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**AIR QUALITY DIV.****AIR EMISSION TEST REPORT**

Title AIR EMISSION TEST REPORT FOR THE LANDFILL  
GAS FUELED INTERNAL COMBUSTION ENGINES  
OPERATED AT PINE TREE ACRES LANDFILL

Report Date April 8, 2015

Test Dates February 9-12, 2015

<b>Facility Information</b>	
Name	Pine Tree Acres, Inc.
Street Address	36600 29-Mile Rd.
City, County	Lenox Township, Macomb
SRN	N5984

<b>Facility Permit Information</b>	
Facility SRN:	N5984
ROP No. :	MI-ROP-N5984-2013

<b>Source Information – FGICENGINES, 8 CAT® Model G3520C IC Engines</b>				
Emission Unit	EUICENGINE1	EUICENGINE2	EUICENGINE3	EUICENGINE4
Serial Number	GZJ00469	GZJ00464	GZJ00467	GZJ00466
Emission Unit	EUICENGINE5	EUICENGINE6	EUICENGINE7	EUICENGINE8
Serial Number	GZJ00462	GZJ00468	GZJ00463	GZJ00465

<b>Testing Contractor</b>	
Company	Derenzo and Associates, Inc.
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1412014



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. County Macomb

Source Address 36600 29 Mile Road City Lenox Township

AQD Source ID (SRN) N5984 ROP No. MI-ROP-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**

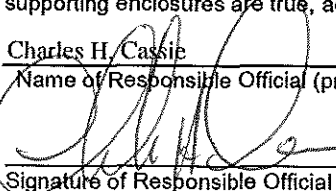
Reporting period (provide inclusive dates): From 2/9/2015 To 2/12/2015

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

Certification for Air Emissions Test Report associated with compliance testing of emission units FGICENGINES,  
as specified by Renewable Operating Permit No. MI-ROP-N5984-2013. Testing was performed February 9-12, 2015.

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 of Responsible Official 4-9-15 Date

\* Photocopy this form as needed.

## **Derenzo and Associates, Inc.**

*Environmental Consultants*

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### AIR EMISSION TEST REPORT FOR THE LANDFILL GAS FUELED INTERNAL COMBUSTION ENGINES OPERATED AT PINE TREE ACRES LANDFILL

#### **1.0 INTRODUCTION**

Pine Tree Acres, Inc. operates eight (8) Caterpillar (CAT®) Model No. G3520C landfill gas (LFG) fueled reciprocating internal combustion engines (RICE) at the Pine Tree Acres (PTA) Landfill gas to energy facility (Facility SRN: N5984) in Lenox Township, Macomb County, Michigan. The facility has been issued Renewable Operating Permit (ROP) No. MI-ROP-N5984-2013 by the Michigan Department of Environmental Quality (MDEQ).

The CAT® Model No. G3520C engines are identified in ROP No. MI-ROP-N5984-2013 as Emission Unit ID: EUIENGINE1 through 8 (Flexible Group ID: FGICENGINES).

Air emission compliance testing was performed to demonstrate ongoing compliance with 40 CFR 60, Subpart JJJJ and FGICENGINES Special Condition No. V.2. of ROP No. MI-ROP-N5984-2013 which states:

*...the permittee shall conduct an initial performance test for each engine in FGICENGINES within one year after startup of the engine and every 8,760 hours of operation (as determined through the use of a non-resettable hour meter) or three years, whichever occurs first, to demonstrate compliance with the emission limits in 40 CFR 60.4233(e)...*

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 Daniel Wilson and Kalan Briggs performed the field sampling and measurements. Testing was completed February 9-12, 2015, within 8,760 hours of the previous performance tests completed April 8-10, 2014.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan that was reviewed and approved by the MDEQ in the January 16, 2015 test plan approval letter. MDEQ representatives Mr. Nathan Hude and Mr. David Patterson observed portions of the testing project.

