AIR EMISSION TEST REPORT
FOR THE
VERIFICATION OF AIR POLLUTANT EMISSIONS
FROM
LANDFILL GAS FIRED ENGINE – GENERATOR SET

Prepared for:

Energy Developments Watervliet, LLC
at the Orchard Hill Sanitary Landfill
SRN N5719

ICT Project No.: 2400033
February 21, 2024

IMPACT COMPLIANCE & TESTING

Report Certification

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Energy Developments Watervliet, LLC
at the Orchard Hill Sanitary Landfill
Watervliet, MI

The material and data in this document were prepared and reviewed under the supervision of the undersigned.

Report Prepared By:
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Executive Summary

ENERGY DEVELOPMENTS WATERVLIET, LLC
AT THE ORCHARD HILL SANITARY LANDFILL
LFG FUELED IC ENGINE
EMISSION TEST RESULTS

Energy Developments Watervliet, LLC (EDW) contracted Impact Compliance & Testing, Inc. (ICT) to conduct a performance demonstration for the determination of carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOC) and formaldehyde (HCOH) concentration and emission rate from two (2) Caterpillar (CAT®) Model No. G3520C gas-fired reciprocating internal combustion engine and electricity generator sets (RICE gensets) identified as EUICEENGINE1 – 2. The performance demonstration also included determination of the HCOH concentration and emission rate from one (1) CAT® Model No. G3516 RICE genset identified as EUICEENGINE3. The RICE gensets are operated at the EDW facility located in Watervliet, Berrien County, Michigan. The RICE gensets are fueled with landfill gas (LFG) that is produced at the Orchard Hills Sanitary Landfill.

Compliance testing was performed with regards to conditions specified in the Michigan Department of Environment, Great Lakes, and Energy - Air Quality Division (EGLE-AQD) Renewable Operating Permit (ROP) No. MI-ROP-N5719-2023. The performance testing was conducted February 6 – 7, 2024.

The following table presents the results from the performance demonstration.

Emission Unit	CO (lb/hr)	CO (g/bhp-hr)	NOx (lb/hr)	NOx (g/bhp-hr)	VOC (g/bhp-hr)	HCOH (lb/hr)
EUICEENGINE1[a]	12.8	2.6	1.36	0.3	0.1	1.78
EUICEENGINE2[a]	11.7	2.4	1.68	0.4	0.2	1.61
EUICEENGINE3[b]	-	-	-	-	-	0.62
Permit Limit	*17.3*	*3.5*	*4.94*	*1.0*	*1.0*	*2.08[a] / 0.75[b]*

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

Emission Unit	Generator Output (kW)	Engine Output (bhp)	LFG Fuel Use (scfm)	Air to Fuel Ratio	Fuel CH_4 Content (%)
EUICEENGINE1	1,569	2,199	529	7.3	49.6
EUICEENGINE2	1,562	2,188	535	7.2	49.0
EUICEENGINE3	741	-	300	-	49.7

The data presented above indicates that RICE gensets were tested while the units operated within 10% of maximum capacity and are in compliance with the emission standards specified in the ROP.

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1.0 Introduction

Energy Developments Watervliet, LLC (EDW) operates RICE gensets at the EDW facility located at the Orchard Hill Sanitary Landfill in Watervliet, Berrien County, Michigan. The EGLE-AQD has issued EDW ROP No. MI-ROP-N5719-2023 for operation of the RICE gensets.

Air emission compliance testing was performed pursuant to conditions specified in ROP No. MI-ROP-N5719-2023. The compliance emission testing was performed on EUICEENGINE1 and 2 (Engine Nos. 1 - 2), which is part of flexible group FGICEENGINES. ROP No. MI-ROP-N5719-2023 states:

The permittee shall conduct performance tests for each engine in FGICEENGINES, to verify NOx, CO, and VOC emission rates. The permittee shall conduct a performance test every 8,760 hours of operation or three years, whichever occurs first, to demonstrate compliance. The performance tests shall be conducted according to 40 CFR 60.4244.

and

The permittee shall verify formaldehyde emission rates from FGICEENGINES by testing at the owner's expense, in accordance with Department requirements. Testing shall be performed using an approved EPA Method listed in 40 CFR Part 60, Appendix A.... The permittee shall verify the formaldehyde... emission rates from FGICEENGINES, at a minimum, every 5 years from the date of the last test.

