EMISSIONS TEST REPORT

Title	Compliance Emissions Testing Report for the Landfill Gas Fueled, Internal Combustion Engine, Operated at the Granger Electric of Pinconning, LLC Facility – Pinconning, Michigan
Report Date	January 23, 2013
Test Date(s)	December 19, 2012

Facility Information	
Name	Granger Electric of Pinconning, LLC
Street Address	2401 East Whitefeather Road
City, County	Pinconning, MI 48650
Phone	(517) 371-9711

Facility Permit Information	
State Registration No.: N5985	Permit No.: PTI 130-08A

Testing Contractor	
Company	Derenzo and Associates, Inc.
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1212004

Compliance Emissions Testing Report
for the
Landfill Gas Fueled, Internal Combustion Engine,
operated at the
Granger Electric of Pinconning, LLC Facility
Pinconning, Michigan

1.0 INTRODUCTION

Granger Electric of Pinconning, LLC (Granger Electric), State Registration No. N5985 operates two (2) Caterpillar (CAT®) Model No. G3520C landfill gas-fueled internal combustion (IC) engines and electricity generator sets at the Granger Electrical Generation Station located in Pinconning, Bay County, Michigan.

Installation and operation of the IC engines are permitted by Michigan Department of Environmental Quality (MDEQ) Air Quality Division (AQD) Permit to Install (PTI) No. 130-08A, issued to Granger Electric on July 23, 2012.

Condition V.2.; of PTI 130-08A, requires that:

Within 180 days after issuance of this permit, the permittee shall verify formaldehyde emission rates from one or more engine(s) in FGICEENGINES by testing at owner's expense, in accordance with Department requirements.

The initial performance test compliance demonstration, performed September 19, 2012 consisted of triplicate, one-hour test runs for the determination of nitrogen oxides (NO_X), carbon monoxide (CO), volatile organic compounds (VOC, as non-methane hydrocarbons) emission rates from both engines identified in the PTI, and formaldehyde (HCOH) concentrations and emission rates from EUICEENGINE1. The calculated HCOH emissions were considered suspect, as data validation for the FTIR portion of the compliance demonstration could not be performed in accordance with USEPA Method 320. Based on the quality assurance review of the HCOH data, it was determined that a retest of HCOH emissions would be warranted.

Testing for HCOH emission rates (retest) was conducted on December 19, 2012 by Prism Analytical Technologies, Inc. of Mt. Pleasant, Michigan and Derenzo and Associates, Inc. of Livonia, Michigan.

Robert Harvey and Mark Baron of Derenzo and Associates and Phillip Kauppi with Prism Analytical Technologies, Inc., performed the testing (retest) on December 19, 2012.

Process operations were coordinated by Mr. Dan Zimmerman of Granger Electric. Testing was witnessed by Mr. Tom Gasloli, Ms. Kathy Brewer, and Ms. Gina McCann with the Michigan Department of Environmental Quality -Air Quality Division (MDEQ-AQD).

The exhaust gas sampling and analysis was performed using procedures specified in the Test Protocol dated July 10, 2012 and approved by the MDEQ-AQD by letter on August 16, 2012.

Questions regarding this emission test report should be directed to:

Mr. Michael Brack
Field Services Manager
Derenzo and Associates, Inc.
39395 Schoolcraft Road
Livonia, MI 48150
(734) 464-3880

Mr. Dan Zimmerman
Compliance Manager
Granger Energy
16980 Wood Road
Lansing, MI 48906-1044
(517) 371-9711

2.0 SUMMARY OF RESULTS

The exhaust gas for the LFG-fueled IC engine was monitored for three (3) one-hour test periods during which the HCOH, O_2, and CO_2 concentrations were measured using instrumental analyzers on EUICEENGINE1. Exhaust gas flowrate measurements were conducted prior to and following each one-hour test period to calculate average flowrates for each engine, and ultimately HCOH mass emission rates.

Testing was performed while the IC engine was operated at normal base load conditions (i.e., 1,600 kW peak electricity output +/- 10%).

The following table presents three-test summaries of the test results and comparison of the results to the permitted pollutant emission rates for the Granger Electric of Pinconning, LLC.

