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

ENERGY DEVELOPMENTS LANSING, LLC
AT THE GRANGER WOOD STREET LANDFILL

1.0 INTRODUCTION

Energy Developments Lansing, LLC (EDL) (Facility SRN: N5997) owns and operates four (4) Caterpillar (CAT®) Model No. G3516 landfill gas (LFG) fueled reciprocating internal combustion engines (RICE) and three (3) CAT® Model No. G3520C LFG fueled RICE at the Granger Wood St. Landfill in Lansing, Clinton County, Michigan. The CAT® Model No. G3516 engines are identified as Emission Unit ID: EUICE1-S1 – EUICE4-S1 (FGICE-S1) and the CAT® Model No. G3520C engines are identified as Emission Unit ID: EUICEENGINE1-S1 – EUICEENGINE3-S1 (FGICEENGINES-S1) in Renewable Operating Permit (ROP) No. MI-ROP-N5997-2013. EUICE1-S1 through EUICE4-S1 are also referred to as Engine Nos. 1 through 4, respectively and EUICEENGINE1-S1 through EUICEENGINE3-S1 are also referred to as Engine Nos. 5 through 7, respectively, in this report and by facility representatives.

Air emission compliance testing was performed to satisfy the following requirements contained in ROP No. MI-ROP-N5997-2013:

- Test air pollutant emissions for FGICEENGINES-S1 in accordance with 40 CFR Part 60 Subpart JJJJ.

The compliance testing was performed by Impact Compliance and Testing, Inc. (ICT), a Michigan-based environmental consulting and testing company. ICT representatives Clay Gaffey and Andrew Rusnak performed the field sampling and measurements March 3 – 4, 2020.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan dated January 30, 2020 that was reviewed and approved by the Michigan Department of Environment, Great Lakes and Energy (EGLE). EGLE representatives Mr. Mark Dziadosz and Ms. Michelle Luplow observed portions of the testing project.

Questions regarding this emission test report should be directed to:

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Report Certification

This test report was prepared by Impact Compliance and Testing, Inc. based on field sampling data collected by Impact Compliance and Testing, Inc. 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 EGLE.

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:

Andy Rusnak, QSTI
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2.0 SOURCE AND SAMPLING LOCATION DESCRIPTION

2.1 General Process Description

Landfill gas (LFG) containing methane is generated in the Granger Wood St. 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 seven (7) RICE. Each RICE is connected to an electricity generator that produces electricity that is transferred to the local utility.

2.2 Rated Capacities and Air Emission Controls

The CAT® Model No. G3520C RICE has a rated output of 2,233 brake-horsepower (bhp) and the connected generator has a rated electricity output of 1,600 kilowatts (kW). The engine is designed to fire low-pressure, lean fuel mixtures (e.g., LFG) and is equipped with an air-to-fuel ratio controller that monitors engine performance parameters and automatically adjusts the air-to-fuel ratio and ignition timing to maintain efficient fuel combustion.

The engine/generator sets are not equipped with add-on emission control devices. Air pollutant emissions are minimized through the proper operation of the gas treatment system and efficient fuel combustion in the engines.

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

2.3 Sampling Locations

The RICE exhaust gas is directed through mufflers and is released to the atmosphere through dedicated vertical exhaust stacks with vertical release points. The three (3) CAT® Model G3520C RICE exhaust stacks are identical.

The exhaust stack sampling ports for the CAT® Model G3520C engines (Engine Nos. 5, 6 and 7) are located in individual exhaust stacks 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 120 inches (>9 duct diameters) upstream and greater than 120.0 inches (>9 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.

3.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS

3.1 Purpose and Objective of the Tests

The conditions of MI-ROP-N5997-2013 and 40 CFR Part 60 Subpart JJJJ require EDL to test each engine contained in FGICEENGINES-S1 for carbon monoxide (CO), nitrogen oxides (NOx) and volatile organic compounds (VOCs) every 8,760 hours of operation. Therefore, each engine contained in FGICEENGINES-S1 was sampled for CO, NO_X and VOC emissions and exhaust gas oxygen (O_2) and carbon dioxide (CO_2) content.

