**Derenzo Environmental Services**
*Consulting and Testing*

# AIR EMISSION TEST REPORT

| | |
|---|---|
| Title | AIR EMISSION TEST REPORT FOR THE VERIFICATION OF AIR POLLUTANT EMISSIONS FROM LANDFILL GAS FUELED INTERNAL COMBUSTION ENGINES |
| Report Date | December 13, 2018 |
| Test Dates | November 30, 2018 |

| **Facility Information** | |
|---|---|
| Name | Energy Developments Brent Run |
| Street Address | 8335 W. Vienna Road |
| City, County | Montrose, Genesee |
| Facility SRN | N5987 |

| **Facility Permit Information** | |
|---|---|
| ROP No.: | MI-ROP-N5987-2015a |
| Emission Units | EUENGINE4, EUENGINE3, and EUENGINE6 |

| **Testing Contractor** | |
|---|---|
| Company | Derenzo Environmental Services |
| Mailing Address | 39395 Schoolcraft Road<br>Livonia, MI 48150 |
| Phone | (734) 464-3880 |
| Project No. | 1810003 |

## TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF APPENDICES

AIR EMISSION TEST REPORT
FOR THE
VERIFICATION OF AIR POLLUTANT EMISSIONS
FROM
LANDFILL GAS FUELED INTERNAL COMBUSTION ENGINES

ENERGY DEVELOPMENTS BRENT RUN

## 1.0 INTRODUCTION

Energy Developments Limited (EDL) owns and operates the EDL Brent Run renewable energy facility located at the Brent Run Landfill in Montrose, Genesee County, Michigan. The EDL facility primarily consists of three (3) Caterpillar (CAT®) Model No. G3520C gas fueled reciprocating internal combustion engines and electricity generator sets (RICE gensets) that are identified as emission units EUENGINE4, EUENGINE3, and EUENGINE6 (collectively flexible emission group FGICEENGINES) in Section 2 of Michigan Renewable Operating Permit (ROP) No. MI-ROP-N5987-2015a issued by the Michigan Department of Environmental Quality – Air Quality Division (MDEQ-AQD).

Engine Nos. 4, 3, and 6 (EUENGINE4, EUENGINE3, and EUENGINE6) are part of the emission group FGICEENGINES. The conditions of MI-ROP-N5987-2015a for FGICEENGINES specify that:

> *Except as provided in 40 CFR 60.4243(b), the permittee shall conduct an initial performance test for EUENGINE3 and EUENGINE6 within one year after startup of the engine and every 8760 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), unless the engine(s) have been certified by the manufacturer ... If a performance test is required, the performance tests shall be conducted according to 40 CFR 60.4244*

The compliance testing was performed by Derenzo Environmental Services (DES). DES representatives Brad Thome and Clay Gaffey performed the field sampling and measurements November 30, 2018.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated October 23, 2018 that was reviewed and approved by the MDEQ-AQD.

Questions regarding this emission test report should be directed to:

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## Report Certification

This test report was prepared by Derenzo Environmental Services based on field sampling data collected by DES. Facility process data were collected and provided by EDL employees or representatives. This test report has been reviewed by EDL representatives and approved for submittal to the MDEQ.

A Report Certification signed by the facility's Responsible Official accompanies this report.

I certify that the testing was conducted in accordance with the specified test methods and submitted test plan unless otherwise specified in this report. I believe the information provided in this report and its attachments are true, accurate, and complete.

Report Prepared By:

Tyler J. Wilson
Livonia Office Supervisor
Derenzo Environmental Services

## 2.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

### 2.1 Purpose and Objective of the Tests

The conditions of ROP No. MI-ROP-N5987-2015a and 40 CFR Part 60 Subpart JJJJ require EDL to test EUENGINE4, EUENGINE3, and EUENGINE6 for carbon monoxide (CO), nitrogen oxides (NOx) and volatile organic compound (VOC) emissions every 8,760 hours of operation.

### 2.2 Operating Conditions During the Compliance Tests

The testing was performed while the RICE generator sets were operated at maximum operating conditions (1,600 kW electricity output +/- 10%). EDL representatives provided the generator electricity output (kW) in 15-minute increments for each test period. The generator kW output ranged between 1,604 and 1,655 kW during the test periods.

