

Executive Summary

AIR QUALITY DIV.

GRANGER ELECTRIC COMPANY - OTTAWA GENERATING STATION
 CAT® G3520C LANDFILL GAS FUELED IC ENGINE EMISSIONS RESULTS

Granger Electric Company contracted Derenzo and Associates, Inc., to conduct a performance demonstration for the determination of nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOC) concentrations and emission rates from a single Caterpillar (CAT®) Model No. G3520C landfill gas-fired reciprocating internal combustion engine and electricity generator set operated at the Ottawa Generating Station in Coopersville, Michigan.

Michigan Department of Environmental Quality (MDEQ) - Air Quality Division (AQD) Renewable Operating Permit (ROP) No. MI-ROP-N5890-2013 requires that performance testing be performed on the CAT® G3520C engine, identified as EURICENGINE7 in the ROP, within 180 days of startup and every 8,760 hours of operation (or every three years) in accordance with the provisions of 40 CFR Part 60 Subpart JJJJ (NSPS for spark ignition internal combustion engines). The annual performance testing was conducted on January 23, 2014.

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

Emission Unit Identification	NOx Emission Rate (lbs/hr)	NOx Emission Factor (g/bhp-hr)	CO Emission Rate (lbs/hr)	CO Emission Factor (g/bhp-hr)	VOC Emission Rate (lbs/hr)	VOC Emission Factor (g/bhp-hr)
EURICENGINE7	2.67	0.56	13.77	2.90	0.84	0.18
Permit Limits	4.92	1.00	16.2	3.3	3.2	0.65

lb/hr = pounds per hour, g/bhp-hr = grams per brake horse power-hour

The following table presents the operating data recorded during the performance demonstration.

Emission Unit Identification	Fuel Usage (scfm)	Fuel Quality (Btu/scf)	Electricity Generation (kW)	Engine Output (bHp-hr)	Exhaust Flowrate (scfm)	Exhaust Flowrate (dscfm)
EURICENGINE7	509	483	1,537	2,154	4,807	4,292

scfm=standard cubic feet per minute, Btu/scf= British thermal unit per standard cubic foot, kW=kilowatt, bHp-hr=brake horse power hour, dscfm=dry standard cubic feet per minute

The data above indicates EURICENGINE7 operated at normal base load conditions and is in compliance with the emission standards presented in 40 CFR 60.4233(e) and MDEQ-AQD ROP No., MI-ROP-N5890-2013.

AIR EMISSION TEST REPORT

Title AIR EMISSION TEST REPORT FOR THE LANDFILL GAS
 FUELED INTERNAL COMBUSTION ENGINE
 OPERATED AT THE OTTAWA GENERATING STATION

Report Date February 4, 2014

Test Dates January 23, 2014

Facility Information	
Name	Granger Electric Company - Ottawa Generating Station
Street Address	15362 68 th Avenue
City, County, Zip	Coopersville, Ottawa, MI 49315

Facility Permit Information	
Permit No.:	MI-ROP-N5890-2013
Facility SRN :	N5890

Testing Contractor	
Company	Derenzo and Associates, Inc.
Mailing Address	39395 Schoolcraft Road Livonia, MI 48150
Phone	(734) 464-3880
Project No.	1310007

TABLE OF CONTENTS

	Page
1.0 INTRODUCTION	1
2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION	3
2.1 General Process Description	3
2.2 Rated Capacities and Air Emission Controls	3
2.3 Sampling Locations.....	3
3.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS	4
3.1 Purpose and Objective of the Tests	4
3.2 Operating Conditions During the Compliance Tests	4
3.3 Summary of Air Pollutant Sampling Results	4
4.0 SAMPLING AND ANALYTICAL PROCEDURES	6
4.1 Summary of Sampling Methods	6
4.2 Exhaust Gas Velocity Determination (USEPA Method 2).....	7
4.3 Exhaust Gas Molecular Weight Determination (USEPA Methods 3A).....	7
4.4 Exhaust Gas Moisture Content (USEPA Method 4).....	7
4.5 NO _x and CO Concentration Measurements (USEPA Methods 7E and 10).....	8
4.6 Measurement of Volatile Organic Compounds (USEPA Method ALT-096).....	8
5.0 QA/QC ACTIVITIES	9
5.1 NO _x Converter Efficiency Test.....	9
5.2 Sampling System Response Time Determination	9
5.3 Gas Divider Certification (USEPA Method 205).....	9
5.4 Instrumental Analyzer Interference Check.....	9
5.5 Instrument Calibration and System Bias Checks	10
5.6 Meter Box Calibrations	10
6.0 RESULTS	11
6.1 Test Results and Allowable Emission Limits	11
6.2 Variations from Normal Sampling Procedures or Operating Conditions.....	11