3.2 Operating Conditions During the Compliance Tests

The testing was performed while the EDL engine/generator sets were operated at maximum operating conditions (1,600 kW electricity output +/- 10%). EDL representatives provided the kW output in 15-minute increments for each test period. The FGICEENGINES-S1 generator kW output ranged between 1,553 and 1,648 kW for each test period.

For the testing performed on FGICEENGINES-S1 fuel flowrate (pounds per hour), fuel methane content (%), fuel oxygen content (%) and the air to fuel ratio were recorded by EDL representatives in 15-minute increments for each test period. The FGICEENGINES-S1 fuel consumption rate ranged between 2,255 and 2,327 pph, fuel methane content ranged between 51.0 and 51.7%, fuel oxygen content ranged between 0.59% and 0.81% and the air to fuel ratio ranged from 7.4 to 8.3 during the test periods.

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 (96.1%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp).

Engine output (bhp) = Electricity output (kW) / (0.961) / (0.7457 kW/hp)

The facility records fuel use rate in units of pounds per hour. To convert to units of standard cubic feet of gas consumed per minute (scfm) the following equation was used:

Fuel Use (scfm) = Fuel Use (pph) / LFG MW (lb/lb-mol) * 385 scf LFG/lb-mol / 60 min/hr

A lower heating value of 909 Btu/ft^3 was used to calculate the LFG heating value.

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

3.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled LFG fueled RICE (Engine Nos. 5, 6 and 7) were each sampled for three (3) one-hour test periods during the compliance testing performed March 3 through March 4, 2020.

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 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	Engine No. 5	Engine No. 6	Engine No. 7
Generator output (kW)	1,612	1,594	1,623
Engine output (bhp)	2,250	2,225	2,265
Engine LFG fuel use (pph)	2,318	2,269	2,283
Engine LFG fuel use (scfm)	547	535	539
LFG methane content (%)	51.5	51.4	51.4
LFG lower heating value (Btu/ft^3)	468	468	467
Exhaust temperature (^{o}F)	841	861	816
LFG oxygen content (%)	0.73	0.80	0.71
Air to fuel ratio	7.4	7.6	8.2

Table 3.2 Average measured emission rates for each engine (three-test average)

	CO Emission Rates		NOx Emission Rates		VOC Emission Rates
Emission Unit	(lb/hr)	(g/bhp-hr)	(lb/hr)	(g/bhp-hr)	(g/bhp-hr)
Engine No. 5	14.5	2.92	3.07	0.62	0.13
Engine No. 6	12.1	2.47	2.81	0.57	0.11
Engine No. 7	11.2	2.24	2.76	0.55	0.11
Permit Limit	**16.23**	**3.30**	**4.92**	**1.0**	**1.0**

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A test protocol for the air emission testing was reviewed and approved by the EGLE. This section provides a summary of the sampling and analytical procedures that were used during the EDL testing 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 paramagnetic and infrared instrumental analyzer.
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 analyzers.
USEPA Method 10	Exhaust gas CO concentration was measured using an infrared 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 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 prior to each traverse 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 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 the RICE exhaust gas stream was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a California Analytics Fuji Model ZRF infrared gas analyzer. The O_2 content of the exhaust was monitored using a California Analytics Fuji Model ZFK3 gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the IC engine exhaust gas stream was extracted from the stack using a stainless steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzers; therefore, measurement of O_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 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 streams were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42c High Level chemiluminescence NO_X analyzer and a California Analytics Fuji Model ZRF 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 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 the engine 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 an alternate test method approving the use of the TEI 55i-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-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 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 within 90% of the expected value.

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO_x concentration was 94.2% 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 (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.

5.3 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), 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.

5.4 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 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 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 each 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 each RICE exhaust stack indicated that the measured NO_x, CO, O_2 and CO_2 concentrations did not vary by more than 5% of the mean across each 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 the RICE exhaust stack.