Fuel flowrate (pounds per hour (lb/hr)) and fuel methane content (%) were also recorded by EDL representatives in 15-minute increments for each test period. The FG-RICENSPS fuel consumption rate ranged between 2,460 and 2,561 lb/hr; fuel methane content ranged between 48.5 and 49.1%. Fuel heat value was calculated using a lower heating value of 910 Btu/scf for methane.

In addition, the engine serial number and operating hours at the beginning of test No. 1 were recorded by the facility operators.

Appendix 2 provides operating records provided by EDL 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).

Engine output (bhp) = Electricity output (kW) / (0.957) / (0.7457 kW/hp)

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

### 2.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the LFG fueled RICE were each sampled for three (3) one-hour test periods during the compliance testing performed November 30, 2018.

Table 2.2 presents the average measured pollutant emission rates for EUENGINE4, EUENGINE3, and EUENGINE6 (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 2.1 Average engine operating conditions during the test periods

| Engine Parameter | EUENGINE4 | EUENGINE3 | EUENGINE6 |
|---|---|---|---|
| Generator output (kW) | 1,631 | 1,642 | 1,628 |
| Engine output (bhp) | 2,286 | 2,301 | 2,281 |
| Engine LFG fuel use (lb/hr) | 2,487 | 2,547 | 2,497 |
| LFG methane content (%) | 48.9 | 48.9 | 48.6 |
| LFG lower heating value (Btu/scf) | 445 | 445 | 442 |
| Exhaust temperature ($^{o}F$) | 805 | 829 | 811 |

Table 2.2 Average measured emission rates (three-test average)

| | NOx Emissions | | CO Emissions | | VOC Emissions | |
|---|---|---|---|---|---|---|
| Emission Unit | (lb/hr) | (g/bhp-hr) | (lb/hr) | (g/bhp-hr) | (lb/hr) | (g/bhp-hr) |
| EUENGINE4 | 2.95 | 0.58 | 12.2 | 2.43 | 0.71 | 0.14 |
| *Permit Limit* | *4.94* | *1.0* | *16.3* | *3.3* | -- | *1.0* |
| EUENGINE3 | 2.78 | 0.55 | 12.2 | 2.40 | 0.70 | 0.14 |
| *Permit Limit* | *4.94* | *1.0* | *16.3* | *3.3* | -- | *1.0* |
| EUENGINE6 | 3.62 | 0.72 | 13.3 | 2.65 | 0.67 | 0.13 |
| *Permit Limit* | *4.94* | *2.0* | *16.3* | *5.0* | *4.94* | *1.0* |

## 3.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

### 3.1 General Process Description

Landfill gas (LFG) containing methane is generated in the Brent Run 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 EDL LFG power station facility where it is treated and used as fuel for the RICE. Each RICE is connected to an electricity generator that produces electricity that is transferred to the local utility.

### 3.2 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 generators have a rated electricity output of 1,600 kilowatts (kW). The engines are designed to fire low-pressure, lean fuel mixtures (e.g., LFG) and are 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 RICE generator sets are not equipped with an add-on emission control device. 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.

### 3.3 Sampling Locations

Each RICE exhaust gas is directed through a muffler and is released to the atmosphere through a dedicated vertical exhaust stack with a vertical release point.

The exhaust stack sampling ports for EUENGINE4, EUENGINE3, and EUENGINE6 are located in the exhaust stack with an inner diameter of 13.5 inches. Each stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location greater than 300 inches (22.2 duct diameters) upstream and greater than 114 inches (8.44 duct diameters) downstream from any flow disturbance and satisfies the USEPA Method 1 criteria for a representative sample location.

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

Appendix 1 provides diagrams of the emission test sampling locations.