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Questions regarding this emission test report should be directed to:

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

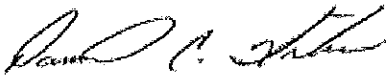
Mr. Steve Walters  
Environmental Engineer  
Waste Management of Michigan, Inc.  
36600 29-Mile Rd.  
Lenox Twp., MI 48048  
Ph: (586) 634-8085

**Report Certification**

This test report was prepared by Derenzo, Associates, Inc. based on field sampling data collected by Derenzo and Associates, Inc. Facility process data were collected and provided Waste Management employees or representatives. This test report has been reviewed by Waste Management 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:

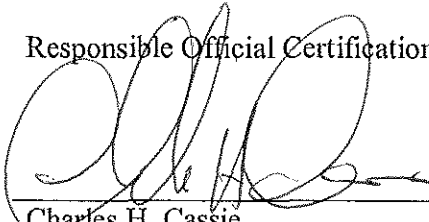


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Daniel Wilson  
Environmental Consultant  
Derenzo and Associates, Inc.

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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Charles H. Cassie  
Senior District Manager  
Waste Management of Michigan, Inc.

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

### **2.1 General Process Description**

LFG containing methane is generated in the PTA 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 PTA landfill gas-to-energy facility where it is treated and used as fuel for the eight (8) 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 with vertical release points. The eight (8) CAT® Model G3520C RICE exhaust stacks are identical.

The exhaust duct sampling ports for the CAT® Model G3520C engines (EUIENGINE1 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). 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.

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 ROP No. MI-ROP-N5984-2013 and 40 CFR Part 60 Subpart JJJJ require PTA Landfill to test each RICE (EUIENGINE1 through 8) for carbon monoxide (CO), nitrogen oxides (NOx) and volatile organic compounds (VOCs) every 8,760 hours of operation. Therefore, each RICE (EUIENGINE1 through 8) was sampled for CO, NOx and VOC emissions and exhaust gas oxygen (O<sub>2</sub>) and carbon dioxide (CO<sub>2</sub>) content.

#### **3.2 Operating Conditions During the Compliance Tests**

The testing was performed while the engine/generator sets were operated at maximum operating conditions (1,600 kW electricity output +/- 10%). PTA Landfill representatives monitored and recorded the kW output in 15-minute increments for each test period. The RICE generator kW output ranged between 1,611 and 1,659 kW during the test periods.

Fuel flowrate (cubic feet per minute) and fuel methane content (%) were also recorded by PTA Landfill representatives in 15-minute increments for each test period. The RICE fuel consumption rate ranged between 552 and 596 scfm and fuel methane content ranged between 46.09 and 48.62% during the test periods.

The MDEQ requested that the hydrogen sulfide content of the landfill gas after the treatment system be recorded once during each day of testing. Testing occurred over a four-day span and the measured LFG hydrogen sulfide content ranged between 100-150 ppm.

Appendix B provides operating records provided by PTA Landfill representatives for the test periods.

Engine output (bhp) cannot be measured directly and was calculated based on the recorded electricity output, the calculated CAT® Model G3520C generator efficiency (96.1%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp).

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

A lower heating value of 910 Btu/scf was used to calculate the LFG heating value.

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 were each sampled for three (3) one-hour test periods during the compliance testing performed February 9-12, 2015.

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Table 3.2 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.

Results of the engine performance tests demonstrate compliance with emission limits specified in 40 CFR 60, Subpart JJJJ and ROP No. 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.

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Table 3.1 Average engine operating conditions during the test periods

Emission Unit	Gen. Output (kW)	Engine Output (bHp)	Fuel Use (scfm)	LFG CH <sub>4</sub> Content (%)	LFG Btu Content (Btu/scf)	Exhaust Temp. (°F)	Air to Fuel Ratio	Inlet Press. (psi)
EUICENGINE1	1,632	2,278	556	48.4	440	931	8.0	2.33
EUICENGINE2	1,643	2,293	572	47.3	430	932	8.2	2.64
EUICENGINE3	1,630	2,274	566	47.2	430	929	7.9	2.78
EUICENGINE4	1,632	2,277	569	47.3	430	913	7.8	2.69
EUICENGINE5	1,635	2,281	577	47.7	434	946	7.9	2.50
EUICENGINE6	1,633	2,279	586	46.9	427	938	7.9	2.77
EUICENGINE7	1,635	2,281	569	46.9	427	927	7.9	2.62
EUICENGINE8	1,624	2,266	573	46.5	423	932	7.8	2.55

