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AIR EMISSION TEST REPORT

AIR QUALITY DIV.

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

Report Date October 18, 2016

Test Dates September 13-14, 2016

Facility Information	
Name	North American Natural Resources Autumn Hills Generating Station
Street Address	5615 Adams Street,
City, County, State	Zeeland, Ottawa, Michigan
Facility SRN	P0264
Phone	(616) 688-5180

Emission Unit and Permit Information	
Operating Permit No.:	MI-ROP-P0264-2012b
Emissions Unit ID Nos.	EUENGINE1, EUENGINE2, EUENGINE4

Testing Contractor	
Company	Derenzo Environmental Services
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1604010



MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
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RENEWABLE OPERATING PERMIT
REPORT CERTIFICATION

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Authorized by 1994 P.A. 451, as amended. Failure to provide this information may result in civil and/or criminal penalties.

Reports submitted pursuant to R 336.1213 (Rule 213), subrules (3)(c) and/or (4)(c), of Michigan's Renewable Operating Permit (ROP) program must be certified by a responsible official. Additional information regarding the reports and documentation listed below must be kept on file for at least 5 years, as specified in Rule 213(3)(b)(ii), and be made available to the Department of Environmental Quality, Air Quality Division upon request.

Source Name North American Natural Resources Autumn Hills County Ottawa
Source Address 5615 Adams Street City Zeeland
AQD Source ID (SRN) P0264 ROP No. P0264-2012b ROP Section No. _____

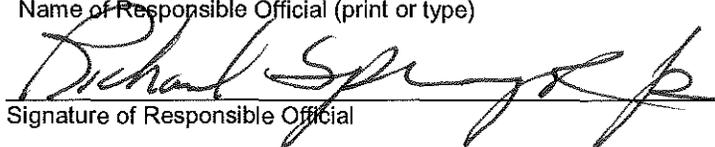
Please check the appropriate box(es):

Annual Compliance Certification (Pursuant to Rule 213(4)(c))
Reporting period (provide inclusive dates): From _____ To _____
 1. During the entire reporting period, this source was in compliance with ALL terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference. The method(s) used to determine compliance is/are the method(s) specified in the ROP.
 2. During the entire reporting period this source was in compliance with all terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference, EXCEPT for the deviations identified on the enclosed deviation report(s). The method used to determine compliance for each term and condition is the method specified in the ROP, unless otherwise indicated and described on the enclosed deviation report(s).

Semi-Annual (or More Frequent) Report Certification (Pursuant to Rule 213(3)(c))
Reporting period (provide inclusive dates): From _____ To _____
 1. During the entire reporting period, ALL monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred.
 2. During the entire reporting period, all monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred, EXCEPT for the deviations identified on the enclosed deviation report(s).

Other Report Certification
Reporting period (provide inclusive dates): From 9-13-2016 To 9-14-2016
Additional monitoring reports or other applicable documents required by the ROP are attached as described:
Test report for CO, NOx and VOC emissions from landfill gas fired CAT G3520C, and 3516LE
RICE-EUENGINE1,2, and 4. The testing was conducted in accordance with
MI-ROP-P0264-2012b. The facility was operated in compliance
with the permit conditions or at the maximum routine operating conditions.

I certify that, based on information and belief formed after reasonable inquiry, the statements and information in this report and the supporting enclosures are true, accurate and complete

Richard Spranger Director of Operations (517) 719-1322
Name of Responsible Official (print or type) Title Phone Number
 Signature of Responsible Official Date 10-31-16

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

NORTH AMERICAN NATURAL RESOURCES
AUTUMN HILLS GENERATING STATION

1.0 INTRODUCTION

North American Natural Resources (NANR) operates gas-fired reciprocating internal combustion engine (RICE) electricity generator sets at the Autumn Hills Generating Station located in Zeeland, Ottawa County, Michigan. The RICE are fueled by landfill gas (LFG) that is recovered from the Autumn Hills Landfill, which is owned and operated by Waste Management of Michigan. The recovered gas is transferred to NANR where it is treated and used as fuel.