## 4.0 SAMPLING AND ANALYTICAL PROCEDURES

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

### 4.1 Summary of Sampling Methods

| | |
|---|---|
| USEPA Method 1 | Exhaust gas velocity measurement locations were determined based on the physical stack arrangement and requirements in USEPA Method 1. |
| USEPA Method 2 | Exhaust gas velocity pressure was determined using a Type-S Pitot tube connected to a red oil incline manometer; temperature was measured using a K-type thermocouple connected to the Pitot tube. |
| USEPA Method 3A | Exhaust gas $O_2$ and $CO_2$ content was determined using zirconia ion/paramagnetic and infrared instrumental analyzers, respectively. |
| USEPA Method 4 | Exhaust gas moisture was determined based on the water weight gain in chilled impingers. |
| USEPA Method 7E | Exhaust gas NOx concentration was determined using chemiluminescence instrumental analyzer. |
| USEPA Method 10 | Exhaust gas CO concentration was measured using an NDIR instrumental analyzer. |
| USEPA Method 25A / ALT-096 | Exhaust gas VOC (as NMHC) concentration was determined using a flame ionization analyzer equipped with methane separation column. |

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

The exhaust stack gas velocities and volumetric flow rates for each RICE were determined using USEPA Method 2 prior to 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.

Appendix 3 provides exhaust gas flowrate calculations and field data sheets.

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

$CO_2$ and $O_2$ content in each RICE exhaust gas stream were measured continuously throughout each test period in accordance with USEPA Method 3A. The $CO_2$ content of the exhaust was monitored using a Servomex 1440D single beam single wavelength (SBSW) infrared gas analyzer. The $O_2$ content of the exhaust was monitored using a Servomex 1440D gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the 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 $CO_2$ concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

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

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

## 4.4 Exhaust Gas Moisture Content (USEPA Method 4)

Moisture content of each 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)

The exhaust for each RICE was monitored for three (3) one-hour test periods during which the NOx and CO concentrations were measured using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence $NO_X$ analyzer and a TEI Model 48i infrared CO analyzer. The measured pollutant concentrations were adjusted based on instrument calibrations performed prior to and following each test period (drift and bias corrected pursuant to equations in specified in the USEPA reference test methods).

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

Appendix 4 provides CO and $NO_X$ calculation sheets. Raw instrument response data are provided in Appendix 5.

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

The VOC emission rate was determined by measuring the nonmethane hydrocarbon (NMHC) concentration in each RICE exhaust gas. NMHC pollutant concentration was determined using a TEI Model 55i Methane / Nonmethane hydrocarbon analyzer. The TEI 55i analyzer contains an internal gas chromatograph column that separates methane from non-methane components. The concentration of NMHC in the sampled gas stream, after separation from methane, is determined relative to a propane standard using a flame ionization detector in accordance with USEPA Method 25A.

The USEPA Office of Air Quality Planning and Standards (OAQPS) has issued several alternate test methods approving the use of the TEI 55-series analyzer as an effective instrument for measuring NMOC from gas-fueled reciprocating internal combustion engines (RICE) in that it uses USEPA Method 25A and 18 (ALT-066, ALT-078 and ALT-096).

Samples of the exhaust gas were delivered directly to the instrumental analyzer using the Teflon® heated sample line to prevent condensation. The sample to the NHMC analyzer was not conditioned to remove moisture. Therefore, VOC measurements correspond to standard conditions with no moisture correction (wet basis).

Prior to, and at the conclusion of each test, the instrument was calibrated using mid-range calibration (propane) and zero gas to determine analyzer calibration error and system bias (described in Section 5.0 of this document).

Appendix 4 provides VOC calculation sheets. Raw instrument response data for the NMHC analyzer is provided in Appendix 5.

## 5.0 QA/QC ACTIVITIES

### 5.1 Flow Measurement

Prior to arriving onsite, the instruments used during the source test to measure exhaust gas properties and velocity (barometer, pyrometer, and Pitot tube) were calibrated to specifications outlined in the sampling methods.

The Pitot tube and connective tubing were leak-checked prior to the test event 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).

### 5.2 $NO_x$ 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 $NO_X$ concentration is greater than or equal to 90% of the expected value.

The $NO_2$ – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured $NO_X$ concentration was greater than 90% of the expected value as required by Method 7E).

### 5.3 Gas Divider Certification (USEPA Method 205)

A STEC Model SGD-710C 10-step gas divider was used to obtain appropriate calibration span gases. The ten-step STEC gas divider was NIST certified (within the last 12 months) with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivered calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas that was introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of gas divider. The field evaluation yielded no errors greater than 2% of the triplicate measured average and no errors greater than 2% from the expected values.