5.6 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 7 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 and stratification checks).

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 concentrations and emission rates for Engine Nos. 5 – 7 are less than the allowable limits specified in Permit to Install No. MI-ROP-N5997-2013 for Emission Unit Nos. EUICEENGINE1-S1 through EUICEENGINE3-S1:

- 4.92 lb/hr and 1.0 g/bhp-hr for NO_X;
- 16.23 lb/hr and 3.3 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 USEPA methods and the approved test protocol. The engine-generator sets were operated within 10% of maximum output (1,600 kW generator output) and no variations from normal operating conditions occurred during the engine test periods.

Table 6.1 Measured exhaust gas conditions and NO_x, CO and VOC air pollutant emission rates for Engine No. 5 (EUICEENGINE1-S1)

Test No. Test date Test period (24-hr clock)	1 3/4/20 730-830	2 3/4/20 848-948	3 3/4/20 1005-1105	Three Test Average
Fuel flowrate (scfm)	548	545	547	547
Generator output (kW)	1,615	1,613	1,608	1,612
Engine output (bhp)	2,254	2,251	2,244	2,250
LFG methane content (%)	51.5	51.6	51.5	51.5
LFG heat content (Btu/scf)	468	469	468	468
LFG O_2 Content (%)	0.74	0.72	0.72	0.73
Air to fuel ratio	7.4	7.5	7.4	7.4
Exhaust Gas Composition				
CO_2 content (% vol)	11.5	11.5	11.6	11.5
O_2 content (% vol)	8.06	8.04	7.96	8.02
Moisture (% vol)	12.4	11.6	12.2	12.1
Exhaust gas temperature (^oF)	845	839	838	841
Exhaust gas flowrate (dscfm)	4,269	4,321	4,238	4,276
Exhaust gas flowrate (scfm)	4,873	4,888	4,826	4,862
Nitrogen Oxides				
NO_X conc. (ppmvd)	103	98.7	98.4	100
NO_X emissions (lb/hr)	3.17	3.06	2.99	3.07
Permit Limit (lb/hr)	-	-	-	4.92
NO_X emissions (g/bhp*hr)	0.64	0.62	0.60	0.62
Permit Limit (g/bhp*hr)	-	-	-	1.0
Carbon Monoxide				
CO conc. (ppmvd)	768	769	791	776
CO emissions (lb/hr)	14.3	14.5	14.6	14.5
Permit Limit (lb/hr)	-	-	-	16.23
CO emissions (g/bhp*hr)	2.88	2.92	2.96	2.92
Permit Limit (g/bhp*hr)	-	-	-	3.30
Volatile Organic Compounds				
VOC conc. (ppmv)	19.6	20.2	19.8	19.9
VOC emissions (g/bhp*hr)	0.13	0.14	0.13	0.13
Permit Limit (g/bhp*hr)	-	-	-	1.0

Table 6.2 Measured exhaust gas conditions and NO_x, CO and VOC air pollutant emission rates for Engine No. 6 (EUICEENGINE2-S1)

