Derenzo Environmental Services
Consulting and Testing

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AIR EMISSION TEST REPORT

Title	TEST REPORT FOR THE VERIFICATION OF AIR POLLUTANT EMISSIONS FROM LANDFILL GAS-FUELED RECIPROCATING ENGINES AND ENCLOSED LANDFILL GAS FLARES
Report Date	April 15, 2016
Test Dates	February 8-18, 2016

Facility Information	
Name	Pine Tree Acres, Inc. (Landfill)
Street Address	36600 29-Mile Rd.
City, County	Lenox Township, Macomb
SRN	N5984

Permit Information	
Permit to Install No.: PTI 160-14	Operating Permit No. MI-ROP-N5984-2013

Source Information				
Emission Unit	EUICENGINE1	EUICENGINE2	EUICENGINE3	EUICENGINE4
Serial No.	GZJ00469	GZJ00464	GZJ00467	GZJ00466
Emission Unit	EUICENGINE5	EUICENGINE6	EUICENGINE7	EUICENGINE8
Serial No.	GZJ00462	GZJ00468	GZJ00463	GZJ00465
Emission Unit	EUFLARE4	EUFLARE6		

Testing Contractor	
Company	Derenzo Environmental Services
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1512002

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DEQ

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: Pine Tree Acres, Inc. (Landfill) County: Macomb

Source Address: 36600 29 Mile Road City: Lenox Twp

AQD Source ID (SRN): N5984 ROP No.: N5984-2013 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 2/8/16 To 2/18/16

Additional monitoring reports or other applicable documents required by the ROP are attached as described:

Test Report for the landfill gas fired IC engines (FGICENGINES), EUFLARE4 and EUFLARE6. The testing was conducted in accordance with the Test Plan dated January 8, 2016 and PTI 160-14. The facility was operated in compliance with the permit conditions or at maximum routine operating conditions for the facility. (except as noted in report)

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

Charles H. Cassie	Senior District Manager	(248) 391-0990
Name of Responsible Official (print or type)	Title	Phone Number

[signature] 4-13-2016

Signature of Responsible Official Date

* Photocopy this form as needed.

EQP 5736 (Rev 11-04)

AIR EMISSION TEST REPORT
FOR THE
VERIFICATION OF AIR POLLUTANT EMISSIONS FROM
LANDFILL GAS-FUELED RECIPROCATING ENGINES AND
ENCLOSED LANDFILL GAS FLARES

PINE TREE ACRES LANDFILL

1.0 INTRODUCTION

Pine Tree Acres, Inc. (PTA) operates eight (8) Caterpillar (CAT®) Model No. G3520C landfill gas (LFG) fueled reciprocating internal combustion engine (RICE) generator sets, two (2) enclosed flares and two open flares at the Pine Tree Acres Landfill (PTAL, Facility SRN: N5984) in Lenox Township, Macomb County, Michigan. The facility has been issued Renewable Operating Permit (ROP) No. MI-ROP-N5984-2013 and Permit to Install (PTI) No. 160-14 by the Michigan Department of Environmental Quality (MDEQ).

Air emission testing was performed to demonstrate compliance with conditions of ROP No. MI-ROP-N5984-2013, PTI No. 160-14, and 40 CFR Part 60 Subpart JJJJ.

All eight (8) of the RICE generator sets, identified as emission units EUICENGINE1 through EUICENGINE8 and flexible group FGICENGINES, were tested for carbon monoxide (CO), nitrogen oxide (NO_X), and volatile organic compound (VOC) emissions. Individual engines were selected for the measurement of formaldehyde (HCOH), sulfur dioxide (SO_2), particulate matter (PM/PM_{10}), and opacity emissions. Each of the two enclosed flares, identified as emission units EUFLARE4 and EUFLARE6, were tested for CO, NOx, SO_2, and opacity emissions.

The compliance testing was performed by Derenzo Environmental Services (DES), a Michigan-based environmental consulting and testing company. DES representatives Tyler Wilson, Blake Beddow, Daniel Wilson, and Robert Harvey performed the field sampling and measurements February 8 through 18, 2016. The engine performance tests were completed within 8,760 engine operating hours of the previous performance tests completed February 9-12, 2015.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan, dated January 8, 2016, that was reviewed and approved by the MDEQ in the January 26, 2016 test plan approval letter. MDEQ representative Mr. David Patterson observed portions of the testing project.

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. Steve Walters
Environmental Engineer
Waste Management of Michigan, Inc.
36600 29-Mile Rd.
Lenox Twp., MI 48048
Ph: (586) 634-8085

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 Waste Management / Pine Tree Acres, Inc employees or representatives. This test report has been reviewed by Waste Management / Pine Tree Acres, Inc. 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:

Tyler J. Wilson
Livonia Office Supervisor
Derenzo Environmental Services

Reviewed By:

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

A Renewable Operating Permit Report Certification form signed by the source responsible official accompanies this report.

2.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

2.1 Purpose and Objective of the Tests

Each LFG-fueled RICE (EUICENGINE1 through 8) was tested for CO, NOx and VOC emissions pursuant to the conditions of MI-ROP-N5984-2013, PTI No. 160-14, and 40 CFR Part 60 Subpart JJJJ, which require the SI-RICE to be tested every 8,760 hours of operation. Additionally, EUICENGINE1 was sampled for HCOH and SO_2 emissions, and EUICENGINE3 was sampled for PM/PM_{10} and opacity emissions to satisfy the conditions of MI-ROP-N5984-2013 and PTI No. 160-14 that require these pollutant emission rates to be measured every five years.

Each enclosed flare (EUFLARE4 and EUFLARE6) was tested for CO, NOx, SO_2, and opacity emissions to satisfy the conditions of MI-ROP-N5984-2013 and PTI No. 160-14 that require these pollutant emission rates to be measured every five years.

2.2 Operating Conditions During the Compliance Tests

The engine testing was performed while the RICE-generator sets were operated at maximum operating conditions (within 10% of the rated electricity output of 1,600 kW). PTAL representatives monitored and recorded the kW output at 15-minute intervals for each test period. The RICE generator kW output ranged between 1,624 and 1,674 kW during the test periods.

Fuel flowrate (cubic feet per minute) and fuel methane content (%) were also recorded during the RICE test periods by PTAL representatives at 15-minute intervals. The RICE fuel consumption rate ranged between 543 and 584 scfm and fuel methane content ranged between 49.7 and 52.3% during the test periods. Other operating data (air-to-fuel ratio, fuel header inlet pressure, and engine operating hours) were recorded as required by the test plan approval letter.

Engine output (bhp) cannot be measured directly and was calculated based on the recorded electricity output, the calculated CAT® Model G3520C generator efficiency (96%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp).

$$\text{Engine output (bhp)} = \text{Electricity output (kW)} / (0.96) / (0.7457 \text{ kW/hp})$$

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

The flare emission testing was performed while the enclosed flares were operated at the highest achievable operating load based on the amount of LFG recovered from the wellfield. LFG flowrate (cubic feet per minute) and methane content (%) were recorded during the test periods by PTAL representatives at 15-minute intervals. The EUFLARE4 LFG flowrate ranged between 5,500 and 5,910 scfm. The EUFLARE6 LFG flowrate ranged between 2,938 and 3,033 scfm. The recovered LFG methane content ranged between 51.2 and 52.8% during the flare test periods. A lower heating value of 909 Btu/scf was used to calculate the LFG heating value for the determination of flare heat input rate (MMBtu/hr).