Emission Unit ID	Standard Flowrate (scfm)	HCOH Concentration (ppmv)	HCOH Emission Rate (lbs/hr)	HCOH Emission Rate Limit (lbs/hr)
EUICEENGINE1	5,087	73.6	1.75	2.10

scfm = standard cubic feet per minute, ppmv=parts per million by volume, lb/hr = pounds per hour,

3.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

3.1 General Process Description

Landfill gas (LFG) is produced in the Pinconning 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 that are connected to a central header (gas collection system). The collected LFG is treated and then directed to the Granger Electrical Generation Station facility where it is used as fuel for the IC engine generators that produce electricity for transfer to the local utility.

FGICENGINES consists of two (2) CAT® Model No.G3520C IC engines (EUICEENGINE1 and EUICEENGINE2) that are connected to individual electricity generators.

Figure 1 presents a process flow diagram for the LFG electricity generation facility.

Figure 2 presents an engine operation flow diagram

3.2 Rated Capacities, Type and Quantity of Raw Materials Used

The EUICEENGINE1 and EUICEENGINE2 engine generator sets have a design mechanical output of 2,233 brake horsepower (bhp) and a design electricity generation rate of 1,600 kilowatts (kW).

Fuel (treated landfill gas) consumption is regulated to maintain the required heat input rate to support engine operations and is dependent on the fuel heat value (methane content) of the treated landfill gas. The average engine fuel consumption rate for each engine is typically between 530 and 560 standard cubic feet per minute (scfm) at full load.

Appendix B provides engine generator process data collected during the compliance test.

3.3 Emission Control System Description

The CAT® G3520 IC engine uses an electronic air-to-fuel ratio controller to fire lean fuel mixtures and produce low combustion by-product emissions. Emissions from the combustion of LFG are released into the ambient air through a stack connected to the IC engine exhaust manifold and noise muffler.

3.4 Sampling Locations (USEPA Method 1)

The exhaust stack sampling port for the Model G3520C IC engines tested satisfied the USEPA Method 1 criteria for a representative sample location. The inner diameter of the engine exhaust stack is 13.5 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 7 inches (0.52 duct diameters) downstream and 111 inches (8.22 duct diameters) upstream from any flow disturbance.

Velocity pressure traverse locations for the sampling points were determined in accordance with USEPA Method 1.

Figure 3 presents the performance test sampling and measurement locations.

4.0 <u>TEST RESULTS AND DISCUSSION</u>

4.1 Purpose and Objectives of the Tests

Compliance testing for FGICENGINES is required by PTI No. 130-08A and 40 CFR Part 60 Subpart JJJJ initially and every 8,760 hours of operation (as determined through the use of a non-resettable hour meter) or three years, whichever occurs first. This compliance demonstration (retest) satisfied the formaldehyde test event required in the PTI.

The exhaust from each LFG-fueled IC engine was monitored for three (3) one-hour test periods during which the HCOH, O_2, and CO_2 concentrations were measured using instrumental analyzers.

Exhaust gas moisture content was determined by gravimetric analysis of the weight gain in chilled impingers in accordance with USEPA Method 4. Velocity and volumetric flow rates were measured during pre-test and post-test times for the gaseous samples.

Testing was performed while the IC engines were operated at normal base load conditions (i.e., 1,600 kW electricity output +/- 10%).

4.2 Variations from Normal Sampling Procedures or Operating Conditions

The compliance retest for all HCOH was performed in accordance with the Test Protocol dated July 10, 2012; the MDEQ Approval Letter dated August 16, 2012, and the specified USEPA test methods.

Instrument calibrations and sampling period results satisfied the quality assurance verifications required by USEPA Methods 3A. No variations from the normal operating conditions of the IC engines occurred during the testing program.

4.3 Operating Conditions during Compliance Tests

The LFG-fueled IC engine was operated at base conditions load (within +/-10% of maximum design capacity) during the compliance testing. The average electricity generator output and fuel use values were recorded by the facility during each test event. Based on data provided by the facility operators, EUICEENGINE1 operated at an average electricity generation rate of 1,606 kW during the test periods and consumed an average of 533 scfm of treated LFG.