LIST OF TABLES

Table	Page
3.1 Average operating conditions during the test periods.....	5
3.2 Average measured emission rates for the tested Granger Ottawa facility RICE (three-test average).....	5
6.1 Measured exhaust gas conditions and NO _x , CO and VOC air pollutant emission rates Granger Ottawa EURICENGINE7	12

LIST OF APPENDICES

APPENDIX A	SAMPLING DIAGRAMS
APPENDIX B	OPERATING RECORDS
APPENDIX C	FLOWRATE CALCULATIONS AND DATA SHEETS
APPENDIX D	CO ₂ , O ₂ , CO, NO _x AND VOC CALCULATIONS
APPENDIX E	INSTRUMENTAL ANALYZER RAW DATA
APPENDIX F	QA/QC RECORDS

Derenzo and Associates, Inc.

Environmental Consultants

AIR EMISSION TEST REPORT
FOR THE
LANDFILL GAS FUELED INTERNAL COMBUSTION ENGINE
OPERATED AT THE
OTTAWA GENERATING STATION

1.0 INTRODUCTION

Granger Electric Company (Granger), State Registration No. N5890, operates one (1) Caterpillar (CAT[®]) Model No., G3520C gas-fired reciprocating internal combustion (IC) engine and electricity generator set at the Ottawa Generating Station in Coopersville, Ottawa County, Michigan. The treated landfill gas (LFG) fueled IC engine generator set is identified as emission unit EURICENGINE7 in Renewable Operating Permit (ROP) No. MI-ROP-N5890-2013 issued by the Michigan Department of Environmental Quality-Air Quality Division (MDEQ-AQD).

Air emission compliance testing was performed to satisfy the following requirements contained in Special Condition No. V.1. of ROP No. MI-ROP-N5890-2013:

- Test air pollutant emissions for EURICENGINE7 in accordance with 40 CFR Part 60 Subpart JJJJ;

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 Jason Logan and Daniel Wilson performed the field sampling and measurements January 23, 2014.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan that was reviewed and approved by the Michigan Department of Environmental Quality (MDEQ) in the November 12, 2013 test plan. MDEQ representative Mr. Nathan Hude observed portions of the testing project.

Questions regarding this emission test report should be directed to:

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

Mr. Dan Zimmerman
Compliance Manger
Granger Electric Company
16980 Wood Road
Lansing, MI 48906
Ph: (517) 371-9711

Derenzo and Associates, Inc.

Granger Energy and Electric – Ottawa Farms Generating Station
EURICENGINE7 Emissions Compliance Test Report

February 4, 2014
Page 2

Report Certification

I certify under penalty of law that I believe the information provided in this document is true, accurate, and complete. I am aware that there are significant civil and criminal penalties, including the possibility of fine or imprisonment or both, for knowingly submitting false, inaccurate, or incomplete information.

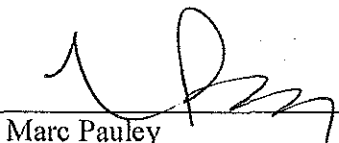
Report Prepared By:



Daniel C. Wilson
Environmental Consultant
Derenzo and Associates, Inc.

RECEIVED
FEB 10 2014
AIR QUALITY DIV.

Responsible Official Certification:



Marc Pauley
Operations Manager
Granger Electric Company

2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 General Process Description

Landfill gas (LFG) is produced at the Ottawa County Farms 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 Ottawa Generating Station where it is used as fuel for the IC engine generator that produce electricity for transfer to the local utility.

2.2 Rated Capacities and Air Emission Controls

The CAT® Model No. G3520C RICE has a rated output of 2,242 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 set is 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 engine.

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 exhaust stack sampling port for the Model G3520C IC engine tested satisfied the USEPA Method 1 criteria for a representative sample location. The inner diameter of the engine exhaust stack is 13.25 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 8 inches (0.6 duct diameters) upstream and 34 inches (2.57 duct diameters) downstream from any flow disturbance.

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-N5890-2013 and 40 CFR Part 60 Subpart JJJJ require Granger to test EURICENGINE7 for carbon monoxide (CO), nitrogen oxides (NOx) and volatile organic compounds (VOCs) every 8,760 hours of operation.

