# Executive Summary

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

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

Michigan Department of Environmental Quality (MDEQ) Air Quality Division (AQD) Permit to Install No. 98-12 requires that performance testing be performed on the CAT® G3520C engines within 180 days of startup and every 8,760 hours of operation (or every three years) in accordance with the provisions of 40 CFR Part 60 Subpart JJJJ (NSPS for spark ignition internal combustion engines). The performance testing was conducted on March 3 – 4, 2014.

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

| Emission Unit | $NO_x$ Emission Rates (lb/hr) | (g/bhp-hr) | CO Emission Rates (lb/hr) | (g/bhp-hr) | VOC Emission Rate (g/bhp-hr) |
|---|---|---|---|---|---|
| EUICEENGINE1 | 3.03 | 0.63 | 12.52 | 2.60 | 0.11 |
| EUICEENGINE2 | 3.20 | 0.64 | 11.42 | 2.28 | 0.07 |
| Permit Limits | 4.94 | 1.0 | 17.3 | 3.5 | 1.0 |

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

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

| Emission Unit | Generator Output (kW) | Engine Output (bhp) | LFG Fuel Use (scfm) | LFG $CH_4$ Content (%) | Exhaust Temp. (°F) |
|---|---|---|---|---|---|
| EUICEENGINE1 | 1,561 | 2,187 | 521 | 49.8 | 754 |
| EUICEENGINE2 | 1,621 | 2,272 | 524 | 49.9 | 750 |

scfm=standard cubic feet per minute, kW=kilowatt

The data presented above indicate that EUICEENGINE1 and EUICENGINE2 operated at normal base load conditions comply with the emission standards presented in 40 CFR 60.4233(e) and MDEQ-AQD PTI No. 98-12.

**Derenzo and Associates, Inc.**
*Environmental Consultants*

## AIR EMISSION TEST REPORT

| | |
|---|---|
| Title | NSPS EMISSION TEST REPORT FOR LFG-FUELED RICE OPERATED AT THE GRANGER ELECTRIC OF WATERVLIET, ORCHARD HILL GENERATING STATION |
| Report Date | March 27, 2014 |
| Test Dates | March 3 – 4, 2014 |

| **Facility Information** | |
|---|---|
| Name | Granger Electric of Watervliet<br>Orchard Hill Generating Station<br>at the Orchard Hill Sanitary Landfill |
| Street Address | 3290 Hennesy Road |
| City, County | Watervliet, Berrien |

| **Facility Permit Information** | | | |
|---|---|---|---|
| Permit No.: | 98-12 | Facility SRN : | N5719 |

| **Testing Contractor** | |
|---|---|
| Company | Derenzo and Associates, Inc. |
| Mailing Address | 39395 Schoolcraft Road<br>Livonia, MI 48150 |
| Phone | (734) 464-3880 |
| Project No. | 1310008 |

39395 Schoolcraft Road • Livonia, MI 48150 • (734) 464-3880 • FAX (734) 464-4368
4990 Northwind, Suite 120 • East Lansing, MI 48823 • (517) 324-1880 • FAX (517) 324-5409

# NSPS EMISSION TEST REPORT
# FOR
# LFG-FUELED RICE
# OPERATEDAT THE
# GRANGER ELECTRIC OF WATERVLIET,
# ORCHARD HILL GENERATING STATION

## 1.0 INTRODUCTION

Granger Electric of Watervliet (Granger) owns and operates two (2) Caterpillar (CAT®) Model No. G3520C landfill gas (LFG) fueled reciprocating internal combustion engines (RICE) at the Granger Electric of Watervliet, Orchard Hill Generating Station in Watevliet, Berrien County, Michigan (Facility SRN: N5719). The CAT® Model No. G3520C engines are identified as Emission Unit ID: EUICEENGINE1 and EUICEENGINE2 (FGICEENGINES) in Permit to Install No. 98-12.

Air emission compliance testing was performed to satisfy the requirements contained in PTI No. 98-12 for FGICEENGINES and the periodic testing requirements specified in 40 CFR Part 60 Subpart JJJJ for spark-ignition stationary RICE.