The engine generator sets have a design mechanical output of 2,233 bhp and a corresponding design electricity generation rate of 1,600 kW. The mechanical output of the engine (bhp) cannot be directly measured. Therefore, it is calculated based on the generator output using the following equation:

$$\text{Engine Output (bhp)} = (kW_{avg}) / (0.961) / (0.7457 \text{ kW/bhp})$$

Where: kW_{avg} = average recorded kW generation rate
0.961 = engine to generator efficiency (96.1%)
0.7457 = unit conversion of kW to bhp

4.4 Air Pollutant Sampling Results

The EUICEENGINE1 HCOH retest was performed on December 19, 2012. The exhaust EUICEENGINE1was monitored for three (3) one-hour test periods during which the HCOH, O_2, and CO_2 concentrations were measured using instrumental analyzers.

Exhaust gas moisture content was determined by gravimetric analysis of the weight gain in chilled impingers in accordance with USEPA Method 4. Velocity and volumetric flow rate were measured near the beginning and end of each sampling period. HCOH mass emission rates were calculated from the pre-test and post-test flowrate averages for each 60-minute sampling period.

The average measured exhaust gas volumetric flow rate for EUICENGINE1 was 5,087 standard cubic feet per minute (scfm). The average measured exhaust gas HCOH concentrations for EUICEENGINE1 was73.6 ppmv. Based on the measured exhaust gas flowrate, the HCOH concentration corresponds to a mass emission rate of 1.75lb/hr, which is equivalent to 0.35 grams per bhp-hr (g/bhp-hr). The allowable formaldehyde emission rate for EUICEENGINE1 is 2.1 lb/hr.

Table 1 presents measured exhaust gas conditions and HCOH emission rates for EUICEENGINE1 retest event.

Appendix C provides computer calculated and field data sheets for the IC engine tests.

Appendix D provides raw instrumental analyzer response data for each test period.

5.0 SAMPLING AND ANALYTICAL PROCEDURES

A test protocol for the compliance testing was prepared by Derenzo and Associates and reviewed, and approved by the MDEQ-AQD-TPU. This section provides a summary of the sampling and analytical procedures that were used during the test and presented in the test plan.

Appendix E presents sample procedures and diagrams for the USEPA sampling methods.

5.1 Exhaust Gas Velocity and Flowrate Determination (USEPA Method 2)

The IC engine exhaust stack gas velocity was determined using USEPA Method 2 prior to and following each 60-minute sampling period. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were leak-checked to verify the integrity of the measurement system.

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

The calculated pre-test and post-test volumetric flowrate values were averaged and used for calculating the mass emission rate for each pollutant for that test period.

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

CO_2 and O_2 content in the IC engine exhaust gas stream was measured continuously throughout each one-hour test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a non-dispersive infrared (NDIR) gas analyzer. The O_2 content of the exhaust was monitored using a gas analyzer that utilizes a Zirconia Ion sensor.

During each one-hour 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 analyzer. Therefore, measurement of O_2 and CO_2 concentrations correspond to standard dry gas conditions. The instrument was calibrated using appropriate calibration gases to determine accuracy and system bias (described in Section 6.3 of this document).

Figure 4 presents a diagram of the instrument analyzer train.

Appendix E presents detailed gas sampling procedures for the USEPA sampling trains.

5.3 Exhaust Gas Moisture Content Determinations (Method 4)

Moisture content of the IC engine exhaust gas was determined in accordance with USEPA Method 4 using a chilled impinger sampling train, which was performed concurrently with the instrumental analyzer sampling methodologies. A non-heated probe was used for the moisture determinations as the engine exhaust temperature exceeded 700 °F. During each sampling period, a gas sample was extracted at a predetermined 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.

Figure 5 presents a diagram of the moisture sampling train.

Appendix E presents detailed gas sampling procedures for the USEPA moisture sampling train.

Appendix C presents the computer calculated and field data from the testing program.

5.4 Formaldehyde Concentration Measurements (USEPA Method 320)

The exhaust gas Formaldehyde concentrations were measured using a Fourier Transform Infrared (FTIR) spectroscopy analyzer operated by Prism Analytical Technologies, Inc.

