompanies report.

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:

Robert L. Harvey, P.E.
Services Director
Impact Compliance & Testing, Inc.

2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 General Process Description

Landfill gas (LFG) containing methane is generated in the South Kent 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 renewable energy power station where it is treated and used as fuel for the two (2) 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. G3520C RICE has a rated output of 2,233 brake-horsepower (bhp) and the connected generator has a rated electricity output of 1,600 kilowatts (kW). The engine is designed to fire low-pressure, lean fuel mixtures (e.g., LFG) and is equipped with an air-to-fuel ratio controller that monitors engine performance parameters and automatically adjusts the air-to-fuel ratio and ignition timing to maintain efficient fuel combustion.

The RICE gensets are 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 two (2) CAT® Model G3520C RICE exhaust stacks are identical.

The exhaust stack sampling ports for the CAT® Model G3520C engines (Engine Nos. 1 and 2) are located in individual exhaust stacks with an inner diameter of 13.5 inches. Each stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location greater than 360 inches (26 duct diameters) upstream and greater than 240 inches (18 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 a diagram of the emission test sampling location.

3.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

3.1 Purpose and Objective of the Tests

The conditions of ROP No. MI-ROP-N1324-2018 and 40 CFR Part 60 Subpart JJJJ require EDL to test each engine in FGICEENGINES for carbon monoxide (CO), nitrogen oxides (NOx) and volatile organic compound (VOCs) emission every 8,760 hours of operation.

3.2 Operating Conditions During the Compliance Tests

The emission testing was performed while the RICE-generator sets were operated within 10% of maximum operating conditions (i.e., 1,600 kW electricity output +/- 10%). EDL representatives recorded the generator electricity output (kW) at least every 15 minutes during each test period. The generator kW output ranged between 1,604 and 1,616 kW during the test periods.

Fuel flowrate (pounds per hour) and fuel methane content (%), were also recorded by EDL representatives at 15-minute intervals for each test period. The FGICEENGINES fuel consumption rate ranged between 2,480 and 2,512 lb/hr and fuel methane content ranged between 50.8 and 51.0%

In addition, the engine serial number and operating hours at the beginning of test No. 1 were recorded by the facility operators.

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

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)

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 LFG fueled RICE (Engine Nos. 1 and 2) were sampled for three (3) one-hour test periods during the compliance testing performed November 5, 2019.

Table 3.2 presents the average measured CO, NO_X, and VOC emission rates for the engines. The data presented in Table 3.2 is the average of three (3) one-hour test periods. Test results for each one hour sampling period are presented in Section 6.0 of this report.

The data presented below indicate that EUICEENGINE1 and EUICEENGINE2 were tested while the units operated within 10% of maximum rated capacity (2,233 bhp and 1,600 kW) and are in compliance with the emission standards specified in 40 CFR 60.4233(e) and MI-ROP-N1324-2018

Table 3.1 Average engine operating conditions during the test periods

Engine Parameter	EUICEENGINE1	EUICEENGINE2
Generator output (kW)	1613	1607
Engine output (bhp)	2,250	2,242
Engine LFG fuel use (lb/hr)	2,484	2,509
LFG methane content (%)	50.8	51.0
Exhaust temperature (°F)	837	839

Table 3.2 Average measured emission rates for each engine (three-test average)

Engine Parameter	EUICEENGINE1	EUICEENGINE2	Permit Limit
NOx Emissions (lb/hr)	2.13	2.67	4.92
NOx Emissions (g/bhp-hr)	0.43	0.54	1.0
CO Emissions (lb/hr)	13.51	12.68	16.23
CO Emissions (g/bhp-hr)	2.72	2.56	3.3
VOC Emissions (g/bhp-hr)	0.19	0.15	1.0

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A 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 was determined using zirconia ion/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 7E	Exhaust gas NOx concentration was determined using chemiluminescence instrumental analyzers.
USEPA Method 10	Exhaust gas CO concentration was measured using an NDIR 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

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 periodically to verify the integrity of the measurement system.

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 with a Servomex Model 1440D analyzer in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a single beam single wavelength (SBSW) infrared gas analyzer. The O_2 content of the exhaust was monitored using a 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 Content (USEPA Method 4)

Moisture content of the RICE exhaust gas was determined in accordance with USEPA Method 4 using a chilled impinger sampling train. The moisture sampling was performed concurrently with the instrumental analyzer sampling. During each sampling period a gas sample was extracted at a constant (non-isokinetic) rate from the source where moisture was removed from the sampled gas stream using impingers that were submersed in an ice bath. 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.

4.5 NO_x and CO Concentration Measurements (USEPA Methods 7E and 10)

NO_x and CO concentration in the RICE exhaust gas stream was measured continuously throughout each test period with a Thermo Environmental Inc. (TEI) Model 42c and TEI Model 48i, respectively, analyzer in accordance with USEPA Methods 7E and 10. The NO_x concentration was measured using a chemiluminescence analyzer and the CO concentration was measured using an infrared analyzer.