### 5.4 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure $NO_X$, CO, $O_2$, and $CO_2$ have had an interference response test preformed 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 2.5% 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, $CO_2$, and $O_2$ analyzers by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and determining the instrument response against the initial instrument calibration readings.

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

The instruments were calibrated with USEPA Protocol 1 certified concentrations of $CO_2$, $O_2$, $NO_x$, and CO in nitrogen or air and zeroed using hydrocarbon-free nitrogen or air. The NMHC (VOC) instrument was calibrated with USEPA Protocol 1 certified concentrations of propane in air and zeroed using hydrocarbon-free air. A STEC Model SGD-710C ten-step gas divider was used to obtain intermediate calibration gas concentrations as needed.

## 5.6 Determination of Exhaust Gas Stratification

A stratification test was performed for each RICE exhaust stack. The stainless steel sample probe was positioned at sample points correlating to 16.7, 50.0 (centroid) and 83.3% of the stack diameter. Pollutant concentration data were recorded at each sample point for a minimum of twice the maximum system response time.

The recorded concentration data for the RICE exhaust stack indicated that the measured NOx concentrations did not vary by more than 5% of the mean across the stack diameter. Therefore, the RICE exhaust gas was considered to be unstratified and the compliance test sampling was performed at a single sampling location within each RICE exhaust stack.

## 5.7 Meter Box Calibrations

The dry gas metering 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 6 presents test equipment quality assurance data ($NO_2$ – NO conversion efficiency test data, instrument calibration and system bias check records, calibration gas and gas divider certifications, interference test results, meter box calibration records, 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 6.3.

The measured air pollutant emission rates for Engine Nos. 4 and 3 are less than the allowable limits specified in ROP No. MI-ROP-N5987-2015a for FG-RICENSPS:

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

The measured air pollutant emission rates for Engine No. 6 are less than the allowable limits specified in ROP No. MI-ROP-N5987-2015a for Emission Unit EUENGINE6:

- 4.94 lb/hr and 2.0 g/bhp-hr for $NO_X$;
- 16.3 lb/hr and 5.0 g/bhp-hr for CO;
- 4.94 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 USEPA methods and the approved test protocol. Each RICE generator set was operated within 10% of maximum output (1,600 kW generator output) during the engine test periods.

The one-minute data averages for the USEPA Method 205 gas divider field certification and USEPA Method 7E NOx converter efficiency test are not shown in the raw data for setup day (11/29/18). This data was not exported correctly following the test event, and the data logger was cleared out prior to completing this Air Emission Test Report. The handwritten field calibration data sheet with all USEPA Method 205 gas divider field certification and USEPA Method 7E NOx converter efficiency test data is included in Appendix 6 of this report.

Table 6.1 Measured exhaust gas conditions and $NO_x$, CO, and VOC air pollutant emission rates for Engine No. 4 (EUENGINE4)