The Michigan Department of Environmental Quality-Air Quality Division (MDEQ-AQD) has issued to NANR a Renewable Operating Permit (MI-ROP-P0264-2012b) for operation of the renewable electricity generation facility, which consists of:

- Two (2) Caterpillar (CAT®) Model No. 3516LE RICE-generator sets identified as emission units EUENGINE1, EUENGINE2 (Flexible Group ID's: FGENGINES and FGSIRICEMACT)
- One (1) CAT® Model No. G3520C RICE-generator set identified as emission unit EUENGINE4 (Flexible Group ID: FGSIRICEMACT).

Air emission compliance testing was performed pursuant to the conditions of MI-ROP-P0264-2012b and the federal Standards of Performance for Stationary Spark Ignition Internal Combustion Engines (the SI-RICE NSPS; 40 CFR Part 60 Subpart JJJJ). The conditions of MI-ROP-P0264-2012b state:

... the permittee shall conduct an initial performance test for [the engines] within one year after startup of the engine and every 8760 hours of operation ... to demonstrate compliance with the emission limits in 40 CFR 60.4233(e) ... If a performance test is required, the performance test shall be conducted according to 40 CFR 60.4244.

The compliance testing presented in this report was performed by Derenzo Environmental Services (DES), a Michigan-based environmental consulting and testing company. DES representatives Tyler Wilson and Blake Beddow performed the field sampling and measurements September 13-14, 2016. The emission testing was performed within 8,760 operating hours of the previous test, which was performed on February 17-18, 2015.

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The engine emission performance tests consisted of triplicate, one-hour sampling periods for nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOC, as non-methane hydrocarbons). Exhaust gas velocity, moisture, oxygen (O₂) content, and carbon dioxide (CO₂) 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 Test Plan dated July 25, 2016 that was reviewed and approved by the MDEQ. Mr. David Patterson of the MDEQ-AQD observed portions of the compliance testing.

Questions regarding this emission test report should be directed to:

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

Mr. Richard Spranger
Director of Operations
North American Natural Resources
300 North 5th Street, Suite 100
Ann Arbor, MI 48104
Ph: (517) 719-1322

Report Certification

This test report was prepared by Derenzo Environmental Services based on field sampling data collected by Derenzo Environmental Services. Facility process data were collected and provided NANR employees or representatives. This test report has been reviewed by NANR 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:



Blake Beddow
Environmental Consultant
Derenzo Environmental Services

Robert Harvey, P.E.
General Manager
Derenzo Environmental Services.

2.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

2.1 Purpose and Objective of the Tests

The conditions of MI-ROP-P0264-2012b and 40 CFR Part 60 Subpart JJJJ require NANR to test engine EUENGINE1, EUENGINE2, and EUENGINE4 for CO, NO_x and VOC emissions every 8,760 hours of operation.

2.2 Operating Conditions During the Compliance Tests

The testing was performed while the NANR engine/generator sets were operated at maximum operating conditions (within 10% of rated capacity). The rated capacities for the two types of CAT® engine generator sets are 800 kW for the 3516LE (EUENGINE1-2), and 1,600 kW electricity output for the 3520C (EUENGINE4). NANR representatives provided kW output in 15-minute increments for each test period. The EUENGINE1-2 generator kW output ranged between 796 and 808 kW, while the EUENGINE4 generator kW output ranged between 1,595 and 1,613 kW for each test period.

Fuel flowrate (cubic feet per minute), fuel methane content (%), fuel inlet pressure (psi) were also recorded by NANR representatives in 15-minute increments for each test period. In addition, the air-to-fuel ratio was recorded on EUENGINE4. The EUENGINE1-2 fuel consumption rate ranged between 292 and 326 scfm, fuel methane content was 51%, and fuel inlet pressure ranged from 36 to 37 psi. The EUENGINE4 fuel consumption rate ranged between 560 and 565 scfm, fuel methane content was 50.5%, fuel inlet pressure was 19 psi and the air-to-fuel ratio was 7.4 for each test period.