Compliance emission testing was also performed on EUICEENGINE3 (Engine No. 3. ROP No. MI-ROP-N5719-2023 states:

Within 5 years from the date of completion of the most recent stack test, the permittee shall verify formaldehyde emission rates from EUICEENGINE3 by testing at the owner's expense, in accordance with Department requirements. Testing shall be performed using an approved EPA Method listed in 40 CFR Part 60, Appendix A.

The compliance testing presented in this report was performed by ICT, a Michigan-based environmental consulting and testing company. ICT representatives Max Fierro, Renee Fromwiller and Andy Rusnak performed the field sampling and measurements February 6 – 7, 2024.

The emission performance tests consisted of triplicate, one-hour sampling periods for CO, NOx, VOC and HCOH on Engine Nos. 1 and 2 and HCOH on Engine No. 3. Exhaust gas velocity, moisture, oxygen (O_2) content, and carbon dioxide (CO_2) content were determined for each test period to calculate pollutant mass emission rates.

The exhaust gas sampling and analysis was performed using procedures specified in the Stack Test Protocol dated January 3, 2024, that was reviewed and approved by EGLE-AQD.

Questions regarding this air emission test report should be directed to:

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2.0 Summary of Test Results and Operating Conditions

2.1 Purpose and Objective of the Tests

The Engine No. 1 and 2 compliance emission testing was performed pursuant to conditions of ROP No. MI-ROP-N5719-2023 and the federal Standards of Performance for Stationary Spark Ignition Internal Combustion Engines (the SI-RICE NSPS; 40 CFR Part 60 Subpart JJJJ), which requires that CO, NOx and VOC testing be performed every 8,760 operating hours or three years, whichever occurs first (unless the engine has been certified by the manufacturer as specified in the SIRICE NSPS). ROP No. MI-ROP-N5719-2023 also specifies that Engine Nos. 1 and 2 be tested every five (5) years for HCOH.

The Engine No. 3 compliance emission testing was performed pursuant to conditions of ROP No. MI-ROP-N5719-2023 which specifes that Engine No. 3 be tested every five (5) years for HCOH.

2.2 Operating Conditions During the Compliance Tests

The testing was performed while the EDW RICE gensets were operated at maximum operating conditions. EDW representatives provided kW output in 15-minute increments for each test period.

LFG fuel flowrate (standard cubic feet per minute, scfm) and fuel methane content (%) were also recorded by EDW representatives in 15-minute increments for each test period.

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)

Appendix 2 provides operating records provided by EDW representatives for the test periods.

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 LFG MW of 30 lb/lb-mol was used.

Average output, fuel consumption and fuel methane content are presented in Table 2.1.

2.3 Summary of Air Pollutant Sampling Results

The gases exhausted from RICE gensets were each sampled for three (3) one-hour test periods during the compliance testing performed February 6 – 7, 2023.

Table 2.2 presents the average measured CO, NOx, VOC and HCOH emission rates (average of the three test periods).

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

Table 2.1 Average engine operating conditions during the test periods

Engine Parameter	Engine No. 1	Engine No. 2	Engine No. 3
Generator output (kW)	1,569	1,562	741
Engine output (bhp)	2,199	2,188	-
Engine LFG fuel use (scfm)	529	535	300
Air to Fuel Ratio	7.3	7.2	-
LFG methane content (%)	49.6	49.0	49.7

Table 2.2 Measured air pollutant emission rates (three-test average)

Emission Unit	CO (lb/hr)	CO (g/bhp-hr)	NOx (lb/hr)	NOx (g/bhp-hr)	VOC (g/bhp-hr)	HCOH (lb/hr)
EUICEENGINE1[a]	12.8	2.6	1.36	0.3	0.1	1.78
EUICEENGINE2[a]	11.7	2.4	1.68	0.4	0.2	1.61
EUICEENGINE3[b]	-	-	-	-	-	0.62
Permit Limit	*17.3*	*3.5*	*4.94*	*1.0*	*1.0*	*2.08[a] / 0.75[b]*

3.0 Source and Sampling Location Description

3.1 General Process Description

LFG containing methane is produced in the Orchard Hills Sanitary Landfill from the anaerobic decomposition of waste materials. The gas is collected and directed to the EDW facility where it is used as fuel for the RICE gensets that produce electricity.