The compliance testing was performed by Derenzo and Associates, Inc. (Derenzo and Associates), a Michigan-based environmental consulting and testing company. Derenzo and Associates representatives Tyler Wilson and Michael Brack performed the field sampling and measurements March 3 and 4, 2014.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated January 7, 2014 that was reviewed and approved by the Michigan Department of Environmental Quality (MDEQ). MDEQ representative Mr. Matthew Deskins observed portions of the testing project.

Questions regarding this emission test report should be directed to:

| | |
|---|---|
| Tyler J. Wilson | Mr. Dan Zimmerman |
| Environmental Consultant | Director of Operations, Compliance & Safety Officer |
| Derenzo and Associates, Inc. | Granger Electric Company |
| 39395 Schoolcraft Road | 16980 Wood Road |
| Livonia, MI 48150 | Lansing, MI 48906 |
| Ph: (734) 464-3880 | Ph: (517) 371-9711 |

**Report Certification**

This test report was prepared by Derenzo, Associates, Inc. based on the field sampling data collected by Derenzo and Associates, Inc. Facility process data were collected and provided by Granger employees or representatives.

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:

Tyler J. Wilson
Environmental Consultant
Derenzo and Associates, Inc.

Reviewed by:

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

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) containing methane is generated in the Orchard Hill Sanitary Landfill from the anaerobic decomposition of disposed waste materials. The LFG is collected from both active and capped landfill cells using a system of wells (gas collection system). The collected LFG is transferred to the Granger Orchard Hill Generating Station where it is treated and used as fuel for the two (2) RICE. Each RICE is connected to an electricity generator that produces electricity that is transferred to the local utility.

### 2.2 Rated Capacities and Air Emission Controls

The CAT® Model No. G3520C RICE has a rated output of 2,242 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 sets are not equipped with add-on emission control devices. Air pollutant emissions are minimized through the proper operation of the gas treatment system and efficient fuel combustion in the engines.

The fuel consumption rate is regulated automatically to maintain the heat input rate required to support engine operations and is dependent on the fuel heat value (methane content) of the treated LFG.

### 2.3 Sampling Locations

The RICE exhaust gas is directed through mufflers and is released to the atmosphere through dedicated vertical exhaust stacks. The two (2) CAT® Model G3520C RICE exhaust stacks are identical.

The exhaust stack sampling ports for the CAT® Model G3520C engines (EUICEENGINE1 and 2) are located in individual exhaust stacks with an inner diameter of 13.25 inches. Each stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 288 inches (21.7 duct diameters) upstream and 96 inches (7.2 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

Individual traverse points were determined in accordance with USEPA Method 1.

Appendix A provides diagrams of the emission test sampling locations.

## 3.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

### 3.1 Purpose and Objective of the Tests

The conditions of Permit to Install No. 98-12 and 40 CFR Part 60 Subpart JJJJ require Granger to test each engine contained in FGICEENGINES for carbon monoxide (CO), nitrogen oxides (NOx) and volatile organic compounds (VOCs) every 8,760 hours of operation. Therefore, the exhaust gas for each engine contained in FGICEENGINES was sampled for CO, $NO_X$ and VOC concentration. Exhaust gas velocity and oxygen ($O_2$), carbon dioxide ($CO_2$) and moisture content were measured to convert the pollutant concentrations to mass emission rates.

### 3.2 Operating Conditions During the Compliance Tests

The testing was performed while the Granger engine/generator sets were operated at maximum operating conditions (1,600 kW electricity output +/- 10%). Granger representatives provided the kW output in 15-minute intervals for each test period. The FGICEENGINES generator kW output ranged between 1,538 and 1,648 kW for each test period.

Fuel flowrate (cubic feet per minute) and fuel methane content (%) were also recorded by Granger representatives in 15-minute intervals for each test period. The FGICEENGINES fuel consumption rate ranged between 509 and 536 scfm, and fuel methane content ranged between 49.5 and 50.1%. Granger operators also recorded the engine serial number and the run-hour meter reading at the beginning of Test No. 1.