| Test No.<br>Test date<br>Test period (24-hr clock) | 1<br>11/30/18<br>7:00-8:00 | 2<br>11/30/18<br>8:33-9:33 | 3<br>11/30/18<br>10:11-11:11 | Three Test Average |
|---|---|---|---|---|
| Fuel flowrate (lb/hr) | 2,478 | 2,490 | 2,494 | 2,487 |
| Generator output (kW) | 1,634 | 1,633 | 1,627 | 1,631 |
| Engine output (bhp) | 2,289 | 2,289 | 2,279 | 2,286 |
| LFG methane content (%) | 49.0 | 48.9 | 48.8 | 48.9 |
| LFG heat content (Btu/scf) | 446 | 445 | 444 | 445 |
| Exhaust Gas Composition | | | | |
| $CO_2$ content (% vol) | 11.3 | 11.3 | 11.4 | 11.4 |
| $O_2$ content (% vol) | 8.92 | 8.92 | 8.93 | 8.93 |
| Moisture (% vol) | 10.2 | 13.3 | 11.7 | 11.7 |
| Exhaust gas temperature (°F) | 805 | 805 | 805 | 805 |
| Exhaust gas flowrate (dscfm) | 4,486 | 4,403 | 4,490 | 4,460 |
| Exhaust gas flowrate (scfm) | 4,994 | 5,066 | 5,085 | 5,048 |
| Nitrogen Oxides | | | | |
| $NO_X$ conc. (ppmvd) | 93.4 | 93.0 | 90.0 | 92.1 |
| $NO_X$ emissions (lb/hr) | 3.00 | 2.94 | 2.90 | 2.95 |
| Permitted emissions (lb/hr) | - | - | - | 4.94 |
| $NO_X$ emissions (g/bhp*hr) | 0.60 | 0.58 | 0.58 | 0.58 |
| Permitted emissions (g/bhp*hr) | - | - | - | 1.0 |
| Carbon Monoxide | | | | |
| CO conc. (ppmvd) | 629 | 629 | 627 | 628 |
| CO emissions (lb/hr) | 12.3 | 12.1 | 12.3 | 12.2 |
| Permitted emissions (lb/hr) | - | - | - | 16.3 |
| CO emissions (g/bhp*hr) | 2.44 | 2.40 | 2.45 | 2.43 |
| Permitted emissions (g/bhp*hr) | - | - | - | 3.3 |
| Volatile Organic Compounds | | | | |
| VOC conc. (ppmv as $C_3$)[1] | 20.2 | 20.6 | 20.8 | 20.6 |
| VOC emissions (lb/hr) | 0.69 | 0.72 | 0.73 | 0.71 |
| VOC emissions (g/bhp*hr) | 0.14 | 0.14 | 0.14 | 0.14 |
| Permitted emissions (g/bhp*hr) | - | - | - | 1.0 |

VOC measured as nonmethane hydrocarbons.

Table 6.2 Measured exhaust gas conditions and $NO_x$, CO, and VOC air pollutant emission rates for Engine No. 3 (EUENGINE3)

| Test No.<br>Test date<br>Test period (24-hr clock) | 1<br>11/30/18<br>11:57-12:57 | 2<br>11/30/18<br>13:34-14:34 | 3<br>11/30/18<br>15:05-16:05 | Three Test<br>Average |
|---|---|---|---|---|
| Fuel flowrate (lb/hr) | 2,544 | 2,552 | 2,545 | 2,547 |
| Generator output (kW) | 1,637 | 1,650 | 1,638 | 1,642 |
| Engine output (bhp) | 2,294 | 2,312 | 2,296 | 2,301 |
| LFG methane content (%) | 48.9 | 48.9 | 48.9 | 48.9 |
| LFG heat content (Btu/scf) | 445 | 445 | 445 | 445 |
| Exhaust Gas Composition | | | | |
| $CO_2$ content (% vol) | 9.01 | 11.5 | 11.5 | 10.7 |
| $O_2$ content (% vol) | 8.76 | 8.76 | 8.76 | 8.76 |
| Moisture (% vol) | 11.5 | 11.6 | 11.7 | 11.6 |
| Exhaust gas temperature (°F) | 827 | 831 | 831 | 829 |
| Exhaust gas flowrate (dscfm) | 4,576 | 4,635 | 4,543 | 4,585 |
| Exhaust gas flowrate (scfm) | 5,173 | 5,242 | 5,146 | 5,187 |
| Nitrogen Oxides | | | | |
| $NO_X$ conc. (ppmvd) | 84.8 | 83.6 | 85.4 | 84.6 |
| $NO_X$ emissions (lb/hr) | 2.78 | 2.78 | 2.78 | 2.78 |
| Permitted emissions (lb/hr) | - | - | - | 4.94 |
| $NO_X$ emissions (g/bhp*hr) | 0.55 | 0.54 | 0.55 | 0.55 |
| Permitted emissions (g/bhp*hr) | - | - | - | 1.0 |
| Carbon Monoxide | | | | |
| CO conc. (ppmvd) | 609 | 605 | 613 | 609 |
| CO emissions (lb/hr) | 12.2 | 12.2 | 12.2 | 12.2 |
| Permitted emissions (lb/hr) | - | - | - | 16.3 |
| CO emissions (g/bhp*hr) | 2.41 | 2.40 | 2.40 | 2.40 |
| Permitted emissions (g/bhp*hr) | - | - | - | 3.3 |
| Volatile Organic Compounds | | | | |
| VOC conc. (ppmv as $C_3$)[1] | 19.5 | 19.6 | 19.5 | 19.5 |
| VOC emissions (lb/hr) | 0.69 | 0.71 | 0.69 | 0.70 |
| VOC emissions (g/bhp*hr) | 0.14 | 0.14 | 0.14 | 0.14 |
| Permitted emissions (g/bhp*hr) | - | - | - | 1.0 |

