

**Executive Summary**

**GRANGER ELECTRIC OF WATERVLIET, ORCHARD HILL GENERATING STATION  
CAT® G3520C LANDFILL GAS FUELED IC ENGINES  
EMISSION TEST RESULTS**

Granger Electric of Watervliet contracted Derenzo and Associates, Inc., to conduct a performance demonstration for the determination of nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOC) concentrations and emission rates from two (2) Caterpillar (CAT®) Model No. G3520C landfill gas-fired reciprocating internal combustion engines and electricity generator sets (EUICEENGINE1-S2 and EUICEENGINE2-S2) operated at the Orchard Hill Generating Station in Watervliet, Michigan.

Michigan Department of Environmental Quality (MDEQ) Air Quality Division (AQD) Renewable Operating Permit (ROP) No. MI-ROP-N5719-2011a 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 internal combustion engines). The performance testing was conducted on February 25, 2015.

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

Emission Unit	NO <sub>x</sub> Emission Rates		CO Emission Rates		VOC Emission Rate
	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)	(g/bhp-hr)
EUICEENGINE1-S2	1.72	0.34	10.35	2.03	0.08
EUICEENGINE2-S2	1.55	0.30	12.34	2.42	0.13
Permit Limits	4.94	1.0	17.3	3.5	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 performance demonstration.

Emission Unit	Generator Output (kW)	Engine Output (bhp)	LFG Fuel Use (scfm)	LFG CH <sub>4</sub> Content (%)	Exhaust Temp. (°F)
EUICEENGINE1-S2	1,657	2,315	584	46.8	784
EUICEENGINE2-S2	1,653	2,309	605	46.3	754

scfm=standard cubic feet per minute, kW=kilowatt

The data presented above indicate that EUICEENGINE1-S2 and EUICEENGINE2-S2 were tested while the units operated within 10% of 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-N5719-2011a.



MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY  
AIR QUALITY DIVISION

**RENEWABLE OPERATING PERMIT  
REPORT CERTIFICATION**

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 Granger Electric of Watervliet, LLC County Berrien

Source Address 3290 Hennessey Road City Watervliet

AQD Source ID (SRN) N5719 ROP No. N5719-2011a ROP Section No. 02

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 \_\_\_\_\_ To \_\_\_\_\_

Additional monitoring reports or other applicable documents required by the ROP are attached as described:  
NSPS Test Report for landfill gas fired IC engines (FGICEENGINES-S2).  
 \_\_\_\_\_  
 The testing was conducted in accordance with the enclosed Test Report and the  
 \_\_\_\_\_  
 facility was operated in compliance with the permit conditions or at the maximum  
 \_\_\_\_\_  
 routine operating conditions for the facility.

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

Marc Pauley Director of Operations (517) 372-8330  
Name of Responsible Official (print or type) Title Phone Number

 Date 4.20.15  
Signature of Responsible Official

**Derenzo and Associates, Inc.**

*Environmental Consultants*

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**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 31, 2015

Test Dates     February 25, 2015

<b>Facility Information</b>	
Name	Granger Electric of Watervliet Orchard Hill Generating Station at the Orchard Hill Sanitary Landfill
Street Address	3290 Hennessey Road
City, County	Watervliet, Berrien

<b>Facility Permit Information</b>			
Permit No.:	MI-ROP-N5719-2011a	Facility SRN :	N5719

<b>Testing Contractor</b>	
Company	Derenzo and Associates, Inc.
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1409009

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

GRANGER ELECTRIC OF WATERVLIET, ORCHARD HILL GENERATING STATION

**1.0 INTRODUCTION**

Granger Electric of Watervliet (Granger) owns and operates two (2) Caterpillar (CAT®) Model No. G3520C gas fueled internal combustion (IC) engines and electricity generator sets at the Granger Electric of Watervliet, Orchard Hill Generating Station in Watervliet, Berrien County, Michigan (Facility SRN: N5719). The two (2) landfill gas (LFG) fueled IC engine-generator sets are identified as emission units EUICEENGINE1-S2 and EUICEENGINE2-S2 (FGICEENGINES-S2) in Renewable Operating Permit (ROP) No. MI-ROP-N5719-2011a issued by the Michigan Department of Environmental Quality (MDEQ).