FTIR data were collected using a MKS MultiGas 2030 FTIR spectrometer, serial number 016252291. The sampling system consisted of a 2 ft., 1/4 inch diameter, stainless steel probe; 2-100 ft., 3/8 inch diameter, Teflon heated transfer line, maintained at 191°C; and a 0.01μ glass filter for particulate matter removal.

The FTIR was equipped with a temperature-controlled, 5.11-meter multi-pass gas cell maintained at 191°C. Gas flows and sampling system pressures were monitored using a rotometer and pressure transducer. All data were collected at 0.5 cm^{-1} resolution. Each spectrum was derived from the co-addition of 64 scans, with a new data point generated approximately every one minute.

Direct FTIR measurements of N2, acetaldehyde, SF6, and ethylene gas standards were made daily to confirm concentrations. See the Engine 1 – FTIR QA/QC Data Appendix for results.

A calibration transfer standard (CTS), 100.0 ppm ethylene standard (Airgas Cylinder # SG881831BAL), was analyzed before and after testing. The concentration determined for all CTS runs were within ± 5% of the certified value of the standard. The ethylene was passed through the entire system (system purge) to determine the sampling system response time and to ensure that the sampling system was leak-free at the stack location.

During post data validation of the Granger Electric FTIR results, it was determined that a leak was present in the sampling system that caused all the FTIR results to be less than the correct emissions concentrations. The leak was also most likely outside the limits allowed by EPA Method 320.

See the Appendix A, Engine 1 – FTIR Report for a detailed explanation of the Method 320 testing.

6.0 INTERNAL QA/QC ACTIVITIES

6.1 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.

Sampling periods did not commence until the sampling probe had been in place for at least twice the system response time.

6.2 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure O_2 and CO_2 have had an interference response test performed prior to their use in the field, pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e. gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 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.

6.3 Instrument Calibration and System Bias Checks

At the beginning of the test day, initial three-point instrument calibrations were performed by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were preformed prior to and at the conclusion of each sampling period by introducing the appropriate 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 verifying the instrument response against the initial instrument calibration readings. If the drift error is within 3% of the span over the period of the test run, the test run is considered acceptable.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2 and O_2 and zeroed using pure nitrogen.

6.4 Meter Box Calibrations

The dry gas meter sampling console used for moisture testing was calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5. The metering consol calibration exhibited no data outside the acceptable ranges presented in USEPA Method 5.

Appendix F presents test equipment quality assurance data (instrument calibration and system bias check records, calibration gas certifications, interference test results, meter box calibration records, and pitot tube calibration records).

Report Prepared By:

Michael J. Brack
Field Services Manager

Report Reviewed By:

for: Robert Harvey
Engineering Services Manager

Table 1.