Appendix 2 provides operating records provided by NANR 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 3516LE generator efficiency (93.9%) or CAT® Model G3520C generator efficiency (96.1%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp).

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

$$\text{Where gen. efficiency} = 0.939 \text{ (CAT® 3516LE)}, \text{ or } 0.961 \text{ (CAT® G3520C)}$$

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

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2.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled LFG fueled RICE (EUENGINE1-2, EUENGINE4) were sampled for three (3) one-hour test periods during the compliance testing performed September 13-14, 2016.

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

Engine Parameter	EUENGINE1 CAT@3516 LE	EUENGINE2 CAT@3516 LE	EUENGINE4 CAT@ G3520C
Generator output (kW)	802	802	1,605
Engine output (bhp)	1,146	1,145	2,239
Engine LFG fuel use (scfm)	300	320	562
LFG methane content (%)	51.0	51.0	50.5
Exhaust temperature (°F)	862	872	950
Inlet fuel pressure (psi)	36	37	19
Air to fuel ratio	--	--	7.4

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

Emission Unit	CO Emission Rates		NO _x Emission Rates		VOC Emission Rates	
	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)
EUENGINE1	5.32	2.10	1.65	0.65	0.39	0.15
EUENGINE2	4.73	1.87	1.16	0.46	0.40	0.16
<i>Permit Limit</i>	--	<i>3.10</i>	--	<i>2.0</i>	--	<i>0.41</i>
EUENGINE4	11.9	2.4	1.79	0.4	0.63	0.13
<i>Permit Limit</i>	<i>20.7</i>	<i>5.0</i>	<i>2.46</i>	<i>0.5</i>	<i>3.2</i>	<i>1.0</i>

3.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

3.1 General Process Description

NANR operates three RICE-generator sets at its Auburn Hills Generating station; two (2) CAT® Model No. 3516LE and one (1) CAT® Model No. 3520C. The units are fired exclusively with LFG that is recovered from the Autumn Hills Landfill solid waste disposal facility and treated prior to use.

3.2 Rated Capacities and Air Emission Controls

The CAT® 3516LE engine generator sets have a rated design capacity of:

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

The CAT® G3520C engine generator set has a rated design capacity of:

- Engine Power; 2,242 bhp
- Electricity Generation; 1,600 kW

Each engine is equipped with an air-to-fuel ratio (AFR) controller that blends the appropriate ratio of combustion air and treated LFG fuel. For the CAT® G3516LE, the AFR controller is set based on the gas quality (methane or heat content) of the treated fuel. The CAT® G3520C engine is equipped with an electronic AFR controller that monitors engine performance parameters and automatically adjusts the AFR and ignition timing to maintain efficient fuel combustion.

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.

3.3 Sampling Locations

The RICE exhaust gas is directed through a muffler and is released to the atmosphere through a dedicated vertical exhaust stack with a vertical release point.

The sampling ports for the CAT® Model G3516LE engines (EUENGINE1-2) are located before the muffler in a horizontal exhaust duct with an inner diameter of 10.0 inches. The duct is equipped with two (2) sample ports, opposed 90°, that provide a sampling 34.5" inches (3.45 duct diameters) upstream and 293 inches (29.3 duct diameters) downstream from any flow disturbance.

The exhaust stack sampling ports for the CAT® Model G3520C engine (EUENGINE4) are located before the muffler in a horizontal exhaust duct with an inner diameter of 13.5 inches. The duct is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 40 inches (2.96 duct diameters) upstream and 120 inches (8.89 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 diagrams of the emission test sampling locations.

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 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 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 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

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 prior to and after 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 prior to each traverse 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)

CO₂ and O₂ content in the RICE exhaust gas stream 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 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 O₂ and CO₂ 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 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 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 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 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.

5.0 QA/QC ACTIVITIES

5.1 Flow Measurement Equipment

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

The absence of cyclonic flow for each sampling location was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each of the velocity traverse points with the planes of the face openings of the Pitot tube perpendicular to the stack cross-sectional plane. The Pitot tube was then rotated to determine the null angle (rotational angle as measured from the perpendicular, or reference, position at which the differential pressure is equal to zero).