The gas-to-energy facility primarily consists of gas treatment equipment, two (2) CAT® Model No. G3520C RICE and one (1) CAT® Model No. G3516 RICE that are each connected an electricity generator.

3.2 Rated Capacities and Air Emission Controls

The CAT® G3520C engine generator set has a rated design capacity of 1,600 kW. The CAT® G3516 engine generator set has a rated design capacity of 800 kW.

The engines are equipped with air-to-fuel ratio (AFR) controllers that blend the appropriate ratio of combustion air and treated LFG fuel.

The RICE are not equipped with add-on emission control devices. The AFR controller maintains efficient fuel combustion, which minimizes air pollutant emissions. Exhaust gas is exhausted directly to atmosphere through dedicated noise mufflers and vertical exhaust stacks.

3.3 Sampling Locations

The 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 sampling locations for all three (3) engines are identical.

The exhaust stack sampling ports for each engine are located in the individual exhaust duct (horizontal section of the stack before the noise muffler) with an inner diameter of 12.5 inches. The duct is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 34 inches (2.7 duct diameters) upstream and 40 inches (3.2 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 1 provides diagrams of the emission test sampling locations with actual stack dimension measurements.

4.0 Sampling and Analytical Procedures

A Stack Test Protocol for the air emission testing was reviewed and approved by EGLE-AQD. This section provides a summary of the sampling and analytical procedures that were used during the testing periods.

4.1 Summary of Sampling Methods

Parameter / Analyte	Sampling Methodology	Analytical Methodology
Velocity traverses	USEPA Method 1	Selection of sample and velocity traverse locations by physical stack measurements
Volumetric flow rate	USEPA Method 2	Measurement of velocity head using a Type-S Pitot tube and inclined manometer
Oxygen and Carbon dioxide	USEPA Method 3A	Zirconia ion or paramagnetic detector for oxygen and infrared for carbon dioxide
Nitrogen oxides	USEPA Method 7E	Chemiluminescence instrumental analyzer
Carbon monoxide	USEPA Method 10	NDIR instrumental analyzer
Non-methane hydrocarbons	USEPA Method 25A / ALT-096	FID instrument with internal methane separation column
Formaldehyde and Moisture	ASTM D6348	FTIR instrumental Analyzer

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 once during each test period. 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 throughout the test periods to verify the integrity of the measurement system.

The absence of significant cyclonic flow for each sampling location 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 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 Model 4900 infrared gas analyzer. The O_2 content of the exhaust was monitored using a Servomex Model 4900 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 8864 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 Measurement of NOx and CO concentrations (USEPA Methods 7E & 10)

RICE exhaust NOx concentrations were determined during each test run sample period using a Thermo Environmental Instruments, Inc. (TEI) Model 42i NO-NO2-NOx analyzer that utilizes chemiluminescence technology in accordance with USEPA Method 7E.

RICE exhaust CO concentrations were determined during each test run sample period using a TEI Model 48i CO analyzer that utilizes non-dispersive infrared (NDIR) technology in accordance with USEPA Method 10 for direct measurement of CO concentration in exhaust gases.

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 NO_x and CO concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8864 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 NO_x and CO calculation sheets. Raw instrument response data are provided in Appendix 5.

4.5 Measurement of VOC concentration (USEPA Method 25A / ALT-096)

VOC as non-methane hydrocarbon (NMHC or NMOC) concentrations in the RICE exhaust was determined using a TEI Model 55i Methane-NMHC analyzer in accordance with USEPA Method 25A and Alternate Method (ALT) 096 for direct measurement of NMHC concentrations in RICE exhaust gas.