Test No.	1	2	3	
Test date	3/3/20	3/3/20	3/3/20	Three Test
Test period (24-hr clock)	740-840	856-956	1014-1114	Average
Fuel flowrate (scfm)	535	535	536	535
Generator output (kW)	1,593	1,588	1,603	1,594
Engine output (bhp)	2,222	2,216	2,237	2,225
LFG methane content (%)	51.5	51.5	51.4	51.5
LFG heat content (Btu/scf)	468	468	467	468
LFG O_2 content (%)	0.80	0.80	0.79	0.80
Air to fuel ratio	7.6	7.6	7.6	7.6
Exhaust Gas Composition				
CO_2 content (% vol)	11.7	11.7	11.7	11.7
O_2 content (% vol)	7.82	7.86	7.86	7.85
Moisture (% vol)	12.5	11.7	11.6	11.9
Exhaust gas temperature (^oF)	868	864	851	861
Exhaust gas flowrate (dscfm)	4,170	4,284	4,293	4,249
Exhaust gas flowrate (scfm)	4,766	4,852	4,854	4,824
Nitrogen Oxides				
NO_X conc. (ppmvd)	95.3	90.3	90.8	92.2
NO_X emissions (lb/hr)	2.85	2.77	2.79	2.81
Permit Limit (lb/hr)	-	-	-	4.92
NO_X emissions (g/bhp*hr)	0.58	0.57	0.57	0.57
Permit Limit (g/bhp*hr)	-	-	-	1.0
Carbon Monoxide				
CO conc. (ppmvd)	649	654	655	653
CO emissions (lb/hr)	11.8	12.2	12.3	12.1
Permit Limit (lb/hr)	-	-	-	16.23
CO emissions (g/bhp*hr)	2.41	2.50	2.49	2.47
Permit Limit (g/bhp*hr)	-	-	-	3.30
Volatile Organic Compounds				
VOC conc. (ppmv)	15.8	16.3	15.9	16.0
VOC emissions (g/bhp*hr)	0.11	0.11	0.11	0.11
Permit Limit (g/bhp*hr)	-	-	-	1.0

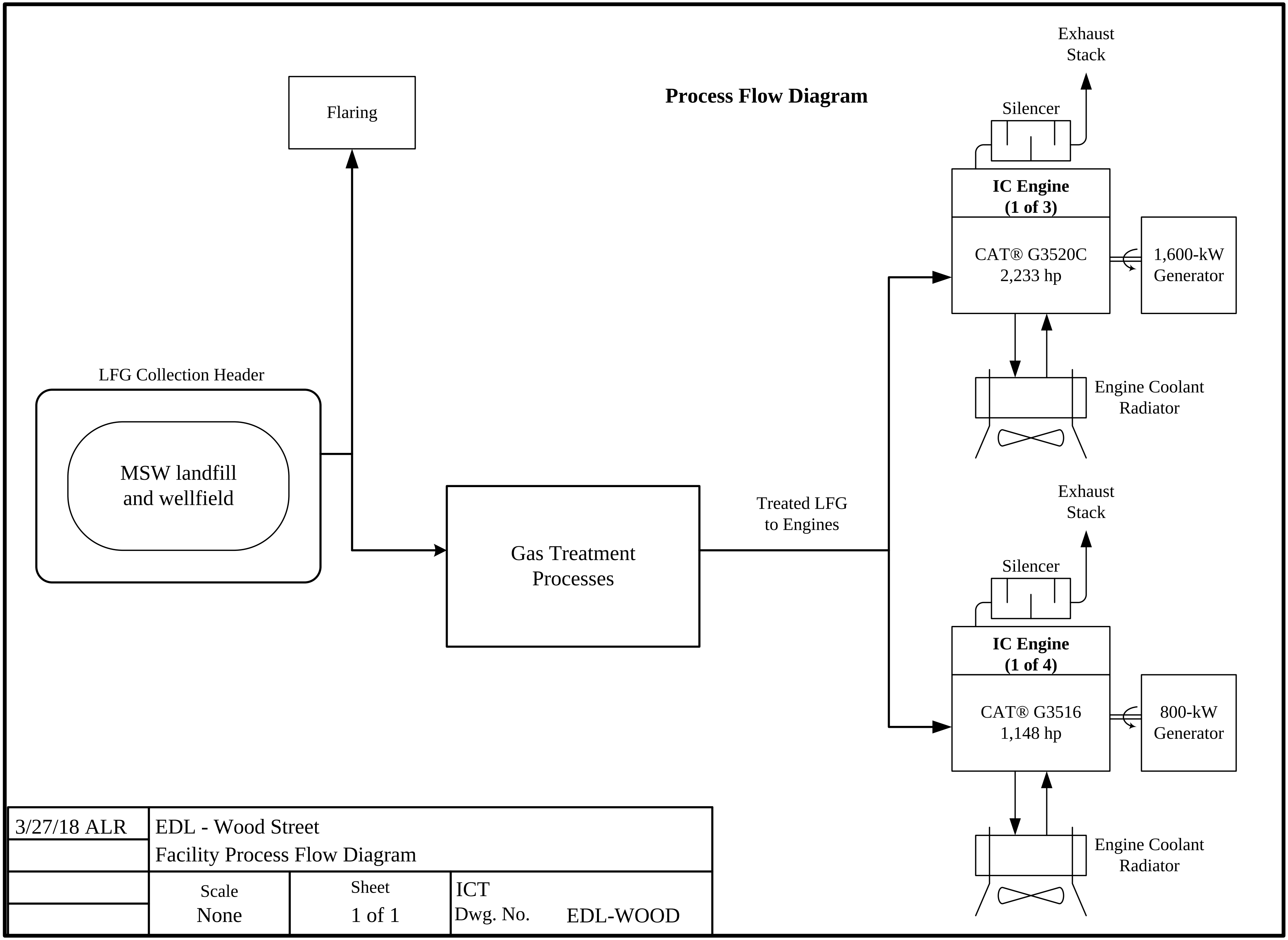
Table 6.3 Measured exhaust gas conditions and NO_x, CO and VOC air pollutant emission rates for Engine No. 7 (EUICEENGINE3-S1)