Throughout each test period, a continuous sample of the engine exhaust gas was extracted from the stack using the Teflon® heated sample line and gas conditioning system and delivered to the instrumental analyzers. Instrument response for each analyzer was recorded on an ESC Model 8816 data acquisition system that 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.

Appendix 4 provides CO and NO_x calculation sheets. Raw instrument response data are provided in Appendix 5.

4.6 Measurement of Volatile Organic Compounds (USEPA Method 25A/ALT-096)

The VOC emission rate was determined by measuring the nonmethane hydrocarbon (NMHC) concentration in the engine exhaust gas. NMHC pollutant concentration was determined using a TEI Model 55i Methane / Nonmethane hydrocarbon analyzer. The TEI 55i analyzer contains an internal gas chromatograph column that separates methane from non-methane components. The concentration of NMHC in the sampled gas stream, after separation from methane, is determined relative to a propane standard using a flame 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 reciprocating internal combustion engines (RICE) in that it uses USEPA Method 25A (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.

5.0 QA/QC ACTIVITIES

5.1 Exhaust Gas Flow

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

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 configurations were 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).

5.2 NO_x Converter Efficiency Test

The NO_2 – NO conversion efficiency of the chemiluminescence NO_x analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO_2 was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO_x concentration is greater than 90% of the expected value.

The on-site NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO_x concentration was greater than 90% of the expected value as required by Method 7E).

5.3 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.

5.4 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NO_x, CO, 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.

5.5 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 NO_x, CO, 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.

At the beginning of each test day, appropriate high-range, mid-range, and low-range span gases followed by a zero gas were introduced to the NMHC analyzer, in series at a tee connection, which is installed between the sample probe and the particulate filter, through a poppet check valve. After each one hour test period, mid-range and zero gases were re-introduced in series at the tee connection in the sampling system to check against the method's performance specifications for calibration drift and zero drift error.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, NO_x, and CO in nitrogen and zeroed using hydrocarbon free nitrogen. The NMHC (VOC) instrument was calibrated with USEPA Protocol 1 certified concentrations of propane 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.

5.6 Determination of Exhaust Gas Stratification

A stratification test was performed for the 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 NO_x, CO, 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.

5.7 Meter Box Calibrations

The dry gas metering console, which was used for exhaust gas moisture content sampling, 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 and gas divider certifications, interference test results, meter box calibration records, Pitot tube 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.

The measured air pollutant concentrations and emission rates for Engine Nos. 1 and 2 are less than the allowable limits specified in MI-ROP-N1324-2018 for Emission Unit Nos. EUICEENGINE1 and EUICEENGINE2:

- 4.92 lb/hr and 1.0 g/bhp-hr for NO_x;
- 16.23 lb/hr and 3.3 g/bhp-hr for CO; and
- 1.0 g/bhp-hr for VOC; and

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 test protocol. The testing for all pollutants was performed in accordance with USEPA methods and the approved test protocol. The engine-generator sets were operated within 10% of maximum output (1,600 kW generator output) and no variations from normal operating conditions occurred during the engine test periods.

Table 6.1 Measured exhaust gas conditions and NO_X, CO and VOC air pollutant emission rates for Engine No. 1 (EUICEENGINE1)

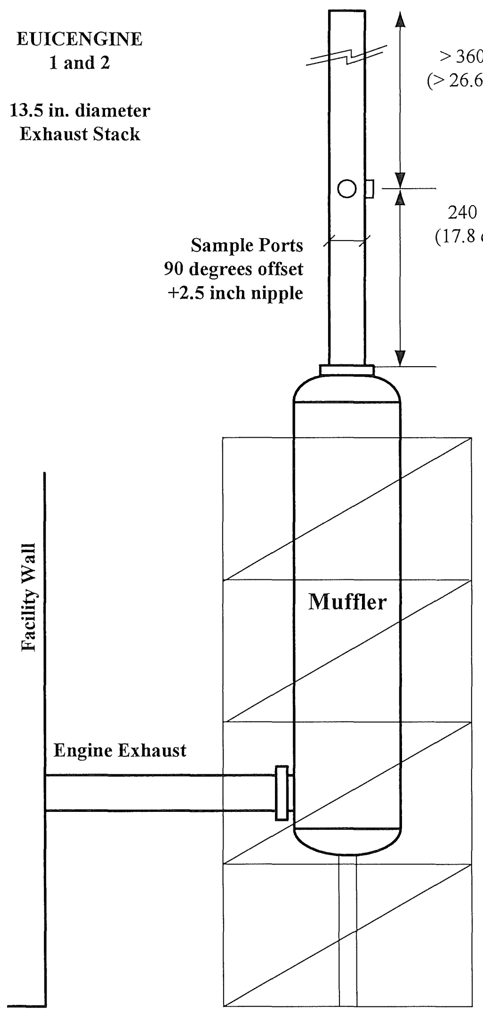
Test No. Test date Test period (24-hr clock)	1 11/5/19 1133-1233	2 11/5/19 1251-1351	3 11/5/19 1409-1509	Three Test Average
Fuel flowrate (lb/hr)	2,512	2,500	2,440	2,484
Generator output (kW)	1,611	1,616	1,611	1,613
Engine output (bhp)	2,248	2,254	2,249	2,250
LFG methane content (%)	50.8	50.8	50.8	50.8
Exhaust Gas Composition				
CO_2 content (% vol)	11.3	11.3	11.3	11.3
O_2 content (% vol)	8.96	8.92	8.92	8.93
Moisture (% vol)	11.2	11.6	10.4	11.0
Exhaust gas temperature (^oF)	824	841	848	837
Exhaust gas flowrate (dscfm)	4,590	4,550	4,618	4,586
Exhaust gas flowrate (scfm)	5,169	5,145	5,154	5,156
Nitrogen Oxides				
NO_X conc. (ppmvd)	62.6	64.4	67.2	64.7
NO_X emissions (lb/hr)	2.06	2.10	2.22	2.13
Permit Limit (lb/hr)	-	-	-	*4.92*
NO_X emissions (g/bhp*hr)	0.42	0.42	0.45	0.43
*Permit Limit (g/bhp*hr)*	-	-	-	*1.0*
Carbon Monoxide				
CO conc. (ppmvd)	671	679	675	675
CO emissions (lb/hr)	13.43	13.48	13.61	13.51
Permit Limit (lb/hr)	-	-	-	*16.23*
CO emissions (g/bhp*hr)	2.71	2.71	2.74	2.72
*Permit Limit (g/bhp*hr)*	-	-	-	*3.3*
Volatile Organic Compounds				
VOC conc. (ppmv)	26.9	26.3	25.7	26.3
VOC emissions (lb/hr)	0.96	0.93	0.91	0.93
VOC emissions (g/bhp*hr)	0.19	0.19	0.18	0.19
*Permit Limit (g/bhp*hr)*	-	-	-	*1.0*

