



Executive Summary

**GRANGER ELECTRIC OF PINCONNING, WHITEFEATHER LANDFILL
CAT® G3520C LANDFILL GAS FUELED IC ENGINES
EMISSION TEST RESULTS**

Granger Electric of Pinconning contracted Derenzo Environmental Services, to conduct a performance demonstration for the determination of pollutant concentrations and emission rates from two (2) Caterpillar (CAT®) Model No. G3520C landfill gas-fired reciprocating internal combustion engines (RICE) and electricity generator sets EUCENGINE1 and EUCENGINE2 (collectively flexible emission group FGICENGINES) operated at the Whitefeather Landfill in Pinconning, Michigan.

Michigan Department of Environmental Quality (MDEQ) Air Quality Division (AQD) Renewable Operating Permit (ROP) No. MI-ROP-P0437-2013 requires that performance testing be performed on 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 RICE) for nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compounds (VOC). In addition, MI-ROP-P0437-2013 requires performance testing for formaldehyde (HCOH) for one (1) of the RICE prior to expiration of the ROP. The performance testing was conducted on March 1, 2018.

The following table presents the emissions results from the performance demonstration.

Emission Unit	NO _x Emissions		CO Emissions		VOC Emissions	HCOH Emissions
	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)	(g/bhp-hr)	(lb/hr)
EUCENGINE1	3.43	0.70	11.8	2.41	0.11	-
EUCENGINE2	3.33	0.70	10.7	2.25	0.10	1.63
Permit Limits	4.92	1.0	16.23	3.3	1.0	2.1

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

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

Emission Unit	Generator Output (kW)	Engine Output (bhp)	LFG Fuel Use (lb/hr)	LFG CH ₄ Content (%)	Exhaust Temp. (°F)
EUCENGINE1	1,599	2,230	2,489	48.0	758
EUCENGINE2	1,544	2,155	2,369	47.6	775

lb/hr=pounds per hour, kW=kilowatt

The data presented above indicate that EUCENGINE1 and EUCENGINE2 were tested while the units operated within 10% of its maximum capacity (2,233 bhp and 1,600 kW) and are in compliance with the emission standards specified in 40 CFR 60.4233(e) and MDEQ-AQD ROP No. MI-ROP-P0437-2013.

AIR EMISSION TEST REPORT

Title AIR EMISSION TEST REPORT FOR THE
VERIFICATION OF AIR POLLUTANT EMISSIONS
FROM LANDFILL GAS FUELED INTERNAL
COMBUSTION ENGINES

Report Date March 29, 2018

Test Date March 1, 2018

Facility Information	
Name	Granger Electric of Pinconning at the Whitefeather Landfill
Street Address	2401 East Whitefeather Road
City, County	Pinconning, Bay

Facility Permit Information	
Permit No.:	MI-ROP-P0437-2013
Facility SRN :	P0437

Testing Contractor	
Company	Derenzo Environmental Services
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1710015

AIR EMISSION TEST REPORT
FOR THE
VERIFICATION OF AIR POLLUTANT EMISSIONS
FROM
LANDFILL GAS FUELED INTERNAL COMBUSTION ENGINES
GRANGER ELECTRIC OF PINCONNING, WHITEFEATHER LANDFILL

1.0 INTRODUCTION

Granger Electric of Pinconning (Granger) owns and operates two (2) Caterpillar (CAT®) Model No. G3520C gas fueled reciprocating internal combustion engines (RICE) and electricity generator sets at the Whitefeather Landfill in Pinconning, Bay County, Michigan (Granger Electric of Pinconning, facility SRN: P0437). The two (2) landfill gas (LFG) fueled RICE-generator sets are identified as emission units EUIENGINE1 and EUIENGINE2 (FGICENGINES) in Renewable Operating Permit (ROP) No. MI-ROP-P0437-2013 issued by the Michigan Department of Environmental Quality (MDEQ).

The conditions of MI-ROP-P0437-2013:

1. Allow for the installation and operation of two (2) spark ignition, lean burn reciprocating internal combustion engine and electricity generation sets (CAT® Model G3520C) that use treated landfill gas as fuel and have a rated horsepower (hp) output of 2,233 at full load.
2. Specify that ... *The permittee shall conduct an initial performance test for each engine in FGICENGINES, to verify NO_x, CO, and VOC emission rates. The permittee shall conduct an initial performance test within 60 days after achieving the maximum production rate but not later than 180 days after initial startup of each engine in FGICENGINES and subsequent performance testing every 8760 hours of operation or three years, whichever occurs first, to demonstrate compliance. The performance tests shall be conducted according to 40 CFR 60.4244.*
3. Specify that formaldehyde emissions testing must be performed for one (1) of the RICE prior to expiration of the ROP.