Table 3.2 Average measured emission rates for each tested PTA Landfill RICE (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)
EUICENGINE1	10.0	2.00	2.19	0.44	0.72	0.14
EUICENGINE2	11.6	2.29	2.35	0.47	0.55	0.11
EUICENGINE3	10.1	2.01	2.25	0.45	0.63	0.13
EUICENGINE4	11.8	2.34	2.39	0.48	0.64	0.13
EUICENGINE5	10.7	2.12	2.09	0.41	0.67	0.13
EUICENGINE6	13.2	2.63	2.38	0.47	0.72	0.14
EUICENGINE7	11.7	2.33	2.34	0.47	0.54	0.11
EUICENGINE8	10.9	2.18	2.38	0.48	0.59	0.12
Emission Limit	16.3	3.3	3.0	0.6	1.0	1.0

#### 4.0 SAMPLING AND ANALYTICAL PROCEDURES

Test protocols for the air emission testing were 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 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 NDIR instrumental analyzers.
USEPA Method ALT-096	Exhaust gas VOC (as NMHC) concentration was determined using flame ionization analyzers equipped with GC columns.

#### **4.2 Exhaust Gas Velocity Determination (USEPA Method 2)**

The RICE exhaust stack gas velocities and volumetric flow rates were determined using USEPA Method 2 prior to and after each test. 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 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 streams were 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 4900 single beam single wavelength (SBSW) infrared gas analyzer. The O<sub>2</sub> content of the exhaust was monitored using a Servomex 4900 gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the IC engine 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> 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 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 Fuji Model ZRF NDIR 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 ALT-096)**

VOC emission rate was determined by measuring the nonmethane hydrocarbon (NMHC) concentration in the exhaust gas for each RICE. NMHC pollutant concentration was determined using TEI Model 55i Methane / Nonmethane hydrocarbon analyzer.

Throughout each one-hour test period, a continuous sample of the IC engine exhaust gas was extracted from the stack using the Teflon® heated sample line described in Section 4.3 of this document, and delivered to the instrumental analyzer. The sampled gas was not conditioned prior to being introduced to the analyzer; therefore, the measurement of NMHC concentration corresponds to standard wet gas conditions. Instrument NMHC (VOC) response for the analyzer was recorded on an ESC Model 8816 data logging 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 instrument was calibrated using mid-range calibration 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/OC 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 -8.01% of the expected value, i.e., within 10% of the expected value as required by Method 7E).

### **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 55i analyzer exhibited the longest system response time at 180 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 (on July 3, 2014) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivered calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

### **5.4 Instrumental Analyzer Interference Check**

The instrumental analyzers used to measure NO<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 April 3, 2012), 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 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.

### **5.6 Determination of Exhaust Gas Stratification**

A stratification test for each IC engine exhaust stack was performed during the performance test sampling periods. 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 data for each IC engine exhaust stack gas indicate 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 stack gas of each IC engine was considered to be unstratified and the compliance test sampling was performed at a single sampling location within each IC engine exhaust stack.

### **5.7 Meter Box Calibrations**

The Clean Air Model #3080 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 Clean Air metering consoles were calibrated using a NIST traceable Omega<sup>®</sup> Model CL 23A temperature calibrator.

Appendix F presents test equipment quality assurance data (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, stratification checks, cyclonic flow determinations sheets, Pitot tube and probe assembly calibration records).

## **6.0 RESULTS**

### **6.1 Test Results and Allowable Emission Limits**

Engine operating data and air pollutant emission measurement results for each one hour test period are presented in Tables 6.1 through 6.8.

The measured air pollutant concentrations and emission rates for Engine Nos. 1 through 8 (EUCENGINE1 through 8) are less than the allowable limits specified in ROP No. MI-ROP-N5984-2013 for the engines:

- 3.0 lb/hr and 0.6 g/bhp-hr for NO<sub>x</sub>;
- 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.