Table 6.2 Measured exhaust gas conditions and NO_x, CO, and VOC air pollutant emission rates for Engine No. 2 (EUICEENGINE2)

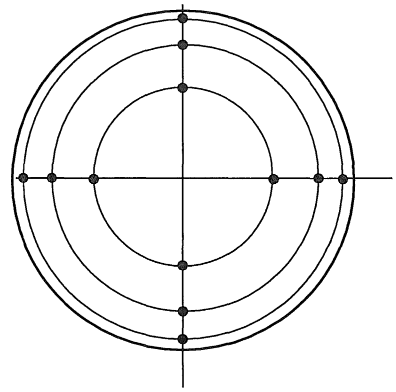
Test No. Test date Test period (24-hr clock)	1 11/5/19 735-835	2 11/5/19 855-955	3 11/5/19 1016-1116	Three Test Average
Fuel flowrate (lb/hr)	2,511	2,507	2,507	2,509
Generator output (kW)	1,610	1,606	1,604	1,607
Engine output (bhp)	2,247	2,241	2,239	2,242
LFG methane content (%)	51.0	51.0	50.9	51.0
Exhaust Gas Composition				
CO_2 content (% vol)	11.5	11.4	11.4	11.4
O_2 content (% vol)	8.68	8.69	8.71	8.69
Moisture (% vol)	13.5	11.5	10.9	12.0
Exhaust gas temperature (°F)	834	840	845	839
Exhaust gas flowrate (dscfm)	4,318	4,375	4,461	4,385
Exhaust gas flowrate (scfm)	4,994	4,944	5,006	4,982
Nitrogen Oxides				
NO_X conc. (ppmvd)	85.1	84.5	85.2	85.0
NO_X emissions (lb/hr)	2.63	2.65	2.73	2.67
Permit Limit (lb/hr)	-	-	-	*4.92*
NO_X emissions (g/bhp*hr)	0.53	0.54	0.55	0.54
*Permit limit (g/bhp*hr)*	-	-	-	*1.0*
Carbon Monoxide				
CO conc. (ppmvd)	671	657	659	662
CO emissions (lb/hr)	12.64	12.56	12.84	12.68
Permit Limit (lb/hr)	-	-	-	*16.23*
CO emissions (g/bhp*hr)	2.55	2.54	2.60	2.56
*Permit limit (g/bhp*hr)*	-	-	-	*3.3*
Volatile Organic Compounds				
VOC conc. (ppmv)	22.2	21.0	20.8	21.3
VOC emissions (lb/hr)	0.76	0.71	0.72	0.73
VOC emissions (g/bhp*hr)	0.15	0.14	0.14	0.15
*Permit Limit (g/bhp*hr)*	-	-	-	*1.0*

APPENDIX 1

- IC Engines No. 1 & 2 Exhaust Sample Locations



Exhaust Stack
Cross-Section with
Traverse Points



Velocity sample locations as measured from stack wall

Pt. #	in.
1	0.59
2	1.97
3	4.00
4	9.50
5	11.53
6	12.91

5/3/16 CG	Granger Electric Byron Center Generating Engine Exhaust Sample Location, CAT® G3520 ICE		
	Scale None	Sheet 1 of 1	Impact Compliance & Testing, Inc. Project No. 1900207