The TEI 55i is an automated batch analyzer that repeatedly collects and analyzes samples of the exhaust gas stream that are drawn into the instrument by the internal sampling pump. The sampled gas is separated by an internal gas chromatography (GC) column into methane and non-methane fractions and each fraction is analyzed separately using a flame ionization detector (FID), in accordance with USEPA Method 25A. The NMHC concentration was reported relative to a propane calibration standard (parts per million as propane, C3) and the molecular weight of propane was used to calculate NMOC mass emissions.

A continuous sample of the RICE exhaust gas was delivered to the VOC instrument analyzer using an extractive gas sampling system described in Attachment 2. The exhaust gas sample bypassed the sample condenser and was delivered directly to the NMHC instrumental analyzer. Therefore, VOC measurements correspond to standard conditions with no moisture correction (wet basis).

The VOC instrument was calibrated using certified propane concentrations in hydrocarbon-free air. The calibration gases were diluted (using a certified gas divider) with hydrocarbon-free air to obtain intermediate concentrations and to demonstrate linearity of the instrument analyzer.

Appendix 4 provides VOC calculation sheets. Raw instrument response data are provided in Appendix 5.

4.6 Measurement of HCOH and Moisture Content via FTIR (ASTM D6348)

HCOH concentration and moisture content in the RICE exhaust gas streams were determined using an MKS Multi-Gas 2030 Fourier transform infrared (FTIR) spectrometer in accordance with test method ASTM D6348.

The USEPA New Source Performance Standard (NSPS) for landfill gas fired engines (Subpart JJJJ) specifies ASTM D6348 as an acceptable test method for moisture concentration determinations. Additionally, the USEPA National Emissions Standard for Hazardous Air Pollutants (NESHAP) for landfill gas fired engines (Subpart ZZZZ) specifies ASTM D6348 as an acceptable test method for moisture and formaldehyde concentration determinations.

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

A calibration transfer standard (CTS), ethylene standard, and nitrogen zero gas were analyzed before and after each test run. Analyte spiking, of each engine, with acetaldehyde and sulfur hexafluoride was performed to verify the ability of the sampling system to quantitatively deliver a sample containing the compound of interest from the base of the probe to the FTIR. Data was collected at 0.5 cm-1 resolution. Instrument response was recorded using MG2000 data acquisition software.

Appendix 4 provides HCOH calculation sheets. Moisture content data is provided in the flowrate calculations presented in Appendix 3. Raw instrument response data for the FTIR analyzer is provided in Appendix 6.

4.0 QA/QC Activities

5.1 Flow Measurement Equipment

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

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 CO, NOx, 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.

5.4 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 CO, NOx, 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 was introduced to the NMHC analyzer, in series at a tee connection, which is installed between the sample probe and the particulate filter, through a spring-loaded 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, NOx, and CO in nitrogen and zeroed using 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 10-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 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 stacks indicated that the measured 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 each RICE exhaust stack.

5.6 System Response Time

The response time of the sampling system was determined prior to the compliance test program by introducing upscale gas and zero gas, in series, into the sampling system using a tee connection at the base of the sample probe. The elapsed time for the analyzer to display a reading of 95% of the expected concentration was determined using a stopwatch.

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

5.7 FTIR QA/QC Activities

At the beginning of each day a calibration transfer standard (CTS, ethylene gas), analyte of interest (acetaldehyde and sulfur hexafluoride) and nitrogen calibration gas was directly injected into the FTIR to evaluate the unit response.

Prior to and after each test run the CTS was analyzed. The ethylene was passed through the entire system (system purge) to verify the sampling system response and to ensure that the sampling system remained leak-free at the stack location. Nitrogen was also passed through the sampling system to ensure the system was free of contaminants.

Analyte spiking, of each emission unit, with acetaldehyde was performed to verify the ability of the sampling system to quantitatively deliver a sample containing the compound of interest from the base of the probe to the FTIR and assure the ability of the FTIR to quantify that compound in the presence of effluent gas.