### **6.2 Variations from Normal Sampling Procedures or Operating Conditions**

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

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Table 6.1 Measured exhaust gas conditions and NO<sub>x</sub>, CO and VOC air pollutant emission rates  
PTA Landfill Engine No. 1 (EUCENGINE1) (SN: GZJ00469)

Test No.	1	2	3	
Test date	2/11/15	2/11/15	2/11/15	Three Test
Test period (24-hr clock)	1415 - 1515	1545 - 1645	1715 - 1815	Average
Fuel flowrate (scfm)	557	555	556	556
Generator output (kW)	1,639	1,631	1,627	1,632
Engine output (bhp)	2,287	2,276	2,270	2,278
LFG methane content (%)	48.6	48.5	48.3	48.4
LFG LHV heat content (Btu/scf)	442	441	440	441
Air / Fuel Ratio	8.0	8.0	8.0	8.0
Inlet Pressure (psi)	2.33	2.33	2.33	2.33
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	11.9	11.9	11.9	11.9
O <sub>2</sub> content (% vol)	8.13	8.12	8.11	8.12
Moisture (% vol)	11.9	11.4	11.2	11.5
Exhaust gas temperature (°F)	930	929	934	931
Exhaust gas flowrate (dscfm)	4,350	4,354	4,351	4,352
Exhaust gas flowrate (scfm)	4,929	4,895	4,863	4,896
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	70.2	70.0	70.8	70.3
NO <sub>x</sub> emissions (g/bhp*hr)	0.43	0.44	0.44	0.44
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO <sub>x</sub> emissions (lb/hr)	2.19	2.18	2.21	2.19
Permitted emissions (lb/hr)	-	-	-	3.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	528	528	529	528
CO emissions (g/bhp*hr)	1.99	2.00	2.01	2.00
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	10.0	10.0	10.0	10.0
Permitted emissions (lb/hr)	-	-	-	16.3
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	22.9	20.9	20.9	21.6
VOC emissions (g/bhp*hr)	0.15	0.14	0.14	0.14
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.78	0.70	0.70	0.72
Permitted emissions (lb/hr)	-	-	-	1.0



Table 6.2 Measured exhaust gas conditions and NO<sub>x</sub>, CO and VOC air pollutant emission rates  
PTA Landfill Engine No. 2 (EUICENGINE2) (SN: GZJ00464)

Test No.	1	2	3	Three Test
Test date	2/12/15	2/12/15	2/12/15	Average
Test period (24-hr clock)	737 - 837	904 - 1004	1034 - 1134	
Fuel flowrate (scfm)	573	572	570	572
Generator output (kW)	1,641	1,642	1,648	1,643
Engine output (bhp)	2,289	2,291	2,299	2,293
LFG methane content (%)	47.4	47.3	47.1	47.3
LFG LHV heat content (Btu/scf)	431	430	429	430
Air / Fuel Ratio	8.2	8.2	8.2	8.2
Inlet Pressure (psi)	2.62	2.62	2.69	2.64
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	12.1	12.1	12.1	12.1
O <sub>2</sub> content (% vol)	7.99	7.91	7.97	7.96
Moisture (% vol)	8.5	11.1	11.2	10.3
Exhaust gas temperature (°F)	933	929	934	932
Exhaust gas flowrate (dscfm)	4,348	4,273	4,275	4,299
Exhaust gas flowrate (scfm)	4,821	4,809	4,812	4,814
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	76.3	77.5	75.4	76.4
NO <sub>x</sub> emissions (g/bhp*hr)	0.47	0.47	0.46	0.47
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO <sub>x</sub> emissions (lb/hr)	2.38	2.37	2.31	2.35
Permitted emissions (lb/hr)	-	-	-	3.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	614	618	618	617
CO emissions (g/bhp*hr)	2.31	2.28	2.27	2.29
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	11.7	11.5	11.5	11.6
Permitted emissions (lb/hr)	-	-	-	16.3
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	16.9	16.6	17.0	16.8
VOC emissions (g/bhp*hr)	0.11	0.11	0.11	0.11
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.56	0.55	0.56	0.55
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.3 Measured exhaust gas conditions and NO<sub>x</sub>, CO and VOC air pollutant emission rates  
PTA Landfill Engine No. 3 (EUIENGINE3) (SN: GZJ00467)