The compliance testing was performed by Derenzo Environmental Services (DES), a Michigan-based environmental consulting and testing company. DES representatives Tyler Wilson, Andy Rusnak, and Kevin Anderson performed the field sampling and measurements March 1, 2018.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated January 19, 2018 that was reviewed and approved by the MDEQ.

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Questions regarding this emission test report should be directed to:

Tyler J. Wilson
Livonia Office Supervisor
Derenzo Environmental Services
39395 Schoolcraft Road
Livonia, MI 48150
Ph: (734) 464-3880

Mr. Dan Zimmerman
Director of North American Health & Safety
Energy Developments, Ltd.
3259 Holt Rd.
Mason, MI 48854
Ph: (517) 896-4417

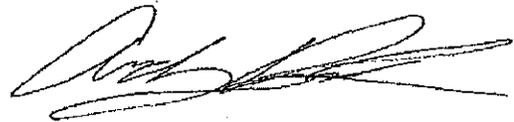
Report Certification

This test report was prepared by Derenzo Environmental Services based on field sampling data collected by DES. Facility process data was collected and provided by Granger employees or representatives. This test report has been reviewed by Granger representatives and approved for submittal to the MDEQ.

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:

Reviewed by:

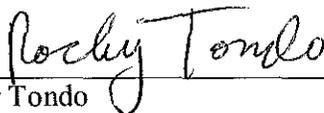


Tyler J. Wilson
Livonia Office Supervisor
Derenzo Environmental Services

Andy Rusnak, QSTI
Technical Manager
Derenzo Environmental Services

I certify that the facility and emission units were operated at maximum routine operating conditions for the test event. Based on information and belief formed after reasonable inquiry, the statements and information in this report are true, accurate and complete.

Responsible Official Certification:



Rocky Tondo
Chief Operations Officer
Granger Electric Company

2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 General Process Description

Landfill gas (LFG) containing methane is generated in the Whitefeather 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 Granger power station facility 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 engine/generator sets 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. The two (2) CAT® Model G3520C RICE exhaust stacks are identical. These exhaust stacks have been replaced since the previous emissions testing event, therefore, the stack dimensions in this test report are different from the stack dimensions in the last test report for this facility.

The exhaust stack sampling ports for the CAT® Model G3520C engines (EUIENGINE1 and EUIENGINE2) are located in individual exhaust stacks with an inner diameter of 14.25 inches. Each stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 240 inches (16.8 duct diameters) upstream and 120 inches (8.4 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 A provides diagrams of the emission test sampling locations.

3.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

3.1 Purpose and Objective of the Tests

The conditions of Renewable Operating Permit (ROP) No. MI-ROP-P0437-2013 and 40 CFR Part 60 Subpart JJJJ require Granger to test each engine (FGICENGINES) for carbon monoxide (CO), nitrogen oxides (NOx) and volatile organic compounds (VOCs) every 8,760 hours of operation. Additionally, ROP No. MI-ROP-P0437-2013 requires formaldehyde emissions testing to be performed for one (1) RICE prior to expiration of the ROP.

3.2 Operating Conditions During the Compliance Tests

The testing was performed while the Granger RICE-generator sets were operated at maximum operating conditions (1,600 kW electricity output +/- 10%). Granger representatives provided the kW output in 15-minute intervals for each test period. The FGICENGINES generator electricity output ranged between 1,517 and 1,624 kW for each test period.

Fuel flowrate (pounds per hour (lb/hr)) and fuel methane content (%) were also recorded by Granger representatives in 15-minute intervals for each test period. The FGICENGINES fuel consumption rate ranged between 2,313 and 2,499 lb/hr, and fuel methane content ranged between 47.4 and 48.1%. There was no fuel flow to the flare or leachate evaporator during the test periods. Fuel heat value was calculated using a lower heating value of 910 Btu/scf for methane.

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

Appendix B provides operating records provided by Granger 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).

$$\text{Engine output (bhp)} = \text{Electricity output (kW)} / (0.961) / (0.7457 \text{ kW/hp})$$

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 each LFG-fueled RICE (EUCENGINE1 and EUCENGINE2) were sampled for three (3) one-hour test periods during the compliance testing performed March 1, 2018.

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Tables 3.2 and 3.3 present the average measured pollutant emission rates for EUIENGINE1 and EUIENGINE2, respectively (average of the three test periods for each engine).

Test results for each one-hour sampling period are presented in Section 6.0 of this report.