As part of the data validation procedure, reference spectra were manually fit to that of the sample spectra (two spectra from each test period) and a concentration was determined. Concentration data was manually validated using the MKS MG2000 method analyzer software. The software used multi-point calibration curves to quantify each spectrum. The software-calculated results were compared with the measured concentrations to ensure the quality of the data.

Appendix 7 presents test equipment quality assurance data (instrument calibration and system bias check records, calibration gas and gas divider certifications, interference test results, FTIR QA/QC data, stratification checks, and field equipment 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 RICE gensets have the following allowable emission limits specified in ROP No. MI-ROP-N5985-2019:

Pollutants and Limits				
Emission Unit ID	**CO Limits**	**NOx Limits**	**VOC Limits**	**HCOH Limits**
EUICEENGINE1 & EUICEENGINE2	17.3 lb/hr & 3.5 g/bhp-hr	4.94 lb/hr & 1.0 g/bhp-hr	1.0 g/bhp-hr*	2.08 lb/hr
EUICEENGINE3	NA	NA	NA	0.75 lb/hr

Note*: This VOC limit does not include formaldehyde (HCOH).

The results of the performance testing for each RICE genset demonstrate compliance with the emission limits specified in ROP No. MI-ROP-N5985-2019.

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 Stack Test Protocol. The RICE-generator sets were operated within 10% of maximum output and no variations from normal operating conditions occurred during the engine test periods.

Table 6.1 Measured exhaust gas conditions and air pollutant emission rates for Engine No. 2 (EUICEENGINE2)

Test No. Test date Test period (24-hr clock)	1 2/6/24 843-943	2 2/6/24 1004-1104	3 2/6/24 1123-1223	Three Test Average
Fuel flowrate (scfm)	534	535	537	535
Generator output (kW)	1,562	1,560	1,564	1,562
Engine output (bhp)	2,189	2,185	2,191	2,188
Air to Fuel Ratio	7.2	7.2	7.2	7.2
LFG methane content (%)	49.1	49.0	48.9	49.0
Exhaust Gas Composition				
CO_2 content (% vol)	11.0	11.0	11.0	11.0
O_2 content (% vol)	8.67	8.67	8.68	8.67
Moisture (% vol)	11.5	11.5	11.5	11.5
Exhaust gas temperature (°F)	914	919	908	914
Exhaust gas flowrate (dscfm)	3,798	3,707	3,840	3,782
Exhaust gas flowrate (scfm)	4,292	4,190	4,341	4,274
Nitrogen Oxides				
NO_X conc. (ppmvd)	61.8	61.9	62.0	61.9
NO_X emissions (lb/hr)	1.68	1.65	1.71	1.68
Permit Limit (lb/hr)	-	-	-	*4.94*
NO_X emissions (g/bhp-hr)	0.4	0.3	0.4	0.4
Permit Limit (g/bhp-hr)	-	-	-	*1.0*
Carbon Monoxide				
CO conc. (ppmvd)	710	705	707	707
CO emissions (lb/hr)	11.8	11.4	11.9	11.7
Permit Limit (lb/hr)	-	-	-	*17.3*
CO emissions (g/bhp-hr)	2.4	2.4	2.5	2.4
Permit Limit (g/bhp-hr)	-	-	-	*3.5*
Volatile Organic Compounds				
NMHC conc. (ppmv)	34.1	24.4	21.6	26.7
VOC emissions (g/bhp-hr)	0.2	0.2	0.1	0.2
Permit Limit (g/bhp-hr)	-	-	-	*1.0*
Formaldehyde				
HCOH conc. (ppmv)	80.2	80.3	80.5	80.3
HCOH emissions (lb/hr)	1.61	1.57	1.63	1.61
Permit Limit (lb/hr)	-	-	-	*2.08*

Table 6.2 Measured exhaust gas conditions and air pollutant emission rates for Engine No. 1 (EUICEENGINE1)