Table 2.2 presents a summary of the average enclosed flare operating conditions during the test periods.

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

2.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the treated LFG fueled RICE were sampled for three (3) one-hour test periods per unit during the compliance testing performed February 8 through 18, 2016.

Table 2.3 presents the average measured CO, NOx, and VOC emission rates for the engines (average of the three test periods for each engine) and applicable emission limits.

Table 2.4 presents the average measured HCOH, SO_2, PM/PM_{10}, and opacity emission rates for two of the engines (average of the three test periods for each engine) and applicable emission limits.

Table 2.5 presents the average measured CO, NOx, SO_2, and opacity emission rates for the enclosed flares (average of the three test periods for each enclosed flare) and applicable emission limits. The permitted SO_2 emission rates referenced in Table 2.5 are those specified in PTI 160-14, which supersede the limits in MI-ROP-N5984-2013.

Test results for each one hour sampling period and comparison to the permitted emission rates are presented in Section 6.0 of this report.

2.4 Measured Emission Rates Compared to Permitted Emission Limits

Results of the RICE performance tests demonstrate compliance with emission standards specified in 40 CFR Part 60 Subpart JJJJ (SI RICE NSPS).

The measured RICE CO, NO_X, VOC, formaldehyde (HCHO), SO_2, PM/PM_{10} and opacity emissions demonstrate compliance with the applicable limits specified in MI-ROP-N5984-2013 and PTI No. 160-14 with one exception. The measured CO emission rate for Engine 5 (EUICENGINE5), 16.8 lb/hr, exceeds the 16.3 lb/hr limit specified in the permits. The exceedance was not discovered until April 14, 2016 during Waste Management's review of the draft test report. An incorrect exhaust diameter was initially used in the emission calculations completed during testing, and in the draft test report, that resulted in a lower calculated CO emission rate. After correcting the calculation, Waste Management received confirmation that Engine 5 had failed the emission test for CO. Upon discovery of the exceedance MDEQ was notified and Waste Management shut Engine 5 down pending additional maintenance. Corrective actions have been taken by the facility and a retest is scheduled for April 20, 2016. The results of the retest will be submitted as a separate test report. Calculated emission rates from all other engines were checked and verified to be in compliance with applicable limits.

The measured CO, NO_X, SO_2 and opacity emissions for both enclosed flares (EUFLARE4 and EUFLARE6) demonstrate compliance with the applicable limits specified in MI-ROP-N5984-2013 and PTI No. 160-14.

Table 2.1 Average engine operating conditions during the RICE test periods

Emission Unit	Gen. Output (kW)	Engine Output (bHp)	Fuel Use (scfm)	LFG CH_4 Content (%)	LFG Btu Content (Btu/scf)	Exhaust Temp. (°F)	Air to Fuel Ratio	Inlet Press. (psi)
EUICENGINE1	1,642	2,295	564	50.7	461	938	8.2	2.32
EUICENGINE2	1,652	2,302	570	50.9	463	950	8.4	2.62
EUICENGINE3	1,643	2,292	574	50.2	457	929	8.0	2.76
EUICENGINE4	1,643	2,296	576	50.2	457	927	8.1	2.62
EUICENGINE5	1,641	2,295	573	51.5	469	900	8.6	2.36
EUICENGINE6	1,644	2,307	554	51.5	469	932	8.4	2.47
EUICENGINE7	1,648	2,294	560	51.2	466	918	8.5	50.2*
EUICENGINE8	1,646	2,299	549	51.5	469	911	8.7	2.40

Notes
*Engine header inlet pressure (psi) was not recorded for EUICENGINE7. Instead, engine manifold inlet pressure (psi) was recorded.

Table 2.2 Average operating conditions during the enclosed flare test periods

Emission Unit	LFG CH_4 Content (% vol)	Inlet Gas Flow to Flare (scfm)	Heat Input Rate (MMBtu/hr)
EUFLARE4	52.3	2,984	85
EUFLARE6	51.9	5,584	158

Table 2.3 Average measured CO, NOx, and VOC emission rates for each RICE generator set (three-test average)

	CO Emission Rates		NOx Emission Rates		VOC Emission Rates	
Emission Unit	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)
EUICENGINE1	12.1	2.39	2.66	0.53	0.58	0.11
EUICENGINE2	13.9	2.75	2.64	0.52	0.64	0.13
EUICENGINE3	12.7	2.52	2.52	0.50	0.66	0.13
EUICENGINE4	14.4	2.85	2.79	0.55	0.70	0.14
EUICENGINE5	16.8	3.33	2.53	0.50	0.72	0.14
EUICENGINE6	13.8	2.72	2.37	0.47	0.77	0.15
EUICENGINE7	13.3	2.63	2.30	0.46	0.75	0.15
EUICENGINE8	12.6	2.48	2.37	0.47	0.82	0.16
NSPS Standard	--	*5.0*	--	*2.0*	--	*1.0*
Permit Limit	*16.3*	*3.3*	*3.0*	*0.6*	*1.0*	*1.0*

Table 2.4 Average measured HCOH, SO_2, PM/PM10, and Opacity emissions for two of the RICE generator sets (three-test average)

	HCOH Emission Rates	SO_2 Emission Rates	PM/PM10 Emission Rates		Opacity
Emission Unit	(lb/hr)	(lb/hr)	(lb/hr)	(g/bhp-hr)	(%)
EUICENGINE1	1.73	0.77	-	-	-
EUICENGINE3	-	-	0.25	0.05	0
Permit Limit	*2.07*	*1.57*	*1.2*	*0.24*	*10*

Table 2.5 Average measured emission rates for Flare 4 and 6 (three-test average)

	CO Emission Rates	NOx Emission Rates	SO_2 Emission Rates		Opacity
Emission Unit	(lb/MMBtu)	(lb/MMBtu)	(lb/hr)		(%)
EUFLARE4	0.06	0.04	1.74	-	0
EUFLARE6	0.003	0.05	-	4.66	0
Permit Limit	*0.2*	*0.06*	*8.1*	*16.1*	*20*

3.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

3.1 General Process Description

LFG recovered from the PTAL is treated and used as fuel in the renewable energy facility or combusted in flaring systems. The renewable energy facility consists of eight (8) Caterpillar (CAT®) Model No. G3520C RICE-generator sets identified as emission units EUICENGINE1 through EUICENGINE8. Excess LFG (gas that is recovered but not used for electricity generation) is controlled in two (2) enclosed flares identified as EUFLARE4 and EUFLARE6.