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

Engine output (bhp) cannot be measured directly. Therefore, it is calculated based on the recorded electricity output, the CAT® Model G3520C generator efficiency (96.0%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp). The following equation was used to calculate average engine horsepower for each test period based on a linear relationship between engine output and electricity generator output:

Engine output (bhp) = Electricity output (kW) / (0.960) / (0.7457 kW/hp)

Table 3.1 presents a summary of the average engine operating conditions during the test periods.

### 3.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled LFG fueled RICE (EUICEENGINE1 and EUICEENGINE2) were each sampled for three (3) one-hour test periods during the compliance testing performed March 3 through March 4, 2014.

Table 3.2 presents the average measured CO, $NO_X$ and VOC emission rates for the engines (average of the three test periods for each engine).
Test results for each one hour sampling period are presented in Section 6.0 of this report.

Table 3.1 Average engine operating conditions during the test periods

| Engine Parameter | EUICENGINE1 | EUICENGINE2 |
|---|---|---|
| Generator output (kW) | 1,561 | 1,621 |
| Engine output (bhp) | 2,187 | 2,272 |
| Engine LFG fuel use (scfm) | 521 | 524 |
| LFG methane content (%) | 49.8 | 49.9 |
| Exhaust temperature (°F) | 754 | 750 |

Table 3.2 Average measured emission rates for each tested Granger Watervliet facility RICE (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 | 12.52 | 2.60 | 3.03 | 0.63 | 0.51 | 0.11 |
| EUICENGINE2 | 11.42 | 2.28 | 3.20 | 0.64 | 0.34 | 0.07 |
| Emission Limit | 17.3 | 3.5 | 4.94 | 1.0 | -- | 1.0 |

## 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 RICE test period.

### 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 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 25A and ALT-096 | Exhaust gas VOC (as NMHC) concentration was determined using a flame ionization analyzers equipped with an internal methane separation column. |

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

The RICE exhaust stack gas velocity and volumetric flowrate was determined using USEPA Method 2 prior to and after each test. An S-type Pitot tube connected to a red-oil manometer was used to determine velocity pressure at each traverse point across the stack cross section. Gas temperature was measured using a K-type thermocouple mounted to the Pitot tube. The Pitot tube and connective tubing were leak-checked periodically to verify the integrity of the measurement system.

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

Appendix C provides exhaust gas flowrate calculations and field data sheets.

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

$CO_2$ and $O_2$ content in the RICE exhaust gas was measured continuously throughout each test period in accordance with USEPA Method 3A. The $CO_2$ content of the exhaust was monitored using a Servomex 4100 single beam single wavelength (SBSW) infrared gas analyzer. The $O_2$ content of the exhaust was monitored using a Servomex 4100 gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the RICE exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzers; therefore, measurement of $O_2$ and $CO_2$ content correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

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

Appendix D provides $O_2$ and $CO_2$ 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. Exhaust gas moisture was calculated based on the total moisture catch in the sampling train and the amount of dry gas metered through the sampling console.

### 4.5 $NO_x$ and CO Concentration Measurements (USEPA Methods 7E and 10)

$NO_X$ and CO pollutant concentrations in the RICE exhaust gas streams were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence $NO_X$ analyzer and a TEI Model 48c infrared CO analyzer.

Throughout each test period, a continuous sample of the engine exhaust gas was extracted from the stack using the Teflon® heated sample line and gas conditioning system and delivered to the instrumental analyzers. Instrument response for each analyzer was recorded on an ESC Model 8816 data acquisition system that logged data as one-minute averages. Prior to, and at the conclusion of each test, the instruments were calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias.

Appendix D provides CO and $NO_X$ calculation sheets. Raw instrument response data are provided in Appendix E.

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

VOC emission rate was determined by measuring the nonmethane hydrocarbon (NMHC) concentration in the RICE exhaust gas. NMHC pollutant concentration was determined using TEI Model 55i Methane / Nonmethane hydrocarbon analyzer. The TEI 55i analyzer contains in internal gas chromatograph column that separates methane from non-methane components and has been approved by the USEPA for measuring VOC relative to 40 CFR Part 60 Subpart JJJJ compliance test demonstrations (Alternative Test Method 096 or ALT-096). 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.