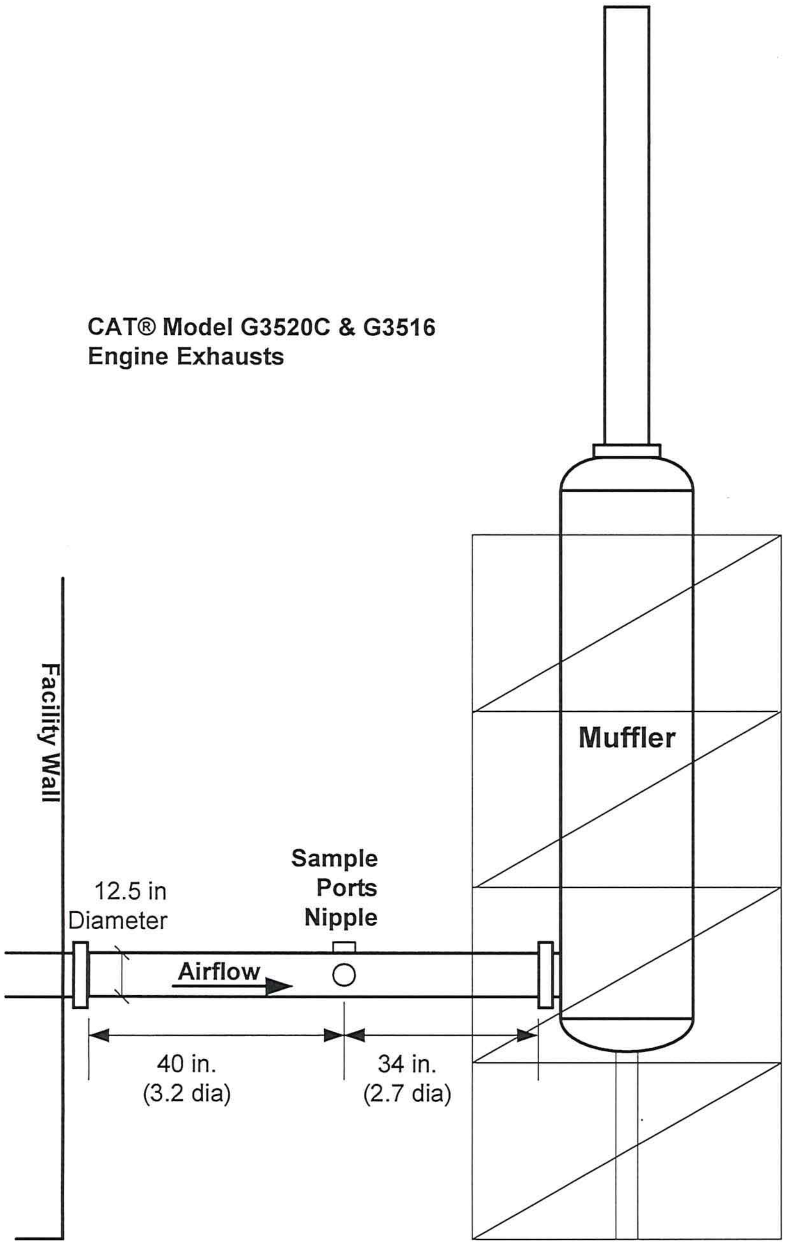
Test No. Test date Test period (24-hr clock)	1 2/6/24 1330-1430	2 2/6/24 1452-1552	3 2/6/24 1610-1710	Three Test Average
Fuel flowrate (scfm)	532	526	531	529
Generator output (kW)	1,564	1,567	1,577	1,569
Engine output (bhp)	2,192	2,196	2,209	2,199
Air to Fuel Ratio	7.3	7.3	7.3	7.3
LFG methane content (%)	49.0	49.9	49.9	49.6
<u>Exhaust Gas Composition</u>				
CO_2 content (% vol)	11.1	11.1	11.1	11.1
O_2 content (% vol)	8.56	8.60	8.58	8.58
Moisture (% vol)	11.7	11.6	11.6	11.6
Exhaust gas temperature (°F)	912	908	908	909
Exhaust gas flowrate (dscfm)	3,705	3,706	3,466	3,626
Exhaust gas flowrate (scfm)	4,193	4,194	3,923	4,103
<u>Nitrogen Oxides</u>				
NO_X conc. (ppmvd)	53.0	52.6	51.5	52.4
NO_X emissions (lb/hr)	1.41	1.40	1.28	1.36
Permit Limit (lb/hr)	-	-	-	*4.94*
NO_X emissions (g/bhp-hr)	0.3	0.3	0.3	0.3
Permit Limit (g/bhp-hr)	-	-	-	*1.0*
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	795	815	820	810
CO emissions (lb/hr)	12.9	13.2	12.4	12.8
Permit Limit (lb/hr)	-	-	-	*17.3*
CO emissions (g/bhp-hr)	2.7	2.7	2.6	2.6
Permit Limit (g/bhp-hr)	-	-	-	*3.5*
<u>Volatile Organic Compounds</u>				
NMHC conc. (ppmv)	20.8	23.2	23.4	22.5
VOC emissions (g/bhp-hr)	0.1	0.1	0.1	0.1
Permit Limit (g/bhp-hr)	-	-	-	*1.0*
<u>Formaldehyde</u>				
HCOH conc. (ppmv)	92.8	93.0	92.9	92.9
HCOH emissions (lb/hr)	1.82	1.83	1.70	1.78
Permit Limit (lb/hr)	-	-	-	*2.08*

