

**AIR EMISSION TEST REPORT
FOR THE
VERIFICATION OF AIR POLLUTANT EMISSIONS
FROM
LANDFILL GAS FIRED ENGINE – GENERATOR SETS
AND A
LANDFILL GAS FUELED TURBINE**

**Prepared for:
C&C Energy, LLC
SRN P0222**

Test Dates: July 23 & 25, 2024

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September 9, 2024**



Report Certification

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**C&C Energy, LLC
at the C&C Expanded Sanitary Landfill
Marshall, MI**

Report Certification

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

Impact Compliance & Testing, Inc.



Tyler J. Wilson
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Table of Contents

1.0 INTRODUCTION.....	1
2.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS	2
2.1 Purpose and Objective of the Tests.....	2
2.2 Operating Conditions During the Compliance Tests	2
2.3 Summary of Air Pollutant Sampling Results	2
3.0 SOURCE AND SAMPLING LOCATION DESCRIPTION.....	4
3.1 General Process Description	4
3.2 Rated Capacities and Air Emission Controls	4
3.3 Sampling Locations	4
4.0 SAMPLING AND ANALYTICAL PROCEDURES.....	6
4.1 Summary of Sampling Methods.....	6
4.2 Exhaust Gas Velocity Determination (USEPA Method 2)	7
4.3 Exhaust Gas Molecular Weight Determination (USEPA Method 3A).....	7
4.4 Exhaust Gas Moisture Content (USEPA Method 4).....	7
4.5 NO _x Concentration Measurements (USEPA Method 7E).....	8
4.6 CO Concentration Measurements (USEPA Method 10)	8
4.7 Measurement of VOC (USEPA Method 25A / ALT-096).....	8
4.8 HCl Emission Sampling (USEPA Method 26)	9
4.9 Test Method Exception (USEPA Method 26).....	9
4.10 Turbine Fuel Gas Analysis (ASTM D-5504 & 1945/3588)	9
5.0 QA/QC ACTIVITIES.....	11
5.1 Flow Measurement Equipment	11
5.2 NO _x Converter Efficiency Test	11
5.3 Gas Divider Certification (USEPA Method 205).....	11
5.4 Instrumental Analyzer Interference Check.....	11
5.5 Instrument Calibration and System Bias Checks	12
5.6 Determination of Exhaust Gas Stratification	12
5.7 System Response Time	13
5.8 Meter Box Calibrations	13
5.9 HCl Recovery and Analysis	13
6.0 RESULTS	14
6.1 Test Results and Allowable Emission Limits.....	14
6.2 Results of Turbine LFG Fuel Gas Analysis.....	14
6.3 Variations from Normal Sampling Procedures or Operating Conditions	14

List of Tables

2.1	Average engine operating conditions during the test periods	3
2.2	Average turbine operating conditions during the test periods	3
2.3	Average measured emission rates for each engine (three-test average)	3
2.4	Average measured emission rates for the turbine (three-test average)	3
3.1	Emission Unit Identification	4
6.1	Measured exhaust gas conditions and air pollutant emission rates for Engine No. 1 (EUIENGINE#1)	16
6.2	Measured exhaust gas conditions and air pollutant emission rates for Engine No. 2 (EUIENGINE#2)	17
6.3	Measured exhaust gas conditions and air pollutant emission rates for Turbine No. 1 (EUTURBINE).....	18
6.4	Summary of LFG fuel sulfur content analyses	19

List of Appendices

APPENDIX 1	SAMPLE PORT DIAGRAMS
APPENDIX 2	OPERATING RECORDS
APPENDIX 3	FLOWRATE CALCULATIONS AND DATA SHEETS
APPENDIX 4	CO ₂ , O ₂ , SO ₂ , CO, NO _x , NMOC, AND HCI CALCULATIONS
APPENDIX 5	INSTRUMENTAL ANALYZER RAW DATA
APPENDIX 6	HCI LABORATORY REPORT
APPENDIX 7	SULFUR LABORATORY REPORT
APPENDIX 8	QA/QC RECORDS

1.0 Introduction

C&C Energy, LLC (C&C Energy) operates gas-fired reciprocating internal combustion engine (RICE) and electricity generator sets (gensets) and a gas fueled turbine (turbine) at the C&C Expanded Sanitary Landfill (C&C Landfill) in Marshall, Calhoun County, Michigan.

The State of Michigan Department of Environment, Great Lakes, and Energy – Air Quality Division (EGLE-AQD) has issued to C&C Energy a Renewable Operating Permit (MI-ROP-P0222-2023) for operation of the renewable electricity generation facility, which consists of:

- Two (2) Waukesha model VHP7042GLD RICE gensets identified as emission units EUCENGINE#1 & EUCENGINE#2 (Flexible Group ID FGICENGINES); and
- One (1) Solar Centaur model T-4500 turbine identified as emission unit EUTURBINE.