Test No. Test date Test period (24-hr clock)	1 3/3/20 1133-1233	2 3/3/20 1257-1357	3 3/3/20 1422-1522	Three Test Average
Fuel flowrate (scfm)	540	539	537	539
Generator output (kW)	1,621	1,616	1,634	1,623
Engine output (bhp)	2,262	2,255	2,280	2,265
LFG methane content (%)	51.4	51.3	51.5	51.4
LFG heat content (Btu/scf)	467	466	468	467
LFG O_2 content (%)	0.79	0.72	0.61	0.71
Air to fuel ratio	8.2	8.2	8.3	8.2
Exhaust Gas Composition				
CO_2 content (% vol)	11.4	11.5	11.5	11.5
O_2 content (% vol)	8.15	8.12	8.13	8.13
Moisture (% vol)	11.6	11.4	11.4	11.5
Exhaust gas temperature (^oF)	820	817	812	816
Exhaust gas flowrate (dscfm)	4,287	4,376	4,359	4,341
Exhaust gas flowrate (scfm)	4,852	4,939	4,920	4,904
Nitrogen Oxides				
NO_X conc. (ppmvd)	89.0	87.5	89.7	88.7
NO_X emissions (lb/hr)	2.74	2.74	2.80	2.76
Permit Limit (lb/hr)	-	-	-	4.92
NO_X emissions (g/bhp*hr)	0.55	0.55	0.56	0.55
Permit Limit (g/bhp*hr)	-	-	-	1.0
Carbon Monoxide				
CO conc. (ppmvd)	590	592	593	592
CO emissions (lb/hr)	11.0	11.3	11.3	11.2
Permit Limit (lb/hr)	-	-	-	16.23
CO emissions (g/bhp*hr)	2.21	2.27	2.25	2.24
Permit Limit (g/bhp*hr)	-	-	-	3.30
Volatile Organic Compounds				
VOC conc. (ppmv)	16.0	16.1	15.9	16.0
VOC emissions (g/bhp*hr)	0.11	0.11	0.11	0.11
Permit Limit (g/bhp*hr)	-	-	-	1.0

APPENDIX 1

- Figure 1-A – Process Flow Diagram
- Figure 1-B – IC Engine Nos. 5 – 7 Sample Port Diagram

Impact Compliance & Testing, Inc.