Test No.	1	2	3	Three Test
Test date	2/12/15	2/12/15	2/12/15	Average
Test period (24-hr clock)	1205 - 1305	1338 - 1438	1500 - 1600	
Fuel flowrate (scfm)	566	562	569	566
Generator output (kW)	1,631	1,629	1,629	1,630
Engine output (bhp)	2,276	2,274	2,273	2,274
LFG methane content (%)	47.2	47.2	47.2	47.2
LFG LHV heat content (Btu/scf)	430	430	430	430
Air / Fuel Ratio	7.9	7.9	7.9	7.9
Inlet Pressure (psi)	2.77	2.77	2.78	2.78
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	12.0	11.9	12.0	12.0
O <sub>2</sub> content (% vol)	8.12	8.11	8.11	8.11
Moisture (% vol)	11.3	11.1	11.1	11.2
Exhaust gas temperature (°F)	930	931	930	930
Exhaust gas flowrate (dscfm)	4,357	4,328	4,070	4,252
Exhaust gas flowrate (scfm)	4,906	4,870	4,582	4,786
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	73.8	74.3	73.5	73.9
NO <sub>x</sub> emissions (g/bhp*hr)	0.46	0.46	0.43	0.45
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO <sub>x</sub> emissions (lb/hr)	2.31	2.31	2.14	2.25
Permitted emissions (lb/hr)	-	-	-	3.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	542	542	545	543
CO emissions (g/bhp*hr)	2.05	2.04	1.93	2.01
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	10.3	10.2	9.7	10.1
Permitted emissions (lb/hr)	-	-	-	16.3
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	19.7	19.1	19.2	19.3
VOC emissions (g/bhp*hr)	0.13	0.13	0.12	0.13
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.66	0.64	0.60	0.63
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.4 Measured exhaust gas conditions and NO<sub>x</sub>, CO and VOC air pollutant emission rates  
PTA Landfill Engine No. 4 (EUCENGINE4) (SN: GZJ00466)

Test No.	1	2	3	
Test date	2/12/15	2/12/15	2/12/15	Three Test
Test period (24-hr clock)	1627 - 1727	1750 - 1850	1912 - 2012	Average
Fuel flowrate (scfm)	566	572	571	569
Generator output (kW)	1,635	1,627	1,633	1,632
Engine output (bhp)	2,282	2,271	2,279	2,277
LFG methane content (%)	47.2	47.3	47.4	47.3
LFG LHV heat content (Btu/scf)	430	430	431	430
Air / Fuel Ratio	7.9	7.8	7.9	7.9
Inlet Pressure (psi)	2.69	2.69	2.69	2.69
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	12.1	12.0	11.9	12.0
O <sub>2</sub> content (% vol)	7.99	8.02	8.00	8.00
Moisture (% vol)	11.3	11.5	11.5	11.4
Exhaust gas temperature (°F)	914	909	917	913
Exhaust gas flowrate (dscfm)	4,297	4,305	4,333	4,312
Exhaust gas flowrate (scfm)	4,850	4,865	4,897	4,871
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	78.8	77.3	75.8	77.3
NO <sub>x</sub> emissions (g/bhp*hr)	0.48	0.48	0.47	0.48
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO <sub>x</sub> emissions (lb/hr)	2.43	2.39	2.35	2.39
Permitted emissions (lb/hr)	-	-	-	3.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	628	625	624	626
CO emissions (g/bhp*hr)	2.34	2.35	2.35	2.34
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	11.8	11.7	11.8	11.8
Permitted emissions (lb/hr)	-	-	-	16.3
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	19.3	19.3	19.2	19.3
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	0.64	0.64
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.5 Measured exhaust gas conditions and NO<sub>x</sub>, CO and VOC air pollutant emission rates  
PTA Landfill Engine No. 5 (EUCENGINE5) (SN: GZJ00462)