1. VOC measured as nonmethane hydrocarbons.

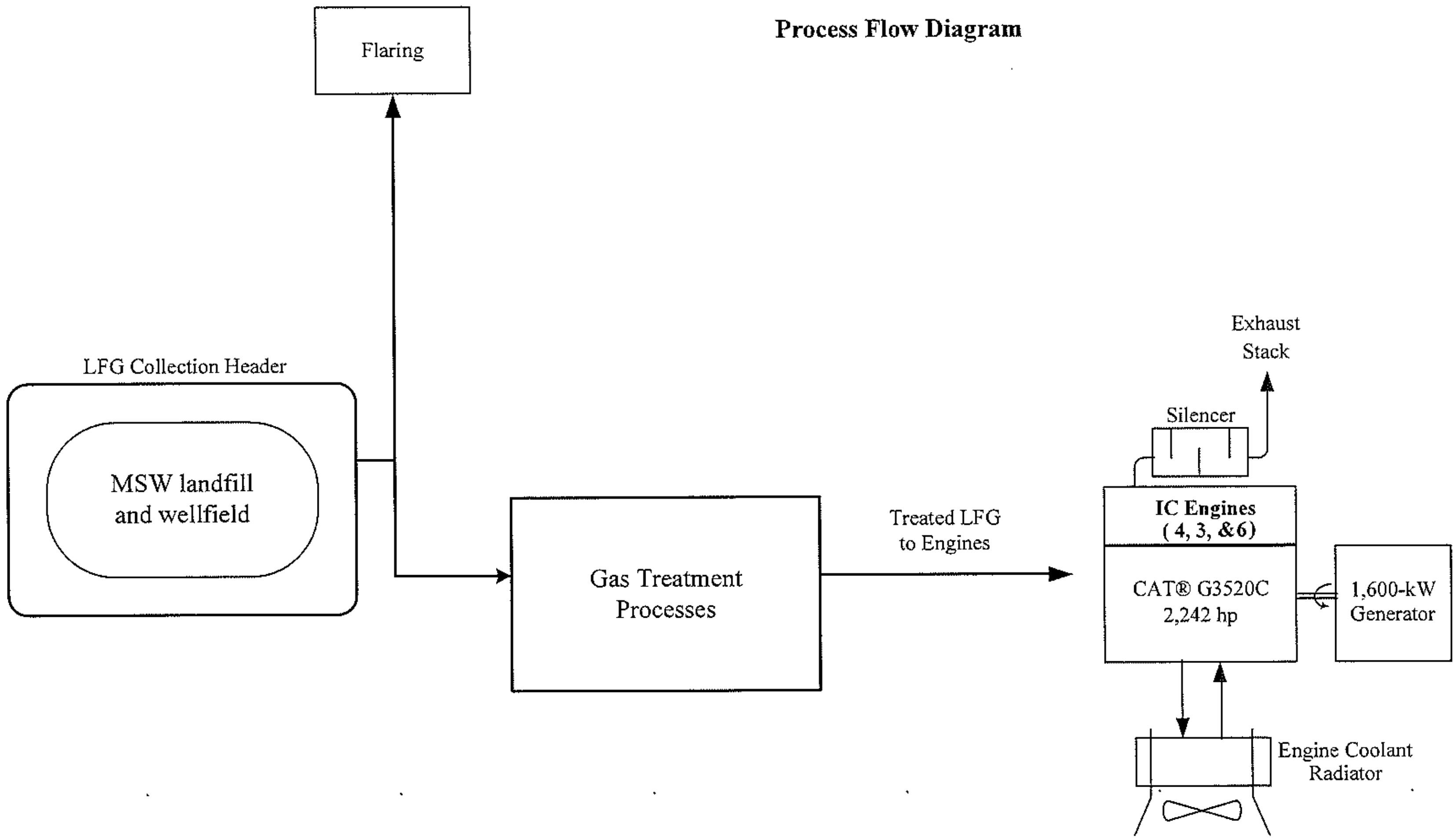
Table 6.3 Measured exhaust gas conditions and $NO_x$, CO, VOC, and air pollutant emission rates for Engine No. 6 (EUENGINE6)