Table 3.1 Average engine operating conditions during the test periods

Engine Parameter	EUIENGINE1	EUIENGINE2
Generator output (kW)	1,598	1,544
Engine output (bhp)	2,230	2,155
Engine LFG fuel use (lb/hr)	2,489	2,369
LFG methane content (%)	48.0	47.6
LFG lower heating value (Btu/scf)	437	433
Air to Fuel Ratio	7.0	6.9
Inlet Pressure (psi)	3.0	3.0
Exhaust temperature (°F)	758	775

Table 3.2 Average measured emission rates for EUIENGINE1 and EUIENGINE2 (three-test average)

Emission Unit	CO		NOx		VOC	HCOH
	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)	(g/bhp-hr)	(lb/hr)
Engine No. 1 Measured Rates	11.8	2.41	3.43	0.70	0.11	-
Engine No. 2 Measured Rates	10.7	2.25	3.33	0.70	0.10	1.63
Permit Limit	16.23	3.3	4.92	1.0	1.0	2.1

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4.0 SAMPLING AND ANALYTICAL PROCEDURES

A test protocol for the air emission testing was reviewed and approved by the MDEQ. This section provides a summary of the sampling and analytical procedures that were used during the Granger 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 NO _x 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
ASTM D6348	Exhaust gas HCOH concentration via Fourier transform infrared spectroscopy (FTIR)

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

The RICE exhaust stack gas velocity and volumetric flowrate was determined using USEPA Method 2 once for 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.

The absence of significant cyclonic flow for the exhaust configuration 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 C provides exhaust gas flowrate calculations and field data sheets.

4.3 Exhaust Gas Molecular Weight Determination (USEPA Method 3A)

CO₂ and O₂ content in the RICE exhaust gas was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO₂ content of the exhaust was monitored using a Servomex 1440D single beam single wavelength (SBSW) infrared gas analyzer. The O₂ 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 sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzers; therefore, measurement of O₂ and CO₂ content 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 D provides O₂ and CO₂ calculation sheets. Raw instrument response data are provided in Appendix E.

4.4 Exhaust Gas Moisture Content (USEPA Method 4)

Moisture content of the RICE exhaust gas (Engine No. 1) 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 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.

Moisture content of the RICE exhaust gas (Engine No. 2) was determined as part of the formaldehyde concentration determination (i.e., using the FTIR instrumental analyzer). Discussion of the FTIR testing procedures is contained in Section 4.7 of this document.

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

NO_x and CO pollutant concentrations in the RICE exhaust gas streams were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence NO_x analyzer and a TEI Model 48i infrared CO 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 D provides CO and NO_x calculation sheets. Raw instrument response data are provided in Appendix E.

4.6 Measurement of Volatile Organic Compounds (USEPA Method 25A and 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 several alternate test methods approving the use of the TEI 55-series analyzer as an effective instrument for measuring NMOC from gas-fueled reciprocating internal combustion engines (RICE) in that it uses USEPA Method 25A and 18 (ALT-066, ALT-078 and 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 NMHC 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 D provides VOC calculation sheets. Raw instrument response data for the NMHC analyzer is provided in Appendix E.

4.7 Measurement of Formaldehyde (ASTM D6348)

Formaldehyde concentration in the RICE exhaust gas streams was determined using a MKS Multi-Gas 2030 Fourier transform infrared (FTIR) spectrometer.

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

Appendix D provides HCOH calculation sheets. Raw instrument response data for the FTIR instrument is provided in Appendix E.

5.0 QA/OC ACTIVITIES

5.1 NO_x Converter Efficiency Test

The NO₂ – NO conversion efficiency of the Model 42c analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO₂ was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO₂ – NO converter uses a catalyst at high temperatures to convert the NO₂ to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO₂ concentration is greater than or equal to 90% of the expected value.

The NO₂ – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO₂ concentration was 100.4% of the expected value, i.e., greater than 90% of the expected value as required by Method 7E).

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 delivers 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 NO_x, CO, O₂ and CO₂ have had an interference response test performed 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 NO_x, CO, CO₂ and O₂ 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 CO₂, O₂, 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.

5.5 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 each RICE exhaust stack indicate that the measured CO, O₂ and CO₂ 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 Meter Box Calibrations

The Nutech Model 2010 sampling 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 Nutech metering console was calibrated using a NIST traceable Omega[®] Model CL 23A temperature calibrator.

5.7 Sampling System Response Time Determination

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.

Results of the response time determinations were recorded on field data sheets. For each test period, test data were collected once the sample probe was in position for at least twice the maximum system response time.

5.8 FTIR QA/QC Activities

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

Analyte spiking, of each emission unit, prior to and after sampling, 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 assured the ability of the FTIR to quantify that compound in the presence of effluent gas. The spike target dilution ratio was 1:10 (1 part cal gas; 9 parts stack gas).