Test No.	1	2	3	
Test date	2/10/15	2/10/15	2/11/15	Three Test
Test period (24-hr clock)	1318 - 1418	1455 - 1555	1228 - 1328	Average
Fuel flowrate (scfm)	585	583	563	577
Generator output (kW)	1,632	1,637	1,635	1,635
Engine output (bhp)	2,278	2,285	2,282	2,281
LFG methane content (%)	47.3	47.4	48.5	47.7
LFG LHV heat content (Btu/scf)	430	431	441	434
Air / Fuel Ratio	7.8	7.8	8.1	7.9
Inlet Pressure (psi)	2.55	2.55	2.40	2.50
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	12.0	12.1	11.9	12.0
O <sub>2</sub> content (% vol)	8.06	8.06	8.10	8.07
Moisture (% vol)	10.7	10.2	11.5	10.8
Exhaust gas temperature (°F)	955	956	928	946
Exhaust gas flowrate (dscfm)	4,533	4,391	4,326	4,417
Exhaust gas flowrate (scfm)	5,063	4,927	4,888	4,959
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	62.4	69.5	65.9	65.9
NO <sub>x</sub> emissions (g/bhp*hr)	0.40	0.43	0.41	0.41
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO <sub>x</sub> emissions (lb/hr)	2.03	2.19	2.04	2.09
Permitted emissions (lb/hr)	-	-	-	3.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	557	552	551	553
CO emissions (g/bhp*hr)	2.19	2.10	2.07	2.12
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	11.0	10.6	10.4	10.7
Permitted emissions (lb/hr)	-	-	-	16.3
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	17.2	16.8	25.5	19.8
VOC emissions (g/bhp*hr)	0.12	0.11	0.17	0.13
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.60	0.57	0.86	0.67
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.6 Measured exhaust gas conditions and NO<sub>x</sub>, CO and VOC air pollutant emission rates  
PTA Landfill Engine No. 6 (EUCENGINE6) (SN: GZJ00468)

Test No.	1	2	3	Three Test
Test date	2/10/15	2/10/15	2/10/15	Average
Test period (24-hr clock)	844 - 944	1013 - 1113	1142 - 1242	
Fuel flowrate (scfm)	588	587	583	586
Generator output (kW)	1,635	1,636	1,630	1,633
Engine output (bhp)	2,281	2,282	2,274	2,279
LFG methane content (%)	46.9	46.8	47.1	46.9
LFG LHV heat content (Btu/scf)	427	426	429	427
Air / Fuel Ratio	7.9	7.9	8.0	7.9
Inlet Pressure (psi)	2.77	2.77	2.77	2.77
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	12.1	12.0	12.0	12.1
O <sub>2</sub> content (% vol)	7.88	8.10	8.08	8.02
Moisture (% vol)	11.7	11.1	11.6	11.5
Exhaust gas temperature (°F)	943	937	937	939
Exhaust gas flowrate (dscfm)	4,308	4,498	4,484	4,430
Exhaust gas flowrate (scfm)	4,864	5,074	5,070	5,003
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	74.3	75.3	74.9	74.8
NO <sub>x</sub> emissions (g/bhp*hr)	0.46	0.48	0.48	0.47
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO <sub>x</sub> emissions (lb/hr)	2.29	2.43	2.41	2.38
Permitted emissions (lb/hr)	-	-	-	3.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	680	683	690	685
CO emissions (g/bhp*hr)	2.54	2.67	2.69	2.63
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	12.8	13.4	13.5	13.2
Permitted emissions (lb/hr)	-	-	-	16.3
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	20.6	21.4	21.1	21.0
VOC emissions (g/bhp*hr)	0.14	0.15	0.15	0.14
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.69	0.74	0.73	0.72
Permitted emissions (lb/hr)	-	-	-	1.0

Table 6.7 Measured exhaust gas conditions and NO<sub>x</sub>, CO and VOC air pollutant emission rates  
PTA Landfill Engine No. 7 (EUCENGINE7) (SN: GZJ00463)