5.2 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 within 90% of the expected value.

The NO₂ – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO₂ concentration was greater than 90% of the expected value).

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, 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.

5.5 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, 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.

5.6 Determination of Exhaust Gas Stratification

A stratification test was performed for each RICE exhaust stack. The stainless steel sample probe was positioned at sample points correlating to 16.7, 50.0 (centroid) and 83.3% of the stack diameter. Pollutant concentration data were recorded at each sample point for a minimum of twice the maximum system response time.

The recorded concentration data for the RICE exhaust stacks indicated that the measured 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 each RICE exhaust stack.

5.7 Meter Box Calibrations

The dry gas meter and 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 consoles were calibrated using a NIST traceable Omega[®] Model CL 23A temperature calibrator.

Appendix 6 presents test equipment quality assurance data (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, and stratification checks).

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 6.3.

The measured air pollutant concentrations and emission rates for EUENGINE1-2, and EUENGINE4 are less than the allowable limits specified in MI-ROP-P0264-2012b.

EUENGINE1-2

- 3.1 g/bhp-hr for CO;
- 2.0 g/bhp-hr for NO_x; and
- 0.41 g/bhp-hr for VOC.

EUENGINE4

- 5.0 g/bhp-hr and 20.7 lb/hr for CO;
- 0.5 g/bhp-hr and 2.46 lb/hr for NO_x; and
- 1.0 g/bhp-hr and 3.2 lb/hr for VOC.

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 engine-generator sets were operated within 10% of maximum output

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(800 kW generator output for CAT® 3516LE and 1,600 kW generator output for CAT® 3520C)
and no variations from normal operating conditions 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 (EUENGINE1)

Test No.	1	2	3	Three Test
Test date	9/13/16	9/13/16	9/13/16	Average
Test period (24-hr clock)	0745-0845	0910-1010	1035-1135	
Fuel flowrate (scfm)	299	299	301	300
Generator output (kW)	801	803	803	802
Engine output (bhp)	1,145	1,147	1,147	1,146
LFG methane content (%)	51.0	51.0	51.0	51.0
Fuel inlet pressure (psi)	35.8	36.0	36.0	36.0
<u>Exhaust Gas Composition</u>				
CO ₂ content (% vol)	12.3	12.3	12.2	12.3
O ₂ content (% vol)	7.54	7.50	7.58	7.54
Moisture (% vol)	12.9	13.1	12.7	12.9
Exhaust gas temperature (°F)	860	862	864	862
Exhaust gas flowrate (dscfm)	2,388	2,403	2,472	2,421
Exhaust gas flowrate (scfm)	2,745	2,759	2,831	2,778
<u>Nitrogen Oxides</u>				
NO _x conc. (ppmvd)	101	104	80.8	95.0
NO _x emissions (lb/hr)	1.73	1.78	1.43	1.65
NO _x emissions (g/bhp*hr)	0.68	0.70	0.57	0.65
Permitted emissions (g/bhp*hr)	-	-	-	2.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	509	509	491	503
CO emissions (lb/hr)	5.31	5.34	5.30	5.32
CO emissions (g/bhp*hr)	2.10	2.11	2.10	2.10
Permitted emissions (g/bhp*hr)	-	-	-	3.10
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	20.3	20.2	20.5	20.3
VOC emissions (lb/hr)	0.38	0.38	0.40	0.39
VOC emissions (g/bhp*hr)	0.15	0.15	0.16	0.15
Permitted emissions (g/bhp*hr)	-	-	-	0.41

Table 6.2 Measured exhaust gas conditions and NO_x, CO and VOC air pollutant emission rates for Engine No. 2 (EUENGINE2)