| Test No.<br>Test date<br>Test period (24-hr clock) | 1<br>11/30/18<br>16:34-17:34 | 2<br>11/30/18<br>18:09-19:09 | 3<br>11/30/18<br>19:40-20:40 | Three Test Average |
|---|---|---|---|---|
| Fuel flowrate (lb/hr) | 2,493 | 2,501 | 2,498 | 2,497 |
| Generator output (kW) | 1,631 | 1,627 | 1,625 | 1,628 |
| Engine output (bhp) | 2,286 | 2,280 | 2,277 | 2,281 |
| LFG methane content (%) | 48.7 | 48.6 | 48.6 | 48.6 |
| LFG heat content (Btu/scf) | 443 | 442 | 442 | 442 |
| Exhaust Gas Composition | | | | |
| $CO_2$ content (% vol) | 11.5 | 11.5 | 11.5 | 11.5 |
| $O_2$ content (% vol) | 8.75 | 8.75 | 8.73 | 8.74 |
| Moisture (% vol) | 11.1 | 12.0 | 11.3 | 11.5 |
| Exhaust gas temperature (°F) | 809 | 808 | 816 | 811 |
| Exhaust gas flowrate (dscfm) | 4,510 | 4,496 | 4,538 | 4,515 |
| Exhaust gas flowrate (scfm) | 5,071 | 5,109 | 5,114 | 5,098 |
| Nitrogen Oxides | | | | |
| $NO_X$ conc. (ppmvd) | 113 | 112 | 111 | 112 |
| $NO_X$ emissions (lb/hr) | 3.64 | 3.60 | 3.60 | 3.62 |
| Permitted emissions (lb/hr) | - | - | - | 4.94 |
| $NO_X$ emissions (g/bhp*hr) | 0.72 | 0.72 | 0.72 | 0.72 |
| Permitted emissions (g/bhp*hr) | - | - | - | 2.0 |
| Carbon Monoxide | | | | |
| CO conc. (ppmvd) | 674 | 673 | 680 | 676 |
| CO emissions (lb/hr) | 13.3 | 13.2 | 13.5 | 13.3 |
| Permitted emissions (lb/hr) | - | - | - | 16.3 |
| CO emissions (g/bhp*hr) | 2.63 | 2.63 | 2.68 | 2.65 |
| Permitted emissions (g/bhp*hr) | - | - | - | 5.0 |
| Volatile Organic Compounds | | | | |
| VOC conc. (ppmv as $C_3$)[2] | 19.5 | 19.2 | 19.0 | 19.3 |
| VOC emissions (lb/hr) | 0.68 | 0.67 | 0.67 | 0.67 |
| Permitted emissions (lb/hr) | - | - | - | 4.94 |
| VOC emissions (g/bhp*hr) | 0.13 | 0.13 | 0.13 | 0.13 |
| Permitted emissions (g/bhp*hr) | - | - | - | 1.0 |