The conditions of MI-ROP-N5719-2011a:

1. Allow for the installation and operation of two (2) spark ignition, lean burn reciprocating internal combustion (IC) engine and electricity generation sets (CAT® Model G3520C) that have a rated horsepower (hp) output of 2,233 at full load.
2. Specify that ... *Except as provided in 40 CFR 60.4243, the permittee shall conduct an initial performance test for each engine in FGICEENGINES-S2 within one year after startup of the engine and every 8760 hours of operation or three years, whichever occurs first, to demonstrate compliance unless the engines have been certified by the manufacturer as required by 40 CFR Part 60 Subpart JJJJ and the permittee maintains the engine as required by 40 CFR 60.4243(a)(1). If a performance test is required, the performance tests shall be conducted according to 40 CFR 60.4244.*

The compliance testing was performed by Derenzo and Associates, Inc. (Derenzo and Associates), a Michigan-based environmental consulting and testing company. Derenzo and Associates representatives Tyler Wilson and Jeff Schlaf performed the field sampling and measurements February 25, 2015.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated November 25, 2014 that was reviewed and approved by the Michigan Department of Environmental Quality (MDEQ). MDEQ representative Mr. Matt Deskins observed portions of the testing project.

**Derenzo and Associates, Inc.**

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Questions regarding this emission test report should be directed to:

Tyler J. Wilson  
Environmental Consultant  
Derenzo and Associates, Inc.  
39395 Schoolcraft Road  
Livonia, MI 48150  
Ph: (734) 464-3880

Mr. Dan Zimmerman  
Director of Operations, Compliance & Safety Officer  
Granger Electric Company  
16980 Wood Road  
Lansing, MI 48906  
Ph: (517) 371-9711

**Report Certification**

This test report was prepared by Derenzo, Associates, Inc. based on field sampling data collected by Derenzo and Associates, Inc. Facility process data were collected and provided 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:



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Jeff Schlaf  
Environmental Consultant  
Derenzo and Associates, Inc.

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Robert L. Harvey, P.E.  
General Manager  
Derenzo and Associates, Inc.

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:



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Marc Pauley  
Operations Manager  
Granger Electric Company

## **2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION**

### **2.1 General Process Description**

Landfill gas (LFG) containing methane is generated in the Orchard Hill Sanitary 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 Orchard Hill Generating 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 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.

The exhaust stack sampling ports for the CAT® Model G3520C engines (EUICEENGINE1-S2 and EUICEENGINE2-S2) are located in individual exhaust stacks with an inner diameter of 13.25 inches. Each stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 288 inches (21.7 duct diameters) upstream and 96 inches (7.2 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-N5719-2011a and 40 CFR Part 60 Subpart JJJJ require Granger to test each engine contained in FGICEENGINES-S2 for carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOCs) every 8,760 hours of operation.

#### 3.2 Operating Conditions During the Compliance Tests

The testing was performed while the Granger engine/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 FGICEENGINES-S2 generator kW output ranged between 1,630 and 1,685 kW for each test period.

Fuel flowrate (cubic feet per minute) and fuel methane content (%) were also recorded by Granger representatives in 15-minute intervals for each test period. The FGICEENGINES-S2 fuel consumption rate ranged between 580 and 605 scfm, and fuel methane content ranged between 46.2 and 46.9%, and fuel inlet pressure ranged between 47.6 to 48.7 psi for each test period. 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 (96.0%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp).

$$\text{Engine output (bhp)} = \text{Electricity output (kW)} / (0.960) / (0.7457 \text{ kW/hp})$$

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 the sampled LFG fueled RICE (EUICEENGINE1-S2 and EUICEENGINE2-S2) were each sampled for three (3) one-hour test periods during the compliance testing performed February 25, 2015.