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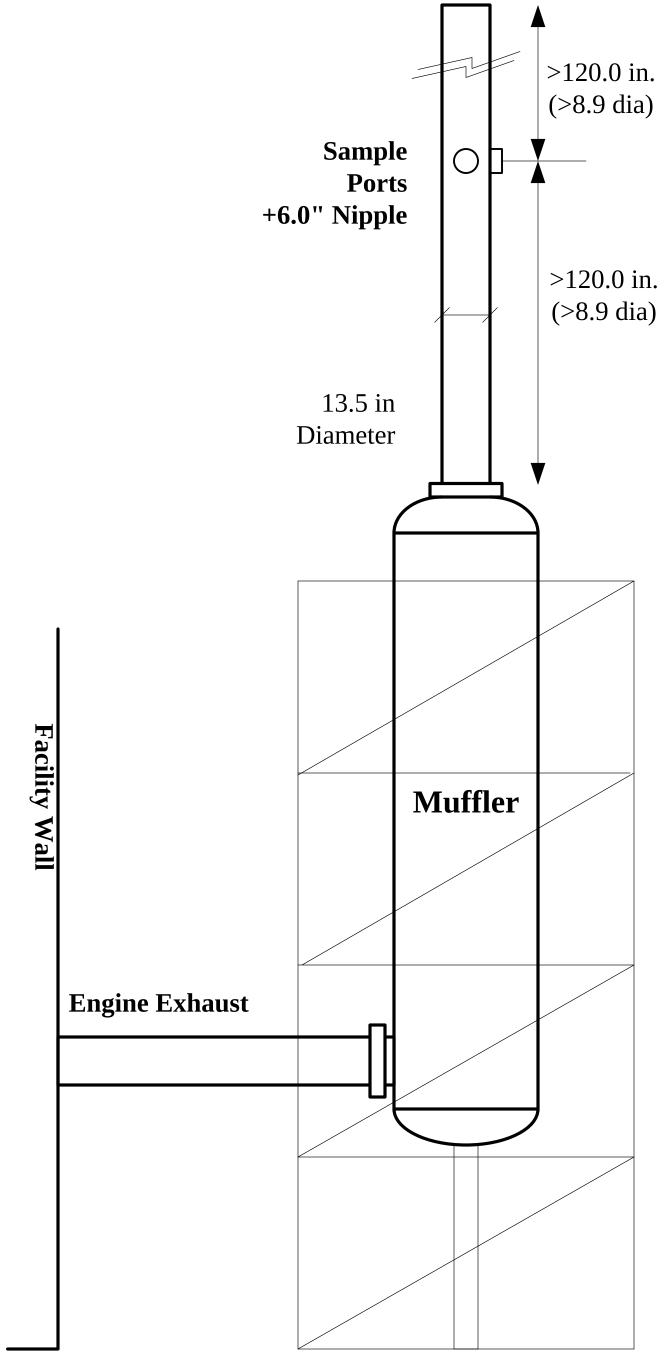
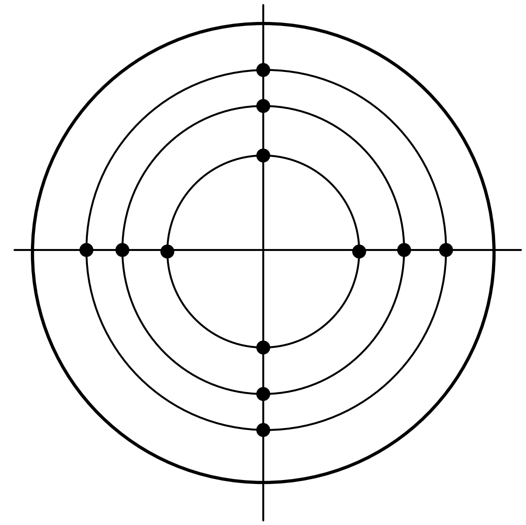


Exhaust Stack
Cross-Section with
Traverse Points



Velocity sample locations as measured from stack wall

Pt. #	in.
1	0.59
2	2.0
3	4.0
4	9.5
5	11.5
6	12.9

3/27/18 ALR	EDL - Wood Street Exhaust Gas Sample Location, CAT G3520 ICE		
	Scale None	Sheet 1 of 1	ICT Dwg. No. EDL-WOOD