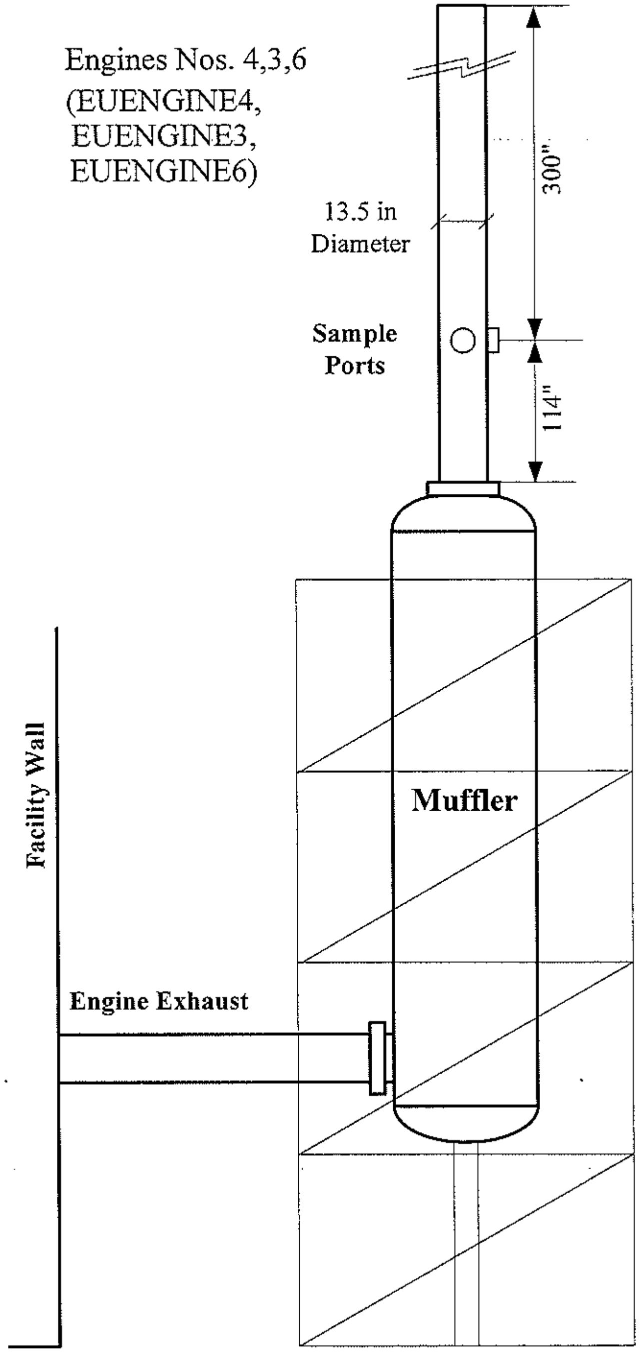
1. VOC measured as nonmethane hydrocarbons.

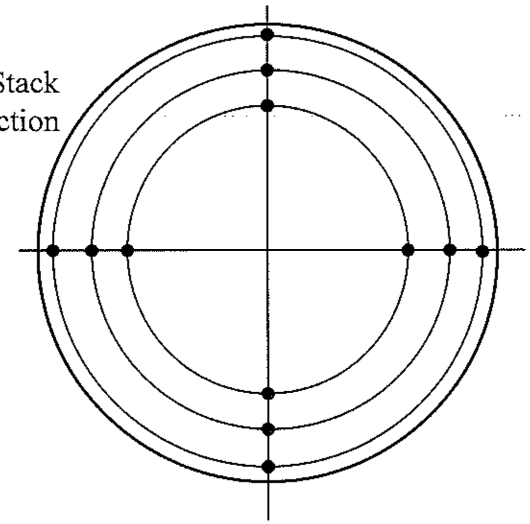
## APPENDIX 1

- Figure 1-A – Process Flow Diagram
- Figure 1-B – IC Engines Nos. 4, 3, & 6 Sample Port Diagram




| | | | |
|---|---|---|---|
| 1/10/17 | **Figure 1-A. Granger Electric Company Brent Run Facility Process Flow Diagram** | | |
| | Scale<br>None | Sheet<br>1 of 1 | Derenzo Environmental Services Project No.1810003 |




Velocity sample locations as measured from stack wall
(not including 5.25" sampling port nipple)

| Pt. # | in. |
|---|---|
| 1 | 0.59 |
| 2 | 1.97 |
| 3 | 4.00 |
| 4 | 9.50 |
| 5 | 11.5 |
| 6 | 12.9 |

| 01/08/15 | **Figure 1-B. Granger Electric - Brent Run Exhaust Sample Locations, CAT G3520 ICE** | | |
|---|---|---|---|
| | Scale None | Sheet 1 of 1 | Derenzo Environmental Services Project No. 1810003 |