3.2 Rated Capacities and Air Emission Controls

The CAT® Model No. G3520C RICE have a rated output of 2,233 brake-horsepower (bhp) and the connected generators have a rated electricity output of 1,600 kilowatts (kW). The engines are designed to fire low-pressure, lean fuel mixtures (e.g., treated LFG) and are equipped with air-to-fuel ratio controllers that monitor engine performance parameters and automatically adjust the air-to-fuel ratio to maintain efficient fuel combustion. 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.

The RICE 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.

EUFLARE4 has a maximum rated LFG inlet capacity of 4,000 scfm, which corresponds to a heat input capacity of 109 British thermal units per hour (MMBtu/hr). EUFLARE6 has a maximum rated LFG inlet capacity of 6,000 scfm, which corresponds to a heat input capacity of 164 MMBtu/hr.

3.3 Sampling Locations

The RICE exhaust gas is directed through mufflers and is released to the atmosphere through dedicated vertical exhaust stacks. The eight (8) CAT® Model G3520C RICE exhaust stacks are identical. The exhaust sampling ports for the CAT® Model G3520C engines (EUICENGINE1 through 8) are located in individual horizontal exhaust ducts, located before the engine silencer, with an inner diameter of 15.0 inches. After the engine silencer the exhaust stack diameter is reduced to 14.0 inches as specified in the permit. Each duct is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 38.0 inches (2.5 duct diameters) upstream and 45.0 inches (3.0 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

The exhaust sampling ports for EUFLARE4 are located near the top of the vertical combustion chamber, which has an inner diameter of 144 inches. There are four (4) sample ports, opposed 90°, that provide a sampling location 72.0 inches (0.5 duct diameters) upstream and 528 inches (3.7 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

The exhaust sampling ports for EUFLARE6 are located near the top of the vertical combustion chamber, which has an inner diameter of 156 inches. There are four (4) sample ports, opposed 90°, that provide a sampling location 78.0 inches (0.5 duct diameters) upstream and 648 inches (4.2 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 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 zirconia ion/paramagnetic and infrared instrumental analyzers, respectively.
USEPA Method 4	Exhaust gas moisture was determined based on the water weight gain in chilled impingers.
USEPA Method 7E	Exhaust gas NOx concentration was determined using a chemiluminescence instrumental analyzer.
USEPA Method 10	Exhaust gas CO concentration was measured using an NDIR instrumental analyzer.
USEPA Method 320	Exhaust gas formaldehyde concentration was measured using a FTIR spectrometer analyzer.
USEPA Method 6C	Exhaust gas SO_2 concentrations determined using an ultraviolet (UV) fluorescence instrumental analyzer.
USEPA Method 25A / ALT-096	Exhaust gas VOC (as NMHC) concentration was determined using a flame ionization analyzer equipped with a GC column.
USEPA Method 9	Exhaust gas visible emissions observation by certified observer.

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

The exhaust stack gas velocities and volumetric flow rates were 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 periodically leak-checked 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 3 provides exhaust gas flowrate calculations and field data sheets.

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

CO_2 and O_2 content in the exhaust gas streams were measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a Servomex 1440D single beam single wavelength (SBSW) infrared gas analyzer. The O_2 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 exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzers; therefore, measurement of O_2 and CO_2 concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

Prior to, and at the conclusion of each test, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document). Sampling times were recorded on field data sheets.

Appendix 4 provides O_2 and CO_2 calculation sheets. Raw instrument response data are provided in Appendix 5.

4.4 Exhaust Gas Moisture Content (USEPA Method 4)

Moisture content of the exhaust gas streams were 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 NOx and CO Concentration Measurements (USEPA Methods 7E and 10)

NOx and CO pollutant concentrations in the exhaust gas streams were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence NOx 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 4 provides CO and NOx calculation sheets. Raw instrument response data are provided in Appendix 5.

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

The RICE VOC emission rate was determined by measuring the nonmethane hydrocarbon (NMHC) concentration in each 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 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.

4.7 Measurement of Formaldehyde Emissions (USEPA Method 320)

The concentration of formaldehyde in the RICE exhaust gas was determined by Extractive Fourier Transform Infrared (FTIR) using a MKS Multi-Gas 2030 FTIR spectrometer. Formaldehyde measurements were performed by Ms. Lindsey Wells and Ms. Sara Mae Thoma of Prism Analytical Technologies, Inc (PATI).

Throughout each one-hour test period, a continuous sample of the engine exhaust gas was extracted from the stack using a Teflon® heated sample line and heated particulate filter, and delivered to FTIR instrument. The sampled gas was not conditioned prior to being introduced to the analyzer; therefore, the measurement of formaldehyde concentration corresponds to standard wet gas conditions. Instrument formaldehyde response for the analyzer was recorded with a data logging system. Prior to, and at the conclusion of each test, analyte spiking was performed to verify the ability of the sampling system to quantitatively deliver a sample from the base of the probe to the FTIR (described in Appendix 7).

Appendix 4 provides formaldehyde calculation sheets. The formaldehyde report prepared by PATI is provided in Appendix 7.

4.8 Measurement of Sulfur Dioxide Emissions (USEPA Method 6C)

SO_2 content in the exhaust gas stream was measured continuously throughout each test period in accordance with USEPA Method 6C. A Thermo Environmental, Inc. Model 43i pulsed ultraviolet fluorescence analyzer was used to determine SO_2 concentration.

Throughout each test period, a continuous sample of the 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 SO_2 emission calculation sheets. Raw instrument response data is provided in Appendix 5.

4.9 Measurement of Particulate Matter Emissions (USEPA Method 5/202)

The conditions of MI-ROP-N5984-2013 and PTI No. 160-14 specify PM and PM_{10} emission limits for the RICE generators sets. The testing was performed using a combined filterable and condensable particulate matter sampling train. The filterable and condensable fractions were added to calculate total PM_{10} emissions (i.e., all filterable and condensable PM emissions were assumed to be in the PM-10 size range).

4.9.1 Filterable Particulate Matter Sample Train (USEPA Method 5)

Filterable PM was determined using USEPA Method 5. RICE exhaust gas was withdrawn from the exhaust stack at an isokinetic sampling rate using an appropriately-sized stainless steel sample nozzle and heated probe. The collected exhaust gas was passed through a pre-tared glass fiber filter that was housed in a heated filter box. The back half of the filter housing was connected to the condensable PM impinger train with a length of Teflon line (due to the horizontal exhaust sampling location, the impinger train could not be directly connected to the filter box).

4.9.2 Condensable Particulate Matter Sample Train (USEPA Method 202)

Condensable PM (CPM) concentrations were measured in accordance with USEPA Method 202. Following the Method 5 filter assembly, the sample gas travelled through the Teflon connecting line to the impinger train which consisted of a condenser, a knock-out impinger, a standard Greenberg-Smith (G-S) impinger (dry), a Teflon-coated CPM filter (with exhaust thermocouple), a modified G-S impinger containing 100 milliliters of deionized water, and a modified G-S impinger containing a known amount of indicating silica gel.