Table 3.2 presents the average measured CO, NO<sub>x</sub> and VOC emission rates for the engines (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.

**Derenzo and Associates, Inc.**

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Table 3.1 Average engine operating conditions during the test periods

Engine Parameter	EUICEENGINE1-S2	EUICEENGINE2-S2
Generator output (kW)	1,657	1,653
Engine output (bhp)	2,315	2,309
Engine LFG fuel use (scfm)	584	605
LFG methane content (%)	46.8	46.3
LFG lower heating value (Btu/scf)	426	422
Inlet fuel pressure (psi)	48.1	47.9
Exhaust temperature (°F)	784	754

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

Emission Unit	CO Emission Rates		NOx Emission Rates		VOC Emission Rates	
	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)
EUICEENGINE1-S2	10.35	2.03	1.72	0.34	0.42	0.08
EUICEENGINE2-S2	12.34	2.42	1.55	0.30	0.67	0.13
Emission Limit	17.3	3.5	4.94	1.0	--	1.0

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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 <sub>2</sub> and CO <sub>2</sub> 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 <sub>x</sub> 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 velocity and volumetric flowrate was determined using USEPA Method 2 prior to and after 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)**

CO<sub>2</sub> and O<sub>2</sub> content in the RICE exhaust gas was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO<sub>2</sub> content of the exhaust was monitored using a Servomex 1440D single beam single wavelength (SBSW) infrared gas analyzer. The O<sub>2</sub> 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 O<sub>2</sub> and CO<sub>2</sub> 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 O<sub>2</sub> and CO<sub>2</sub> 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 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<sub>x</sub> and CO Concentration Measurements (USEPA Methods 7E and 10)**

NO<sub>x</sub> 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<sub>x</sub> analyzer and a TEI Model 48c 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<sub>x</sub> 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.

### **5.0 QA/QC ACTIVITIES**

#### **5.1 NO<sub>x</sub> Converter Efficiency Test**

The NO<sub>2</sub> – NO conversion efficiency of the Model 42c analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO<sub>2</sub> was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO<sub>2</sub> – NO converter uses a catalyst at high temperatures to convert

the NO<sub>2</sub> to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO<sub>2</sub> concentration is within 90% of the expected value. The NO<sub>2</sub> – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO<sub>2</sub> concentration was -1.08% of the expected value, i.e., within 10% 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<sub>x</sub>, CO, O<sub>2</sub> and CO<sub>2</sub> have had an interference response test performed prior to their use in the field (July 26, 2006, June 21, 2011 and June 12, 2014), 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 3.0% 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<sub>x</sub>, CO, CO<sub>2</sub> and O<sub>2</sub> 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<sub>2</sub>, O<sub>2</sub>, NO<sub>x</sub>, 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 the RICE exhaust stack indicated that the measured CO, O<sub>2</sub> and CO<sub>2</sub> 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 consoles were calibrated using a NIST traceable Omega<sup>®</sup> Model CL 23A temperature calibrator.

Appendix F presents test equipment quality assurance data for the emission test equipment (NO<sub>2</sub> – 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 Renewable Operating Permit (ROP) No. MI-ROP-N5719-2011a for Emission Unit Nos. EUICEENGINE1-S2 and EUICEENGINE2-S2:

- 4.94 lb/hr and 1.0 g/bhp-hr for NO<sub>x</sub>;
- 17.3 lb/hr and 3.5 g/bhp-hr for CO; and
- 1.0 g/bhp-hr for VOC.

### **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.

During test No. 1 on IC engine No. 2, the test was paused for ten (10) minutes because the analyzer probe was dislodged from the exhaust stack while positioning the moisture train. The probe was immediately returned to its location within the exhaust stack, and more than twice the greatest system response time passed before resuming the test. Mr. Matt Deskins of the MDEQ-AQD observed this event and approved the corrective action.