Table 6.3 Measured exhaust gas conditions and air pollutant emission rates for Engine No. 3 (EUICEENGINE3)

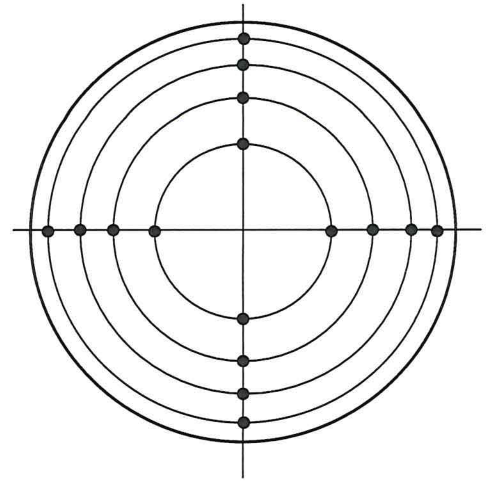
Test No. Test date Test period (24-hr clock)	1 2/7/24 737-837	2 2/7/24 851-951	3 2/7/24 1003-1103	Three Test Average
Fuel flowrate (scfm)	299	300	300	300
Generator output (kW)	726	746	749	741
LFG methane content (%)	49.6	49.7	49.7	49.7
<u>Exhaust Gas Composition</u>				
CO_2 content (% vol)	12.7	12.8	12.8	12.8
O_2 content (% vol)	6.69	6.69	6.54	6.64
Moisture (% vol)	13.6	13.2	13.3	13.4
Exhaust gas temperature (^oF)	818	837	845	833
Exhaust gas flowrate (dscfm)	1,758	1,750	1,730	1,746
Exhaust gas flowrate (scfm)	2,034	2,017	1,996	2,016
<u>Formaldehyde</u>				
HCOH conc. (ppmv)	67.8	65.2	64.1	65.7
HCOH emissions (lb/hr)	0.65	0.62	0.60	0.62
Permit Limit (lb/hr)	-	-	-	*0.75*

APPENDIX 1

- RICE Engine Sample Port Diagram



Exhaust Stack Cross-Section with Traverse Points



Velocity sample locations as measured from stack wall

Pt. #	in.
1	0.50
2	1.31
3	2.42
4	4.03
5	8.63
6	10.1
7	11.2
8	12.0

2/21/24 ALR	**Energy Developments Watervliet, LLC** **Exhaust Sample Locations, Engine Nos. 1 - 3**		
	Scale None	Sheet 1 of 1	Impact Comp. & Testing, Inc. Dwg. No. EDW-1