The CPM components of the Method 202 sampling train (dry knockout impinger and dry GS impinger) were placed in a tempered water bath and a pump was used to circulate water through the condenser. Crushed ice was used to maintain the temperature of the bath such that the CPM filter outlet temperature remained between 65 and 85°F. Crushed ice was placed around the last two impingers to chill the gas to below 65°F.

4.9.3 Sample Recovery and Analysis (USEPA Method 5/202)

At the conclusion of each one-hour test period, the sample train was leak-checked and disassembled. The sample nozzle, stainless steel probe liner, and filter holder (i.e., front half) were brushed and rinsed with acetone. The recovered particulate filter and acetone rinses were stored in sealed containers and sent to Enthalpy Analytical, Inc. (Durham, North Carolina) for gravimetric measurements.

The impingers were transported to the recovery area where they were weighed. The exhaust gas contained significant amounts of moisture. Therefore, prior to recovery, the CPM portion of the sample train underwent the nitrogen purge step of Method 202. The Teflon connecting line and glassware (between the particulate filter and CPM filter) were rinsed with DI water, acetone, and hexane in accordance with the Method 202 sample recovery procedures. The CPM filter and recovered rinses were clearly and uniquely labeled and transferred to Enthalpy Analytical, Inc. for analysis.

Diluent gas content (Method 3A O_2 and CO_2) measurements were performed with each of the PM/PM_{10} isokinetic sampling periods.

Appendix 4 provides PM/PM_{10} calculation sheets. The PM/PM_{10} laboratory report by Enthalpy Analytical is provided in Appendix 8.

4.10 Visible Emission Observations (USEPA Method 9)

USEPA Method 9 procedures were used to evaluate the opacity of the exhaust gas during one 15-minute test period on each of the following sources: EUICENGINE3, EUFLARE4, and EUFLARE6. All visible emissions determinations were performed by a qualified observer in accordance with USEPA Method 9, Section 3. The qualified observer was located at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140° sector to his/her back. As much as possible, the line of vision was approximately perpendicular to the plume direction.

Opacity observations were made at the point of greatest opacity in the portion of the plume where condensed water vapor was not present. Observations were recorded at 15-second intervals for at least 15 minutes for each source.

Appendix 4 provides opacity observation sheets. The certificate for the qualified observer of visible emissions is provided in Appendix 9.

5.0 QA/QC ACTIVITIES

5.1 NOx Converter Efficiency Test

The NO_2 – NO conversion efficiency of the Model 42c analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO_2 was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO_2 concentration is within 90% of the expected value:

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria. The measured NO_2 concentration was within 94% of the expected value.

5.2 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.

The TEI Model 42c analyzer exhibited the longest system response time at 60 seconds. 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.

5.3 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 SO_2, NOx, CO, O_2 and CO_2 have had an interference response test preformed prior to their use in the field (November 12, 2015, 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.

5.5 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 SO_2, NOx, CO, CO_2 and O_2 analyzers by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and determining the instrument response against the initial instrument calibration readings.

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

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, SO_2, NOx, 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 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 exhaust stack indicated that the measured CO and O_2 concentrations did not vary by more than 5% of the mean across the stack diameter. Therefore, the exhaust gas was considered to be unstratified and the compliance test sampling was performed at a single sampling location within each exhaust stack.

5.7 Particulate Matter Recovery and Analysis

All recovered particulate matter samples were stored and shipped in pre-rinsed glass sample bottles with Teflon® lined caps. The liquid level on each bottle was marked with a permanent marker prior to shipment and the caps were secured closed with tape. Samples of the reagents used in the test event (200 milliliters each of deionized high-purity water, acetone and hexane) were sent to the laboratory for analysis to verify that the reagents used to recover the samples have low particulate matter residues.

The glassware used in the condensable PM impinger trains was washed and rinsed prior to use in accordance with the procedures of USEPA Method 202. The glassware was not baked prior to use; therefore, DES used the field train proof blank option provided in USEPA Method 202. Analysis of the collected field train proof blank rinses (sample train rinse performed prior to use) indicated a total of 2.7 milligrams (mg) of recovered PM from the sample train. In addition, a field train recovery proof blank was performed following the second sampling period. Analysis of the field train recovery proof blank resulted in 1.7 mg of recovered PM from the sample train. The reported condensable PM test results were blank-corrected according to the method (USEPA Method 202 allows a blank correction of up to 2 mg).

5.8 Laboratory QA Procedures

The particulate matter analyses were conducted by a qualified third-party laboratory according to the appropriate QA/QC procedures specified in the USEPA Methods 5 and 202 and are included in the final laboratory report provided by Enthalpy Analytical.

5.9 Meter Box Calibrations

The Nutech Model 2010 sampling console, which was used for the particulate matter and 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 digital pyrometer in the metering console was calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

Appendix 6 presents test equipment quality assurance data (NO_2 – NO conversion efficiency test data, instrument calibration and system bias check records, calibration gas and gas divider certifications, interference test results, meter box calibration records, stratification checks, cyclonic flow determinations sheets, Pitot tube and probe assembly calibration records).

6.0 RESULTS

6.1 RICE NO_X, CO and VOC Emissions

All eight (8) RICE generator sets (EUICENGINE1 through 8) were tested for NO_X, CO and VOC emission rates. The measured air pollutant concentrations and emission rates for each one-hour test period are presented in Tables 6.1 through 6.8.

The measured emission rates are less than 40 CFR Part 60 Subpart JJJJ (SI RICE NSPS) emission standards; 2.0 g/bhp-hr NO_X, 5.0 g/bhp-hr CO and 1.0 g/bhp-hr VOC.

With one exception, the measured emission rates are less than the allowable rates specified in, MI-ROP-N5984-2013, and PTI No. 160-14:

- 3.0 lb/hr and 0.6 g/bhp-hr for NO_X;
- 16.3 lb/hr and 3.3 g/bhp-hr for CO; and
- 1.0 lb/hr and 1.0 g/bhp-hr for VOC.

The measured CO emission rate for Engine 5 (EUICENGINE5), 16.8 lb/hr, exceeds the 16.3 lb/hr limit specified in the permits. The exceedance was not discovered until April 14, 2016 during Waste Management's review of the draft test report. An incorrect exhaust diameter was initially used in the emission calculations completed during testing, and in the draft test report, that resulted in a lower calculated CO emission rate. After correcting the calculation, Waste Management received confirmation that Engine 5 had failed the emission test for CO. Upon discovery of the exceedance MDEQ was notified and Waste Management shut Engine 5 down pending additional maintenance. Corrective actions have been taken by the facility and a retest is scheduled for April 20, 2016. The results of the retest will be submitted as a separate test report. Calculated emission rates from all other engines were checked and verified to be in compliance with applicable limits.