Test No.	1	2	3	Three Test
Test date	2/09/15	2/09/15	2/09/15	Average
Test period (24-hr clock)	1345 - 1445	1510 - 1610	1645 - 1745	
Fuel flowrate (scfm)	567	569	570	569
Generator output (kW)	1,628	1,638	1,638	1,635
Engine output (bhp)	2,272	2,286	2,286	2,281
LFG methane content (%)	47.0	47.0	46.8	46.9
LFG LHV heat content (Btu/scf)	428	428	426	427
Air / Fuel Ratio	7.9	7.9	7.9	7.9
Inlet Pressure (psi)	2.62	2.62	2.62	2.62
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	12.2	12.1	12.2	12.2
O <sub>2</sub> content (% vol)	8.06	8.07	8.06	8.06
Moisture (% vol)	12.2	10.3	11.5	11.3
Exhaust gas temperature (°F)	926	927	928	927
Exhaust gas flowrate (dscfm)	4,287	4,323	4,324	4,311
Exhaust gas flowrate (scfm)	4,830	4,852	4,885	4,856
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	75.2	76.2	75.8	75.7
NO <sub>x</sub> emissions (g/bhp*hr)	0.46	0.47	0.47	0.47
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO <sub>x</sub> emissions (lb/hr)	2.31	2.36	2.35	2.34
Permitted emissions (lb/hr)	-	-	-	3.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	624	627	617	623
CO emissions (g/bhp*hr)	2.33	2.35	2.31	2.33
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	11.7	11.8	11.6	11.7
Permitted emissions (lb/hr)	-	-	-	16.3
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	15.9	16.3	16.0	16.1
VOC emissions (g/bhp*hr)	0.11	0.11	0.11	0.11
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.53	0.54	0.54	0.54
Permitted emissions (lb/hr)	-	-	-	1.0

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Table 6.8 Measured exhaust gas conditions and NO<sub>x</sub>, CO and VOC air pollutant emission rates  
PTA Landfill Engine No. 8 (EUCENGINE8) (SN: GZJ00465)

Test No.	1	2	3	Three Test
Test date	2/09/15	2/09/15	2/09/15	Average
Test period (24-hr clock)	905 - 1005	1045 - 1145	1215 - 1315	
Fuel flowrate (scfm)	575	571	572	573
Generator output (kW)	1,625	1,622	1,625	1,624
Engine output (bhp)	2,267	2,263	2,267	2,266
LFG methane content (%)	46.2	46.6	46.7	46.5
LFG LHV heat content (Btu/scf)	420	424	425	423
Air / Fuel Ratio	7.8	7.8	7.8	7.8
Inlet Pressure (psi)	2.55	2.55	2.55	2.55
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	13.0	12.1	12.2	12.5
O <sub>2</sub> content (% vol)	7.08	7.28	8.13	7.86
Moisture (% vol)	11.8	11.7	11.2	11.6
Exhaust gas temperature (°F)	933	932	931	932
Exhaust gas flowrate (dscfm)	4,447	4,485	4,377	4,436
Exhaust gas flowrate (scfm)	5,041	5,065	4,929	5,012
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	77.7	75.6	70.8	74.7
NO <sub>x</sub> emissions (g/bhp*hr)	0.50	0.49	0.44	0.48
Permitted emissions (g/bhp*hr)	-	-	-	0.6
NO <sub>x</sub> emissions (lb/hr)	2.48	2.43	2.22	2.38
Permitted emissions (lb/hr)	-	-	-	3.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	585	553	552	563
CO emissions (g/bhp*hr)	2.27	2.17	2.11	2.18
Permitted emissions (g/bhp*hr)	-	-	-	3.3
CO emissions (lb/hr)	11.3	10.8	10.5	10.9
Permitted emissions (lb/hr)	-	-	-	16.3
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	17.2	17.1	17.0	17.1
VOC emissions (g/bhp*hr)	0.12	0.12	0.12	0.12
Permitted emissions (g/bhp*hr)	-	-	-	1.0
VOC emissions (lb/hr)	0.60	0.59	0.58	0.59
Permitted emissions (lb/hr)	-	-	-	1.0