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 a mid-range calibration and zero gas to determine calibration drift and zero drift error (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 <u>QA/QC ACTIVITIES</u>

### 5.1 $NO_x$ 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 (measured $NO_2$ concentration was 0.1% of the expected value, i.e., within 10% of the expected value as required by Method 7E).

## 5.2 Gas Divider Certification (USEPA Method 205)

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The ten-step STEC gas divider was NIST certified (on December 20, 2013) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivers calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

## 5.3 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure $NO_X$, CO, $O_2$ and $CO_2$ 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.

## 5.4 Instrument Calibration and System Bias Checks

At the beginning of each day of the testing program, initial three-point instrument calibrations were performed for the $NO_x$, 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 Method 3A, 7E and 10 instruments were calibrated with USEPA Protocol 1 certified concentrations of $CO_2$, $O_2$, $NO_x$, 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.

## 5.5 Meter Box Calibrations

The Nutech Model 2010 sampling console, which was used for exhaust gas moisture content sampling, was calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5. The metering console calibration exhibited no data outside the acceptable ranges presented in USEPA Method 5.

The digital pyrometer in the Nutech metering consoles were calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

Appendix F presents test equipment quality assurance data for the emission test equipment ($NO_2$ – 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, Pitot tube calibration records).

## 6.0 RESULTS

### 6.1 Test Results and Allowable Emission Limits

Engine operating data and air pollutant emission measurement results for each one hour test period are presented in Tables 6.1 through 6.2.

The measured air pollutant concentrations and emission rates for Engine Nos. 1 and 2 are less than the allowable limits specified in Permit to Install No. 98-12 for Emission Unit Nos. EUICEENGINE1 and EUICEENGINE2:

- 4.94 lb/hr and 1.0 g/bhp-hr for $NO_X$;
- 17.3 lb/hr and 3.5 g/bhp-hr for CO; and
- 1.0 g/bhp-hr for VOC.

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

The testing for all pollutants was performed in accordance with the approved test protocol. The engine-generator sets were operated within 10% of maximum output (1,600 kW generator output) and no variations from the normal operating conditions of the RICE occurred during the engine test periods.

Testing was postponed from the originally scheduled February 27, 2014 test date due to significant wind gusts that posed hazardous working conditions for the aerial sampling location. The testing took place the following week on March 3 and 4, 2014. Derenzo and Associates personnel informed Mr. Matthew Deskins and Mr. David Patterson of the MDEQ-AQD of this reschedule on February 27, 2014.

Table 6.1 Measured exhaust gas conditions and $NO_x$, CO and VOC air pollutant emission rates Granger Electric of Watervliet, Engine No. 1 (EUICEENGINE1)

| Test No. | 1 | 2 | 3 | |
|---|---|---|---|---|
| Test date | 3/3/14 | 3/3/14 | 3/3/14 | Three Test |
| Test period (24-hr clock) | 1520 - 1620 | 1725 - 1825 | 1945 – 2045 | Average |
| Fuel flowrate (scfm) | 519 | 520 | 524 | 521 |
| Generator output (kW) | 1,565 | 1,558 | 1,558 | 1,561 |
| Engine output (bhp) | 2,193 | 2,184 | 2,183 | 2,187 |
| LFG methane content (%) | 49.9 | 49.8 | 49.6 | 49.8 |
| Exhaust Gas Composition | | | | |
| $CO_2$ content (% vol) | 10.7 | 10.3 | 10.8 | 10.6 |
| $O_2$ content (% vol) | 8.54 | 8.78 | 8.73 | 8.69 |
| Moisture (% vol) | 11.1 | 10.6 | 10.5 | 10.7 |
| Exhaust gas temperature (°F) | 749 | 752 | 762 | 754 |
| Exhaust gas flowrate (dscfm) | 4,228 | 4,250 | 4,278 | 4,252 |
| Exhaust gas flowrate (scfm) | 4,753 | 4,752 | 4,778 | 4,761 |
| Nitrogen Oxides | | | | |
| $NO_X$ conc. (ppmvd) | 100.2 | 97.3 | 100.4 | 99.3 |
| $NO_X$ emissions (g/bhp*hr) | 0.63 | 0.62 | 0.64 | 0.63 |
| Permitted emissions (g/bhp*hr) | - | - | - | 1.0 |
| $NO_X$ emissions (lb/hr) | 3.04 | 2.96 | 3.08 | 3.03 |
| Permitted emissions (lb/hr) | - | - | - | 4.94 |
| Carbon Monoxide | | | | |
| CO conc. (ppmvd) | 678 | 674 | 674 | 675 |
| CO emissions (g/bhp*hr) | 2.59 | 2.60 | 2.61 | 2.60 |
| Permitted emissions (g/bhp*hr) | - | - | - | 3.5 |
| CO emissions (lb/hr) | 12.50 | 12.50 | 12.57 | 12.52 |
| Permitted emissions (lb/hr) | - | - | - | 17.3 |
| Volatile Organic Compounds | | | | |
| VOC conc. (ppmv as $C_3$) | 14.3 | 13.2 | 19.0 | 15.5 |
| VOC emissions (g/bhp*hr) | 0.10 | 0.09 | 0.13 | 0.11 |
| Permitted emissions (g/bhp*hr) | - | - | - | 1.0 |