3.2 Operating Conditions During the Compliance Tests

The testing was performed while the Granger engine/generator set was operated at or near maximum operating conditions (1,600 kW electricity output +/- 10%). Granger representatives provided the kW output in 15-minute increments for each test period. The EURICENGINE7 generator kW output ranged between 1,531 and 1,546 kW for each test period.

Fuel flowrate (cubic feet per minute) and fuel methane content were also recorded by Granger representatives in 15-minute increments for each test period. The EURICENGINE7 fuel consumption rate was approximately 509 scfm and fuel methane content ranged between 52.5 and 53.7% for each test period.

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

Engine output (bhp) cannot be measured directly and was calculated based on the recorded electricity output, the calculated CAT® Model G3520C generator efficiency (95.7%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp).

$$\text{Engine output (bhp)} = \text{Electricity output (kW)} / (0.957) / (0.7457 \text{ kW/hp})$$

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 gas exhausted from the sampled LFG fueled RICE was sampled for three (3) one-hour test periods during the compliance testing performed January 23, 2014.

Table 3.2 presents the average measured CO, NOx, and VOC emission rates for the engine (average of the three test periods).

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

Table 3.1 Average engine operating conditions during the test periods

Engine Parameter	EURICENGINE7
Generator output (kW)	1,537
Engine output (bhp)	2,154
Engine LFG fuel use (scfm)	509
LFG methane content (%)	53.1
LFG lower heating value (Btu)	483
Exhaust temperature (°F)	832

Table 3.2 Average measured emission rates for the Granger Ottawa facility 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)
EURICENGINE7	13.77	2.90	2.67	0.56	0.84	0.18

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A test protocol for the air emission testing was reviewed and approved by the MDEQ. This section provides a summary of the sampling and analytical procedures that were used during the Granger testing periods.

4.1 Summary of Sampling Methods

USEPA Method 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 NO _x 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 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)

CO₂ and O₂ content in the RICE exhaust gas stream was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO₂ content of the exhaust was monitored using a Servomex 4900 single beam single wavelength (SBSW) infrared gas analyzer. The O₂ 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 and heated stainless steel filter. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzers; therefore, measurement of O₂ and CO₂ concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

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

Appendix D provides O₂ and CO₂ 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_x and CO Concentration Measurements (USEPA Methods 7E and 10)

NO_x and CO pollutant concentrations in the RICE exhaust gas stream was determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence NO_x analyzer and a FUJI Model ZRF Non-Dispersive Infrared (NDIR) Gas CO analyzer.

Throughout each test period, a continuous sample of the engine exhaust gas was extracted from the stack using the stainless steel probe, Teflon® heated sample line, heated stainless steel filter 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_x 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 the 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 system 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/QC ACTIVITIES

5.1 NO_x Converter Efficiency Test

The NO₂ – NO conversion efficiency of the Model 42c analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO₂ was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO₂ – NO converter uses a catalyst at high temperatures to convert the NO₂ to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO₂ concentration is within 90% of the expected value.

The NO₂ – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO₂ concentration was 2.0% 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 135 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 11, 2013) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivered calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

5.4 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NO_x, CO, O₂ and CO₂ have had an interference response test preformed 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_x, CO, CO₂ and O₂ analyzers by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and determining the instrument response against the initial instrument calibration readings.

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

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO₂, O₂, NO_x, and CO in nitrogen and zeroed using hydrocarbon free nitrogen. The NMHC (VOC) instrument was calibrated with USEPA Protocol 1 certified concentrations of propane in air and zeroed using hydrocarbon-free air. A STEC Model SGD-710C ten-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

5.6 Meter Box Calibrations

The Clean Air Express Model #0028 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 console was calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

Appendix F presents test equipment quality assurance data (NO₂ – NO conversion efficiency test data, instrument calibration and system bias check records, calibration gas and gas divider certifications, interference test results, meter box calibration records, 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 Table No. 6.1.

The measured air pollutant concentrations and emission rates for EURICENGINE7 is less than the allowable limits specified in Renewable Operating Permit No. MI-ROP-N5890-2013.

- 4.92 lb/hr and 1.0 g/bhp-hr for NO_x;
- 16.2 lb/hr and 3.3 g/bhp-hr for CO; and
- 3.2 lb/hr and 0.65 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 set was operated within 10% of maximum output (1,600 kW generator output) and no variations from the normal operating conditions of the RICE occurred during the engine test periods.