6.2 RICE Formaldehyde, Particulate Matter, SO_2 and Opacity Emissions

EUICENGINE1 was tested for formaldehyde and SO_2 emissions, which were measured concurrently with NO_X, CO and VOC emissions. The measured formaldehyde and SO_2 concentrations and emission rates for each one-hour test period are presented in Table 6.9 and are less than the limits specified in MI-ROP-N5984-2013 and PTI No. 160-14:

- 2.07 lb/hr for HCOH; and
- 1.57 lb/hr for SO_2

EUICENGINE3 was tested for particulate matter emissions and exhaust gas opacity. The measured PM/PM_{10} emission rate for each one-hour test period and opacity results are presented in Table 6.10 and are less than limits specified in MI-ROP-N5984-2013 and PTI No. 160-14:

- 1.2 lb/hr and 0.24 g/bhp-hr for PM/PM_{10}; and
- 10% opacity.

6.3 Enclosed Flare Emission Rates

The two enclosed flares, EUFLARE4 and EUFLARE6, were tested for CO, NO_X, and SO_2 emission rates and exhaust gas opacity. The measured air pollutant concentrations, emission rates and opacity for each one-hour test period for EUFLARE4 and EUFLARE6 are presented in Tables 6.11 and 6.12, respectively. The measured emissions are less than those specified in MI-ROP-N5984-2013 and/or PTI No. 160-14:

- 0.2 lb/MMBtu for CO;
- 0.06 lb/MMBtu for NOx;
- 8.1 lb/hr for SO_2 (EUFLARE4)
- 16.1 lb/hr for SO_2 (EUFLARE6); and
- 20% opacity.

6.4 Variations from Normal Sampling Procedures or Operating Conditions

The testing for all pollutants was performed in accordance with the approved test protocols and any test method exceptions are noted below. The RICE generator sets were operated within 10% of maximum output. The enclosed flare testing was performed while the enclosed flares were operated at the highest achievable operating load.

The laboratory report from Enthalpy Analytical for the filterable and condensable PM samples noted that, "The filter for Run 2 had a similar catch pattern (visually), but was damaged around the edges. All recovered filter fragments were piled on the filter and weighed, but it does appear the sample's result is biased low." The Run 2 particulate filter adhered to the filter holder O-ring, which cause some damage when extracted from the filter holder. Any filter material remaining on the filter holder and O-ring was recovered or brushed into the petri dish and included with the filter that was sent to the laboratory for analysis. The filter weight for Run 2 is lower than the filter weights measured for Run Nos. 1 and 3. However, the measured PM/PM_{10} emission rates for all three runs are well below the allowable rate. The highest measured PM/PM_{10} emission rate for any of the three runs is less than 30% of the allowable emission rate specified in MI-ROP-N5984-2013 and PTI No. 160-14.

The measured CO concentration for EUFLARE4 Test No. 2 exceeded the initial analyzer calibration span value (120 ppmvd) for eight (8) one-minute averages. Following the test period, the TEI Model 48c infrared CO analyzer was challenged with a higher span gas to verify instrument accuracy at concentrations up to 160 ppmvd. The instrument response was within 1.1% of the expected calibration gas value (161.8 ppmvd compared to the 160 ppmvd CO calibration gas). Therefore, the recorded concentration data for Test No. 2 were determined to be accurate. The additional instrument calibration data are presented in Appendix 5 (the additional high gas calibration check occurred at 12:41 PM on 2/17/16).

Upon completion of this emissions testing project, a post calibration was performed on the Nutech Model 2010 sampling console that was used for USEPA Methods 4 and 5/202 test periods. The Y-Variation for one (1) out of the three (3) critical orifices was slightly over the 2.00% difference limit. The initial post-test calibration was performed by a newer technician at DES and a second calibration was performed by a more experienced DES employee without making any adjustments to the Nutech Model 2010 sampling console. The second calibration passed the 2.00% difference limit for all three (3) critical orifices. Both post-test dry gas meter calibration sheets are provided in Appendix 6.

Table 6.1 Measured exhaust gas conditions and NOx, CO, and VOC emission rates
Engine No. 1 (EUICENGINE1, SN: GZJ00469)

Test No. Test date Test period (24-hr clock)	1 2/10/16 745 - 845	2 2/10/16 919 - 1019	3 2/10/16 1050 - 1150	Three Test Average
Fuel flowrate (scfm)	564	567	562	564
Generator output (kW)	1,640	1,643	1,647	1,643
Engine output (bhp)	2,290	2,295	2,300	2,295
LFG methane content (%)	50.7	50.7	50.7	50.7
LFG LHV heat content (Btu/scf)	461	461	461	461
Air / Fuel Ratio	8.2	8.2	8.2	8.2
Inlet Pressure (psi)	2.29	2.33	2.33	2.32
Exhaust Gas Composition				
CO_2 content (% vol)	11.4	11.4	11.4	11.4
O_2 content (% vol)	8.3	8.3	8.3	8.3
Moisture (% vol)	12.1	9.82	10.8	10.9
Exhaust gas temperature (°F)	941	935	934	938
Exhaust gas flowrate (dscfm)	4,360	4,454	4,401	4,405
Exhaust gas flowrate (scfm)	4,895	4,967	4,936	4,933
Nitrogen Oxides				
NOx conc. (ppmvd)	81.3	84.2	87.1	84.2
NOx emissions (g/bhp*hr)	0.50	0.53	0.54	0.53
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NOx emissions (lb/hr)	2.54	2.69	2.75	2.66
Permitted emissions (lb/hr)	-	-	-	3.0
Carbon Monoxide				
CO conc. (ppmvd)	632	628	627	629
CO emissions (g/bhp*hr)	2.38	2.41	2.38	2.39
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	12.0	12.2	12.1	12.1
Permitted emissions (lb/hr)	-	-	-	16.3
Volatile Organic Compounds				
VOC conc. (ppmv)	16.6	16.9	17.7	17.1
VOC emissions (g/bhp*hr)	0.11	0.11	0.12	0.11
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.56	0.58	0.60	0.58
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.2 Measured exhaust gas conditions and NOx, CO, and VOC emission rates Engine No. 2 (EUICENGINE2, SN: GZJ00464)

Test No. Test date Test period (24-hr clock)	1 2/10/16 1223 - 1323	2 2/10/16 1349 - 1449	3 2/10/16 1518 - 1618	Three Test Average
Fuel flowrate (scfm)	571	570	568	570
Generator output (kW)	1,654	1,647	1,644	1,648
Engine output (bhp)	2,311	2,300	2,296	2,302
LFG methane content (%)	50.8	50.9	50.9	50.9
LFG LHV heat content (Btu/scf)	462	463	463	463
Air / Fuel Ratio	8.4	8.4	8.4	8.4
Inlet Pressure (psi)	2.61	2.62	2.62	2.62
Exhaust Gas Composition				
CO_2 content (% vol)	11.3	11.3	11.4	11.3
O_2 content (% vol)	8.4	8.4	8.4	8.4
Moisture (% vol)	11.5	10.3	11.6	11.1
Exhaust gas temperature (°F)	949	952	951	950
Exhaust gas flowrate (dscfm)	4,516	4,481	4,475	4,491
Exhaust gas flowrate (scfm)	5,071	5,034	5,065	5,056
Nitrogen Oxides				
NOx conc. (ppmvd)	81.5	81.5	83.2	82.0
NOx emissions (g/bhp*hr)	0.52	0.52	0.53	0.52
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NOx emissions (lb/hr)	2.64	2.62	2.67	2.64
Permitted emissions (lb/hr)	-	-	-	3.0
Carbon Monoxide				
CO conc. (ppmvd)	709	710	715	712
CO emissions (g/bhp*hr)	2.74	2.74	2.76	2.75
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	14.0	13.9	14.0	13.9
Permitted emissions (lb/hr)	-	-	-	16.3
Volatile Organic Compounds				
VOC conc. (ppmv)	18.3	18.4	18.2	18.3
VOC emissions (g/bhp*hr)	0.13	0.13	0.13	0.13
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.64	0.64	0.63	0.64
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.3 Measured exhaust gas conditions and NOx, CO, and VOC emission rates
Engine No. 3 (EUICENGINE3, SN: GZJ00467)