Table 6.2 Measured exhaust gas conditions and $NO_x$, CO and VOC air pollutant emission rates Granger Electric of Watervliet, Engine No. 2 (EUICEENGINE2)

| Test No.<br>Test date<br>Test period (24-hr clock) | 1<br>3/4/14<br>1025 - 1125 | 2<br>3/4/14<br>1220 – 1320 | 3<br>3/4/14<br>1355 – 1455 | Three Test Average |
|---|---|---|---|---|
| Fuel flowrate (scfm) | 524 | 529 | 520 | 524 |
| Generator output (kW) | 1,610 | 1,621 | 1,632 | 1,621 |
| Engine output (bhp) | 2,257 | 2,272 | 2,287 | 2,272 |
| LFG methane content (%) | 49.8 | 49.9 | 49.9 | 49.9 |
| <u>Exhaust Gas Composition</u> | | | | |
| $CO_2$ content (% vol) | 10.9 | 11.0 | 11.1 | 11.0 |
| $O_2$ content (% vol) | 8.69 | 8.53 | 8.48 | 8.57 |
| Moisture (% vol) | 11.7 | 10.7 | 11.1 | 11.1 |
| Exhaust gas temperature (°F) | 751 | 754 | 744 | 750 |
| Exhaust gas flowrate (dscfm) | 4,178 | 4,203 | 4,232 | 4,204 |
| Exhaust gas flowrate (scfm) | 4,730 | 4,706 | 4,759 | 4,732 |
| <u>Nitrogen Oxides</u> | | | | |
| $NO_X$ conc. (ppmvd) | 106.8 | 103.8 | 107.3 | 106.0 |
| $NO_X$ emissions (g/bhp*hr) | 0.64 | 0.62 | 0.65 | 0.64 |
| Permitted emissions (g/bhp*hr) | - | - | - | 1.0 |
| $NO_X$ emissions (lb/hr) | 3.20 | 3.13 | 3.26 | 3.20 |
| Permitted emissions (lb/hr) | - | - | - | 4.94 |
| <u>Carbon Monoxide</u> | | | | |
| CO conc. (ppmvd) | 624 | 622 | 621 | 623 |
| CO emissions (g/bhp*hr) | 2.29 | 2.28 | 2.28 | 2.28 |
| Permitted emissions (g/bhp*hr) | - | - | - | 3.5 |
| CO emissions (lb/hr) | 11.38 | 11.42 | 11.48 | 11.42 |
| Permitted emissions (lb/hr) | - | - | - | 17.3 |
| <u>Volatile Organic Compounds</u> | | | | |
| VOC conc. (ppmv as $C_3$) | 14.2 | 8.1 | 9.4 | 10.6 |
| VOC emissions (g/bhp*hr) | 0.09 | 0.05 | 0.06 | 0.07 |
| Permitted emissions (g/bhp*hr) | - | - | - | 1.0 |