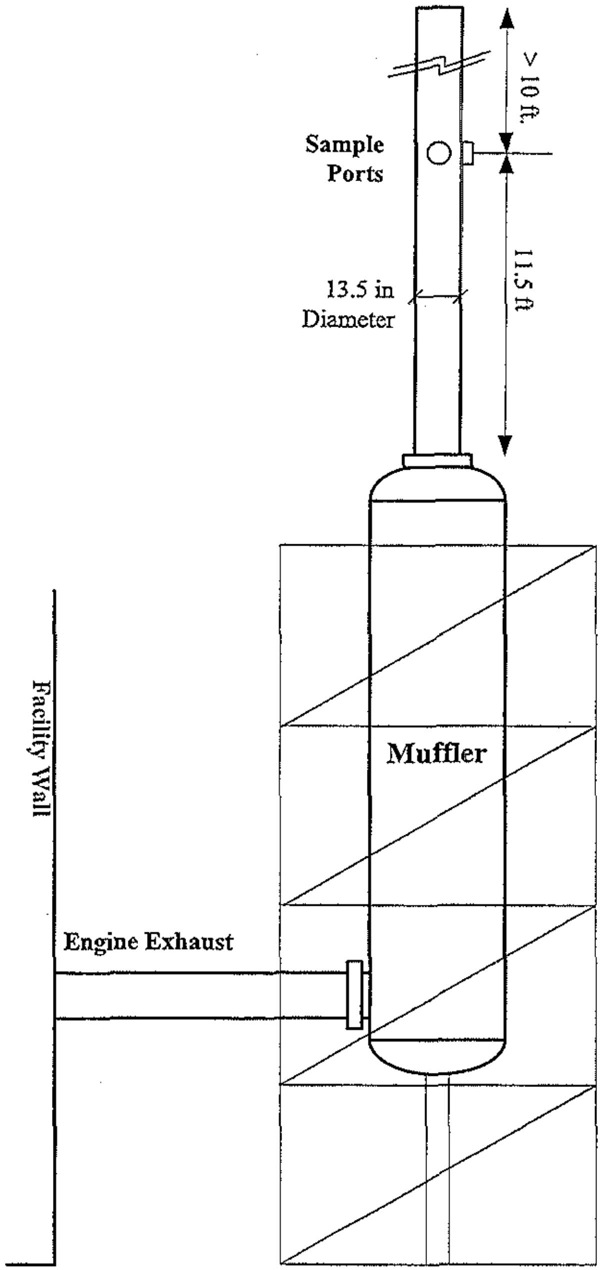
Measured Exhaust Gas Conditions and Formaldehyde Emission Rates for the Granger Electric of Pinconning, LLC., CAT® G3520C Landfill Gas Fueled Internal Combustion Engine

Unit ID: **EUICEENGINE1**

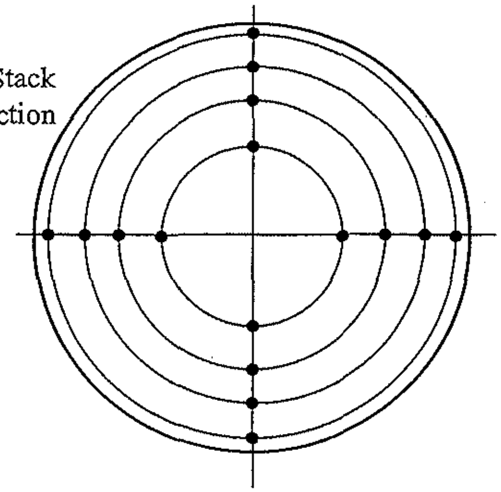
Test No.	1	2	3	
Test date	12/19/2012	12/19/2012	12/19/2012	Three Test
Test period (24-hr clock)	0850-0950	1027-1127	1150-1250	Averages
Engine Operating Parameters				
Generator output (kW)	1,603	1,606	1,609	1,606
Engine Horsepower (Hp)	2,237	2,241	2,246	2,241
Exhaust Gas Composition				
CO_2 content (% vol)	10.9	10.8	10.7	10.8
O_2 content (% vol)	8.47	8.62	8.53	8.54
Moisture (% vol)	12.0	11.8	11.4	11.7
Exhaust Gas Flowrate				
Standard Conditions (scfm)	4,988	5,095	5,177	5,087
Dry Basis (dscfm)	4,395	4,503	4,585	4,494
Formaldehyde Emission Rates				
HCOH conc. (ppmv)	73.2	73.9	73.7	73.6
HCOH emissions (lb/hr)	1.71	1.76	1.79	1.75
HCOH emissions limit (lb/hr)				*2.10*
HCOH emissions (g/bhp-hr)	0.35	0.36	0.36	0.35

Definitions

kW - kilowatt
Hp - horsepower
% vol - percent by volume
lb/hr - pounds per hour
scfm - standard cubic feet per minute
dscfm - dry standard cubic feet per minute
ppmv - parts per million by volume
g/bhp-hr - grams per brake horsepower hour



Exhaust Stack
Cross-Section



Velocity sample locations as measured from stack wall

Pt. #	in.
1	0.50
2	1.4
3	2.6
4	4.4
5	9.1
6	10.9
7	12.1
8	13.0

12/27/12	**Granger Electric of Pinconning, LLC Exhaust Sample Location, CAT G3520 ICE**		
	Scale None	Sheet 1 of 1	Derenzo and Associates Project No. 1207001