**Derenzo and Associates, Inc.**

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Table 6.1 Measured exhaust gas conditions and NO<sub>x</sub>, CO and VOC air pollutant emission rates for Engine No. 1 (EUICEENGINE1-S2)

Test No.	1	2	3	Three Test
Test date	2/25/15	2/25/15	2/25/15	Average
Test period (24-hr clock)	1335 - 1435	1505 - 1605	1650 - 1750	
Fuel flowrate (scfm)	585	584	584	584
Generator output (kW)	1,657	1,663	1,652	1,657
Engine output (bhp)	2,315	2,322	2,308	2,315
LFG methane content (%)	46.8	46.7	46.8	46.8
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	10.9	10.9	10.9	10.9
O <sub>2</sub> content (% vol)	8.32	8.32	8.35	8.33
Moisture (% vol)	10.7	11.3	11.0	11.0
Exhaust gas temperature (°F)	773	771	794	784
Exhaust gas flowrate (dscfm)	4,550	4,535	4,360	4,481
Exhaust gas flowrate (scfm)	5,114	5,103	4,896	5,038
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	53.1	53.6	53.9	53.6
NO <sub>x</sub> emissions (g/bhp*hr)	0.34	0.34	0.33	0.34
Permitted emissions (g/bhp*hr)	-	-	-	1.0
NO <sub>x</sub> emissions (lb/hr)	1.73	1.74	1.69	1.72
Permitted emissions (lb/hr)	-	-	-	4.94
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	530	529	529	529
CO emissions (g/bhp*hr)	2.06	2.05	1.98	2.03
Permitted emissions (g/bhp*hr)	-	-	-	3.5
CO emissions (lb/hr)	10.5	10.5	10.1	10.4
Permitted emissions (lb/hr)	-	-	-	17.3
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv as C <sub>3</sub> )	12.2	12.1	11.8	12.1
VOC emissions (g/bhp*hr)	0.08	0.08	0.08	0.08
Permitted emissions (g/bhp*hr)	-	-	-	1.0

Table 6.2 Measured exhaust gas conditions and NO<sub>x</sub>, CO and VOC air pollutant emission rates for Engine No. 2 (EUICEENGINE2-S2)

Test No.	1	2	3	Three Test
Test date	2/25/15	2/25/15	2/25/15	Average
Test period (24-hr clock)	0830 - 1930	1015 - 1115	1145 - 1245	
Fuel flowrate (scfm)	605	605	605	605
Generator output (kW)	1,647	1,658	1,654	1,653
Engine output (bhp)	2,300	2,316	2,310	2,309
LFG methane content (%)	46.3	46.3	46.4	46.3
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	10.7	10.7	10.7	10.7
O <sub>2</sub> content (% vol)	8.70	8.68	8.69	8.69
Moisture (% vol)	9.1	9.4	11.0	9.8
Exhaust gas temperature (°F)	754	753	754	754
Exhaust gas flowrate (dscfm)	4,853	4,813	4,775	4,814
Exhaust gas flowrate (scfm)	5,348	5,360	5,366	5,358
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	45.2	44.1	45.6	44.9
NO <sub>x</sub> emissions (g/bhp*hr)	0.31	0.30	0.31	0.30
Permitted emissions (g/bhp*hr)	-	-	-	1.0
NO <sub>x</sub> emissions (lb/hr)	1.57	1.52	1.56	1.55
Permitted emissions (lb/hr)	-	-	-	4.94
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	580	592	590	587
CO emissions (g/bhp*hr)	2.42	2.44	2.41	2.42
Permitted emissions (g/bhp*hr)	-	-	-	3.5
CO emissions (lb/hr)	12.3	12.4	12.3	12.3
Permitted emissions (lb/hr)	-	-	-	17.3
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv as C <sub>3</sub> )	18.3	18.1	18.3	18.2
VOC emissions (g/bhp*hr)	0.13	0.13	0.13	0.13
Permitted emissions (g/bhp*hr)	-	-	-	1.0