Appendix F presents test equipment quality assurance data for the emission test equipment (NO₂ – 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 through 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-P0437-2013 for Emission Unit Nos. EUCENGINE1 and EUCENGINE2:

- 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;
- 1.0 g/bhp-hr for VOC; and
- 2.1 lb/hr for HCOH.

6.2 Variations from Normal Sampling Procedures or Operating Conditions

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

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Table 6.1 Measured exhaust gas conditions and NO_x, CO and VOC air pollutant emission rates for Engine No. 1 (EUCENGINE1)

Test No.	1	2	3	Three Test
Test date	3/1/18	3/1/18	3/1/18	Average
Test period (24-hr clock)	11:54-12:54	13:20-14:20	14:38-15:38	
Fuel flowrate (lb/hr)	2,491	2,487	2,489	2,489
Generator output (kW)	1,599	1,589	1,607	1,598
Engine output (bhp)	2,231	2,217	2,242	2,230
LFG methane content (%)	47.9	48.0	48.0	48.0
Air to fuel ratio	7.0	7.0	7.0	7.0
Inlet pressure (psi)	3.0	3.0	3.0	3.0
<u>Exhaust Gas Composition</u>				
CO ₂ content (% vol)	11.3	11.5	11.7	11.5
O ₂ content (% vol)	8.37	8.53	8.69	8.53
Moisture (% vol)	11.1	10.3	11.4	10.9
Exhaust gas temperature (°F)	759	757	758	758
Exhaust gas flowrate (dscfm)	4,419	4,551	4,456	4,475
Exhaust gas flowrate (scfm)	4,970	5,072	5,027	5,023
<u>Nitrogen Oxides</u>				
NO _x conc. (ppmvd)	106	108	107	107
NO _x emissions (g/bhp*hr)	0.68	0.72	0.69	0.70
Permitted emissions (g/bhp*hr)	-	-	-	1.0
NO _x emissions (lb/hr)	3.34	3.51	3.43	3.43
Permitted emissions (lb/hr)	-	-	-	4.92
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	605	608	605	606
CO emissions (g/bhp*hr)	2.37	2.47	2.38	2.41
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	11.7	12.1	11.8	11.8
Permitted emissions (lb/hr)	-	-	-	16.23
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv as C ₃)	15.3	15.3	15.3	15.3
VOC emissions (g/bhp*hr)	0.11	0.11	0.11	0.11
Permitted emissions (g/bhp*hr)	-	-	-	1.0

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Table 6.2 Measured exhaust gas conditions and NO_x, CO, VOC and HCOH air pollutant emission rates for Engine No. 2 (EUCENGINE2)

Test No.	1	2	3	Three Test
Test date	3/1/18	3/1/18	3/1/18	Average
Test period (24-hr clock)	7:38-8:38	8:57-9:57	10:16-11:16	
Fuel flowrate (lb/hr)	2,381	2,356	2,370	2,369
Generator output (kW)	1,547	1,542	1,544	1,544
Engine output (bhp)	2,159	2,151	2,155	2,155
LFG methane content (%)	47.6	47.4	47.7	47.6
Air to fuel ratio	6.9	6.9	6.9	6.9
Inlet pressure (psi)	3.0	3.0	3.0	3.0
<u>Exhaust Gas Composition</u>				
CO ₂ content (% vol)	11.4	11.3	11.3	11.4
O ₂ content (% vol)	7.91	8.25	8.15	8.10
Moisture (% vol)	11.9	11.9	11.8	11.9
Exhaust gas temperature (°F)	778	773	772	775
Exhaust gas flowrate (dscfm)	4,173	4,187	4,313	4,225
Exhaust gas flowrate (scfm)	4,735	4,751	4,891	4,792
<u>Nitrogen Oxides</u>				
NO _x conc. (ppmvd)	112	109	109	110
NO _x emissions (g/bhp*hr)	0.70	0.69	0.71	0.70
Permitted emissions (g/bhp*hr)	-	-	-	1.0
NO _x emissions (lb/hr)	3.34	3.27	3.38	3.33
Permitted emissions (lb/hr)	-	-	-	4.92
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	582	578	579	580
CO emissions (g/bhp*hr)	2.23	2.23	2.29	2.25
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	10.6	10.6	10.9	10.7
Permitted emissions (lb/hr)	-	-	-	16.23
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv as C ₃)	14.4	14.3	14.4	14.4
VOC emissions (g/bhp*hr)	0.10	0.10	0.10	0.10
Permitted emissions (g/bhp*hr)	-	-	-	1.0
<u>Formaldehyde</u>				
HCOH conc. (ppmv)	72.7	72.8	72.5	72.7
HCOH emissions (lb/hr)	1.61	1.62	1.66	1.63
Permitted emissions (lb/hr)	-	-	-	2.1