Test No. Test date Test period (24-hr clock)	1 2/11/16 825 - 925	2 2/11/16 1004 - 1104	3 2/11/16 1126 - 1226	Three Test Average
Fuel flowrate (scfm)	571	576	575	574
Generator output (kW)	1,639	1,641	1,642	1,640
Engine output (bhp)	2,289	2,292	2,293	2,292
LFG methane content (%)	50.3	50.2	50.1	50.2
LFG LHV heat content (Btu/scf)	458	457	456	457
Air / Fuel Ratio	8.0	8.0	8.0	8.0
Inlet Pressure (psi)	2.77	2.75	2.77	2.76
Exhaust Gas Composition				
CO_2 content (% vol)	11.4	11.3	11.4	11.4
O_2 content (% vol)	8.3	8.4	8.4	8.4
Moisture (% vol)	11.0	10.0	12.1	11.0
Exhaust gas temperature (°F)	929	929	929	929
Exhaust gas flowrate (dscfm)	4,641	4,636	4,526	4,601
Exhaust gas flowrate (scfm)	5,185	5,211	5,151	5,182
Nitrogen Oxides				
NO_X conc. (ppmvd)	77.1	75.7	76.1	76.3
NO_X emissions (g/bhp*hr)	0.51	0.50	0.49	0.50
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO_X emissions (lb/hr)	2.56	2.52	2.47	2.52
Permitted emissions (lb/hr)	-	-	-	3.0
Carbon Monoxide				
CO conc. (ppmvd)	633	633	633	633
CO emissions (g/bhp*hr)	2.54	2.54	2.47	2.52
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	12.8	12.8	12.5	12.7
Permitted emissions (lb/hr)	-	-	-	16.3
Volatile Organic Compounds				
VOC conc. (ppmv)	19.1	18.2	18.2	18.5
VOC emissions (g/bhp*hr)	0.14	0.13	0.13	0.13
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.68	0.65	0.64	0.66
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.4 Measured exhaust gas conditions and NOx, CO, and VOC emission rates
Engine No. 4 (EUICENGINE4, SN: GZJ00466)

Test No. Test date Test period (24-hr clock)	1 2/11/16 1259 - 1359	2 2/11/16 1431 - 1531	3 2/11/16 1649 - 1749	Three Test Average
Fuel flowrate (scfm)	574	577	577	576
Generator output (kW)	1,642	1,648	1,642	1,644
Engine output (bhp)	2,294	2,302	2,293	2,296
LFG methane content (%)	50.2	50.3	50.2	50.2
LFG LHV heat content (Btu/scf)	457	458	457	457
Air / Fuel Ratio	8.1	8.2	8.1	8.1
Inlet Pressure (psi)	2.62	2.62	2.63	2.62
Exhaust Gas Composition				
CO_2 content (% vol)	11.5	10.9	11.5	11.3
O_2 content (% vol)	8.2	8.2	8.2	8.2
Moisture (% vol)	11.6	11.3	11.7	11.5
Exhaust gas temperature (°F)	929	927	925	927
Exhaust gas flowrate (dscfm)	4,567	4,574	4,536	4,559
Exhaust gas flowrate (scfm)	5,157	5,168	5,135	5,153
Nitrogen Oxides				
NO_X conc. (ppmvd)	84.8	85.2	85.8	85.3
NO_X emissions (g/bhp*hr)	0.55	0.55	0.55	0.55
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO_X emissions (lb/hr)	2.78	2.79	2.79	2.79
Permitted emissions (lb/hr)	-	-	-	3.0
Carbon Monoxide				
CO conc. (ppmvd)	730	721	724	725
CO emissions (g/bhp*hr)	2.88	2.84	2.83	2.85
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	14.5	14.4	14.3	14.4
Permitted emissions (lb/hr)	-	-	-	16.3
Volatile Organic Compounds				
VOC conc. (ppmv)	18.8	19.8	20.6	19.8
VOC emissions (g/bhp*hr)	0.13	0.14	0.14	0.14
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.67	0.70	0.73	0.70
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.5 Measured exhaust gas conditions and NOx, CO, and VOC emission rates
Engine No. 5 (EUICENGINE5, SN: GZJ00462)

Test No. Test date Test period (24-hr clock)	1 2/8/16 858 - 958	2 2/8/16 1042 - 1142	3 2/8/16 1209 - 1309	Three Test Average
Fuel flowrate (scfm)	572	572	575	573
Generator output (kW)	1,640	1,638	1,650	1,643
Engine output (bhp)	2,291	2,288	2,305	2,295
LFG methane content (%)	51.6	51.5	51.5	51.5
LFG LHV heat content (Btu/scf)	470	469	469	469
Air / Fuel Ratio	8.6	8.7	8.6	8.6
Inlet Pressure (psi)	2.40	2.34	2.33	2.36
Exhaust Gas Composition				
CO_2 content (% vol)	11.4	11.4	11.4	11.4
O_2 content (% vol)	8.3	8.3	8.3	8.3
Moisture (% vol)	6.7	9.7	10.6	9.0
Exhaust gas temperature (°F)	905	903	897	902
Exhaust gas flowrate (dscfm)	4,512	4,513	4,520	4,515
Exhaust gas flowrate (scfm)	4,915	5,024	5,060	5,000
Nitrogen Oxides				
NO_X conc. (ppmvd)	79.8	79.8	74.6	78.1
NO_X emissions (g/bhp*hr)	0.51	0.51	0.48	0.50
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO_X emissions (lb/hr)	2.58	2.58	2.42	2.53
Permitted emissions (lb/hr)	-	-	-	3.0
Carbon Monoxide				
CO conc. (ppmvd)	855	859	848	854
CO emissions (g/bhp*hr)	3.33	3.36	3.29	3.33
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	16.8	16.9	16.7	16.8
Permitted emissions (lb/hr)	-	-	-	16.3
Volatile Organic Compounds				
VOC conc. (ppmv)	20.1	21.3	21.7	21.1
VOC emissions (g/bhp*hr)	0.13	0.15	0.15	0.14
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.68	0.74	0.76	0.72
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.6 Measured exhaust gas conditions and NOx, CO, and VOC emission rates
Engine No. 6 (EUICENGINE6, SN: GZJ00468)