Test No.	1	2	3	Three Test
Test date	9/13/16	9/13/16	9/13/16	Average
Test period (24-hr clock)	1202-1302	1325-1425	1448-1548	
Fuel flowrate (scfm)	318	319	322	320
Generator output (kW)	801	803	802	802
Engine output (bhp)	1,144	1,147	1,145	1,145
LFG methane content (%)	51.0	51.0	51.0	51.0
Fuel inlet pressure (psi)	37.0	37.0	37.0	37.0
<u>Exhaust Gas Composition</u>				
CO ₂ content (% vol)	12.2	12.2	12.3	12.2
O ₂ content (% vol)	7.56	7.58	7.55	7.56
Moisture (% vol)	12.0	13.8	13.3	13.0
Exhaust gas temperature (°F)	873	869	871	872
Exhaust gas flowrate (dscfm)	2,543	2,511	2,490	2,515
Exhaust gas flowrate (scfm)	2,919	2,905	2,873	2,899
<u>Nitrogen Oxides</u>				
NO _x conc. (ppmvd)	62.8	63.6	66.3	64.3
NO _x emissions (lb/hr)	1.15	1.15	1.18	1.16
NO _x emissions (g/bhp*hr)	0.45	0.45	0.47	0.46
Permitted emissions (g/bhp*hr)	-	-	-	2.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	431	430	432	431
CO emissions (lb/hr)	4.78	4.71	4.69	4.73
CO emissions (g/bhp*hr)	1.90	1.86	1.86	1.87
Permitted emissions (g/bhp*hr)	-	-	-	3.10
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	20.0	20.0	19.8	19.9
VOC emissions (lb/hr)	0.40	0.40	0.39	0.40
VOC emissions (g/bhp*hr)	0.16	0.16	0.15	0.16
Permitted emissions (g/bhp*hr)	-	-	-	0.41

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Table 6.3 Measured exhaust gas conditions and NO_x, CO and VOC air pollutant emission rates for Engine No. 4 (EUENGINE4)

Test No.	1	2	3	Three Test Average
Test date	9/14/16	9/14/16	9/14/16	
Test period (24-hr clock)	0745-0845	0910-1010	1035-1135	
Fuel flowrate (scfm)	561	562	562	562
Generator output (kW)	1,603	1,606	1,605	1,605
Engine output (bhp)	2,237	2,241	2,240	2,239
LFG methane content (%)	50.5	50.5	50.5	50.5
Fuel inlet pressure (psi)	19.0	19.0	19.0	19.0
Air to fuel ratio	7.4	7.4	7.4	7.4
<u>Exhaust Gas Composition</u>				
CO ₂ content (% vol)	11.6	11.6	11.6	11.6
O ₂ content (% vol)	8.25	8.25	8.31	8.27
Moisture (% vol)	12.4	12.8	9.70	11.6
Exhaust gas temperature (°F)	949	950	951	950
Exhaust gas flowrate (dscfm)	4,575	4,648	4,743	4,655
Exhaust gas flowrate (scfm)	5,233	5,235	5,253	5,240
<u>Nitrogen Oxides</u>				
NO _x conc. (ppmvd)	53.8	54.1	52.7	53.6
NO _x emissions (lb/hr)	1.77	1.80	1.79	1.79
<i>Permitted emissions (lb/hr)</i>	-	-	-	2.46
NO _x emissions (g/bhp*hr)	0.36	0.36	0.36	0.36
<i>Permitted emissions (g/bhp*hr)</i>	-	-	-	0.5
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	587	587	585	586
CO emissions (lb/hr)	11.7	11.9	12.1	11.9
<i>Permitted emissions (lb/hr)</i>	-	-	-	20.7
CO emissions (g/bhp*hr)	2.37	2.41	2.45	2.41
<i>Permitted emissions (g/bhp*hr)</i>	-	-	-	5.0
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	17.2	17.5	17.5	17.4
VOC emissions (lb/hr)	0.62	0.63	0.63	0.63
<i>Permitted emissions (lb/hr)</i>	-	-	-	3.20
VOC emissions (g/bhp*hr)	0.13	0.13	0.13	0.13
<i>Permitted emissions (g/bhp*hr)</i>	-	-	-	1.0