Test No. Test date Test period (24-hr clock)	1 2/8/16 1336 - 1436	2 2/8/16 1505 - 1605	3 2/8/16 1633 - 1733	Three Test Average
Fuel flowrate (scfm)	553	554	556	554
Generator output (kW)	1,659	1,652	1,645	1,652
Engine output (bhp)	2,317	2,307	2,298	2,307
LFG methane content (%)	51.6	51.4	51.4	51.5
LFG LHV heat content (Btu/scf)	470	468	468	469
Air / Fuel Ratio	8.4	8.4	8.4	8.4
Inlet Pressure (psi)	2.44	2.47	2.50	2.47
Exhaust Gas Composition				
CO_2 content (% vol)	11.4	11.4	11.4	11.4
O_2 content (% vol)	8.3	8.3	8.3	8.3
Moisture (% vol)	11.7	10.5	13.2	11.8
Exhaust gas temperature (°F)	930	935	934	932
Exhaust gas flowrate (dscfm)	4,237	4,253	4,266	4,252
Exhaust gas flowrate (scfm)	4,767	4,827	4,917	4,837
Nitrogen Oxides				
NO_X conc. (ppmvd)	78.4	79.4	75.5	77.8
NO_X emissions (g/bhp*hr)	0.47	0.48	0.46	0.47
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO_X emissions (lb/hr)	2.38	2.42	2.31	2.37
Permitted emissions (lb/hr)	-	-	-	3.0
Carbon Monoxide				
CO conc. (ppmvd)	747	749	739	745
CO emissions (g/bhp*hr)	2.71	2.73	2.72	2.72
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	13.8	13.9	13.8	13.8
Permitted emissions (lb/hr)	-	-	-	16.3
Volatile Organic Compounds				
VOC conc. (ppmv)	22.7	23.0	23.4	23.1
VOC emissions (g/bhp*hr)	0.15	0.15	0.16	0.15
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.74	0.76	0.79	0.77
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.7 Measured exhaust gas conditions and NOx, CO, and VOC emission rates
Engine No. 7 (EUICENGINE7, SN: GZJ00463)

Test No. Test date Test period (24-hr clock)	1 2/09/16 740 - 840	2 2/09/16 905 - 1005	3 2/09/16 1030 - 1130	Three Test Average
Fuel flowrate (scfm)	558	562	561	560
Generator output (kW)	1,646	1,639	1,641	1,642
Engine output (bhp)	2,299	2,290	2,293	2,294
LFG methane content (%)	51.4	51.1	51.2	51.2
LFG LHV heat content (Btu/scf)	468	465	466	466
Air / Fuel Ratio	8.6	8.5	8.5	8.5
Inlet Pressure (psi)*	50.3	50.2	50.1	50.2
Exhaust Gas Composition				
CO_2 content (% vol)	11.2	11.2	11.2	11.2
O_2 content (% vol)	8.6	8.5	8.5	8.5
Moisture (% vol)	12.6	8.0	12.7	11.1
Exhaust gas temperature (°F)	915	923	922	918
Exhaust gas flowrate (dscfm)	4,356	4,327	4,262	4,315
Exhaust gas flowrate (scfm)	4,856	4,827	4,883	4,855
Nitrogen Oxides				
NO_X conc. (ppmvd)	74.6	74.3	74.5	74.5
NO_X emissions (g/bhp*hr)	0.46	0.46	0.45	0.46
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO_X emissions (lb/hr)	2.33	2.31	2.28	2.30
Permitted emissions (lb/hr)	-	-	-	3.0
Carbon Monoxide				
CO conc. (ppmvd)	704	708	704	705
CO emissions (g/bhp*hr)	2.64	2.65	2.59	2.63
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	13.4	13.4	13.1	13.3
Permitted emissions (lb/hr)	-	-	-	16.3
Volatile Organic Compounds				
VOC conc. (ppmv)	22.5	22.7	22.7	22.6
VOC emissions (g/bhp*hr)	0.15	0.15	0.15	0.15
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.75	0.75	0.76	0.75
Permitted emissions (lb/hr)	-	-	-	1.0

* Engine header inlet pressure (psi) was not recorded for EUICENGINE7. Instead, engine manifold inlet pressure (psi) was recorded.

Table 6.8 Measured exhaust gas conditions and NOx, CO, and VOC emission rates
Engine No. 8 (EUICENGINE8, SN: GZJ00465)

Test No.	1	2	3	
Test date	2/09/16	2/09/16	2/09/16	Three Test
Test period (24-hr clock)	1244 - 1344	1407 - 1507	1532 - 1632	Average
Fuel flowrate (scfm)	548	548	551	549
Generator output (kW)	1,651	1,644	1,644	1,646
Engine output (bhp)	2,306	2,296	2,296	2,299
LFG methane content (%)	51.9	51.4	51.2	51.5
LFG LHV heat content (Btu/scf)	472	468	466	469
Air / Fuel Ratio	8.7	8.7	8.6	8.7
Inlet Pressure (psi)	2.40	2.40	2.40	2.40
Exhaust Gas Composition				
CO_2 content (% vol)	11.1	11.1	11.1	11.1
O_2 content (% vol)	8.7	8.7	8.7	8.7
Moisture (% vol)	10.1	10.3	11.4	10.6
Exhaust gas temperature (°F)	904	916	912	911
Exhaust gas flowrate (dscfm)	4,406	4,298	4,253	4,319
Exhaust gas flowrate (scfm)	4,907	4,821	4,797	4,842
Nitrogen Oxides				
NO_X conc. (ppmvd)	79.1	76.5	73.7	76.4
NO_X emissions (g/bhp*hr)	0.49	0.47	0.44	0.47
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO_X emissions (lb/hr)	2.50	2.36	2.25	2.37
Permitted emissions (lb/hr)	-	-	-	3.0
Carbon Monoxide				
CO conc. (ppmvd)	668	666	666	667
CO emissions (g/bhp*hr)	2.53	2.47	2.44	2.48
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	12.9	12.5	12.4	12.6
Permitted emissions (lb/hr)	-	-	-	16.3
Volatile Organic Compounds				
VOC conc. (ppmv)	24.5	24.5	24.6	24.5
VOC emissions (g/bhp*hr)	0.16	0.16	0.16	0.16
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.83	0.81	0.81	0.82
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.9 Measured exhaust gas conditions and HCOH and SO_2 emission rates
Engine No. 1 (EUICENGINE1, SN: GZJ00469)

Test No.	1	2	3	
Test date	2/10/16	2/10/16	2/10/16	Three Test
Test period (24-hr clock)	745 - 845	919 - 1019	1050 - 1150	Average
Fuel flowrate (scfm)	564	567	562	564
Generator output (kW)	1,640	1,643	1,647	1,643
Engine output (bhp)	2,290	2,295	2,300	2,295
LFG methane content (%)	50.7	50.7	50.7	50.7
LFG LHV heat content (Btu/scf)	461	461	461	461
Air / Fuel Ratio	8.2	8.2	8.2	8.2
Inlet Pressure (psi)	2.29	2.33	2.33	2.32
Exhaust Gas Composition				
CO_2 content (% vol)	11.4	11.4	11.4	11.4
O_2 content (% vol)	8.3	8.3	8.3	8.3
Moisture (% vol)	12.1	9.8	10.8	10.9
Exhaust gas temperature (°F)	941	935	934	938
Exhaust gas flowrate (dscfm)	4,360	4,454	4,401	4,405
Exhaust gas flowrate (scfm)	4,895	4,967	4,936	4,933
Formaldehyde				
HCOH conc. (ppmv)	75.6	74.8	74.6	75.0
HCOH emissions (g/bhp*hr)	0.34	0.34	0.34	0.34
HCOH emissions (lb/hr)	1.73	1.74	1.72	1.73
Permitted emissions (lb/hr)	-	-	-	2.07
Sulfur Dioxide				
SO_2 conc. (ppmvd)	16.8	18.5	17.3	17.5
SO_2 emissions (lb/hr)	0.73	0.82	0.76	0.77
Permitted emissions (lb/hr)	-	-	-	1.57

Table 6.10 Measured exhaust gas conditions and PM/PM_{10} emission rates and opacity Engine No. 3 (EUICENGINE3, SN: GZJ00467)

Test No. Test date Test period (24-hr clock)	1 2/15/16 1002 - 1133	2 2/15/16 1227 - 1506	3 2/15/16 1603 - 1748	Three Test Average
Fuel flowrate (scfm)	573	569	577	573
Generator output (kW)	1,643	1,637	1,649	1,643
Engine output (bhp)	2,295	2,287	2,303	2,295
LFG methane content (%)	50.0	50.0	49.8	49.9
LFG LHV heat content (Btu/scf)	455	455	453	454
Air / Fuel Ratio	8.1	8.1	8.0	8.1
Inlet Pressure (psi)	2.72	2.69	2.69	2.70
<u>Exhaust Gas Composition</u>				
CO_2 content (% vol)	11.4	11.5	11.5	11.5
O_2 content (% vol)	8.2	8.2	8.2	8.2
Moisture (% vol)	11.3	11.3	11.1	11.2
Exhaust gas temperature (°F)	920	923	923	923
Exhaust gas flowrate (dscfm)	4,291	4,345	4,496	4,377
Exhaust gas flowrate (scfm)	4,838	4,895	5,059	4,931
<u>Particulate Matter</u>				
Sampled volume (dscf)	45.2	45.8	46.9	46.0
Filterable catch (mg)	12.0	2.1	11.4	8.5
Condensable catch (mg)	10.7	10.4	12.1	11.1
Total PM/PM10 catch (mg)	22.7	12.5	23.5	19.6
PM/PM10 emissions (g/bhp*hr)	0.06	0.03	0.06	0.05
Permitted emissions (g/bhp*hr)	-	-	-	0.24
PM/PM10 emissions (lb/hr)	0.28	0.16	0.30	0.25
Permitted emissions (lb/hr)	-	-	-	1.2
<u>Opacity</u>				
Opacity emissions (%)	0	0	0	0
Permitted emissions (%)	-	-	-	10

Table 6.11 Measured exhaust gas conditions and NOx, CO, and SO_2 emission rates EUFLARE4

Test No.	1	2	3	
Test date	2/17/16	2/17/16	2/17/16	Three Test
Test period (24-hr clock)	920 - 1020	1114 - 1214	1328 - 1428	Average
Fuel flowrate (scfm)	2,995	3,009	2,948	2,984
LFG methane content (%)	52.4	52.3	52.1	52.3
LFG LHV heat content (Btu/scf)	477	476	474	476
Heat input rate (lb/MMBtu)	85.6	85.8	83.8	85.1
Exhaust Gas Composition				
CO_2 content (% vol)	8.21	7.76	8.10	8.02
O_2 content (% vol)	11.9	12.5	12.0	12.1
Moisture (% vol)	8.88	8.41	8.19	8.49
Exhaust gas temperature (°F)	1,437	1,445	1,464	1,450
Exhaust gas flowrate (dscfm)	29,130	27,153	28,319	28,201
Nitrogen Oxides				
NO_X conc. (ppmvd)	16.6	15.3	16.5	16.1
NO_X emissions (lb/hr)	3.48	2.97	3.35	3.27
NO_X emissions (lb/MMBtu)	0.04	0.03	0.04	0.04
Permitted emissions (lb/MMBtu)	-	-	-	0.06
Carbon Monoxide				
CO conc. (ppmvd)	42.7	81.4	1.3	41.8
CO emissions (lb/hr)	5.43	9.65	0.16	5.08
CO emissions (lb/MMBtu)	0.06	0.11	0.002	0.06
Permitted emissions (lb/MMBtu)	-	-	-	0.2
Sulfur Dioxide				
SO_2 conc. (ppmvd)	7.72	7.08	3.73	6.18
SO_2 emissions (lb/hr)	2.24	1.92	1.06	1.74
Permitted emissions (lb/hr)	-	-	-	8.1

Table 6.12 Measured exhaust gas conditions and NOx, CO, and SO_2 emission rates EUFLARE6

Test No. Test date Test period (24-hr clock)	1 2/18/16 1040 - 1140	2 2/18/16 1203 - 1303	3 2/18/16 1327 - 1427	Three Test Average
Fuel flowrate (scfm)	5,512	5,515	5,725	5,584
LFG methane content (%)	51.7	51.7	52.3	51.9
LFG LHV heat content (Btu/scf)	471	471	476	472
Heat input rate (lb/MMBtu)	155	156	163	158
Exhaust Gas Composition				
CO_2 content (% vol)	8.63	8.87	8.87	8.79
O_2 content (% vol)	11.3	11.0	11.0	11.1
Moisture (% vol)	7.80	8.02	7.52	7.78
Exhaust gas temperature (°F)	1,603	1,625	1,631	1,617
Exhaust gas flowrate (dscfm)	53,200	50,115	45,690	49,668
Nitrogen Oxides				
NO_X conc. (ppmvd)	19.8	20.4	20.5	20.2
NO_X emissions (lb/hr)	7.56	7.34	6.70	7.20
NO_X emissions (lb/MMBtu)	0.05	0.05	0.04	0.05
Permitted emissions (lb/MMBtu)	-	-	-	0.06
Carbon Monoxide				
CO conc. (ppmvd)	2.84	1.63	0.86	1.78
CO emissions (lb/hr)	0.66	0.36	0.17	0.40
CO emissions (lb/MMBtu)	0.004	0.002	0.001	0.003
Permitted emissions (lb/MMBtu)	-	-	-	0.2
Sulfur Dioxide				
SO_2 conc. (ppmvd)	9.03	9.11	10.1	9.42
SO_2 emissions (lb/hr)	4.80	4.56	4.62	4.66
Permitted emissions (lb/hr)	-	-	-	16.1