Air emission compliance testing was performed pursuant to conditions of MI-ROP-P0222-2023 for FGICENGINES (EUCENGINE#1 & EUCENGINE#2) and EUTURBINE.

The compliance testing presented in this report was performed by Impact Compliance & Testing, Inc. (ICT), a Michigan-based environmental consulting and testing company. ICT representatives Tyler Wilson, Clay Gaffey, and Amanda Ellsworth performed the field sampling and measurements July 23 & 25, 2024.

The engine emission performance tests consisted of triplicate, one-hour sampling periods for nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOC, as non-methane hydrocarbons (NMHC)), and hydrogen chloride (HCl). Exhaust gas velocity, moisture, oxygen (O₂) content, and carbon dioxide (CO₂) content were determined for each test period to calculate pollutant mass emission rates.

The turbine emission performance tests consisted of triplicate, one-hour sampling periods for nitrogen oxides (NO_x). Exhaust gas velocity, moisture, oxygen (O₂) content, and carbon dioxide (CO₂) content were determined for each test period to calculate pollutant mass emission rates.

In addition, the inlet gas used as fuel for the turbine was sampled and analyzed to determine sulfur and heat content.

The exhaust gas sampling and analysis was performed using procedures specified in the Stack Test Protocols dated June 17, 2022 and June 4, 2024, that were reviewed and approved by EGLE-AQD. Mr. Jared Edgerton of EGLE-AQD observed portions of the compliance testing.

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

Conditions of MI-ROP-P0222-2023 require C&C Energy to test each engine in FGICENGINES for CO, NO_x, NMOC, and HCl emissions. Conditions of MI-ROP-P0222-2023 also require C&C Energy to test EUTURBINE for NO_x emissions. Engine Nos. 1 & 2 (EUCENGINE#1 & EUCENGINE#2, respectively) and EUTURBINE were tested during this compliance test event.

2.2 Operating Conditions During the Compliance Tests

The testing was performed while the C&C Energy engine/generator sets and turbine were operated at maximum operating conditions (within 10% of 997-kilowatt (kW) electricity output for the engine/generator sets; within 25% of 3,500-kW electricity output for the turbine). C&C Energy representatives provided kW output in 15-minute increments for each test period.

Fuel flowrate (standard cubic feet per minute (scfm)) and fuel methane (CH₄) content (%) were also recorded by C&C Energy representatives in 15-minute increments for each test period.

Appendix 2 provides operating records provided by C&C Energy representatives for the test periods.

Average output (kW), fuel consumption (scfm), and fuel methane content (%) for each RICE and the turbine is presented in Tables 2.1-2.2 and Tables 6.1-6.3.

2.3 Summary of Air Pollutant Sampling Results

The gases exhausted from the sampled LFG fueled RICE (Engine Nos. 1 & 2 / EUCENGINE#1 & EUCENGINE#2) and turbine (EUTURBINE) were each sampled for three (3) one-hour test periods during the compliance testing performed July 23 & 25, 2024.

Table 2.3 presents the average measured CO, NO_x, VOC, and HCl emission rates for each engine (average of the three test periods).

Table 2.4 presents the average measured NO_x emission rate for the turbine (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

Emission Unit	Generator Output (kW)	Horsepower (HP)	LFG Fuel Use (scfm)	LFG CH ₄ Content (%)
EUICENGINE#1	908	1,283	313	57.2
EUICENGINE#2	959	1,354	313	55.3

Table 2.2 Average turbine operating conditions during the test periods

Emission Unit	Turbine Output (kW)	Turbine Output (MW)	LFG Fuel Use (scfm)	LFG CH ₄ Content (%)
EUTURBINE	2,727	2.73	1,232	55.8

Table 2.3 Average measured emission rates for each engine (three-test average)

Emission Unit	CO		NO _x		VOC		HCl
	(lb/hr)	g/bhp-hr	(lb/hr)	g/bhp-hr	(lb/hr)	g/bhp-hr	(lb/hr)
EUICENGINE#1	5.95	2.10	0.98	0.35	0.44	0.16	0.01
EUICENGINE#2	6.21	2.08	1.94	0.65	0.32	0.11	0.01
Permit Limit	7.33	2.30	2.93	0.90	0.81	0.25	0.60

Table 2.4 Average measured emission rates for the turbine (three-test average)

Emission Unit	NO _x	SO ₂
	(lb/MWh)	(lb/MMBtu)
EUTURBINE	1.85	0.08
Permit Limit	5.5	0.15

3.0 Source and Sampling Location Description

3.1 General Process Description

C&C Energy is permitted to operate two (2) RICE-generator sets (Waukesha model VHP7042GLD) and one (1) turbine (Solar Centaur model T-4500) at its facility. The units are fired exclusively with LFG that is recovered from the C&C Landfill and treated prior to use.

Table 3.1 Emission Unit Identification

Emission Unit	ROP Identification	Serial Number
Engine No. 1	EUCENGINE#1	C-12054-2
Engine No. 2	EUCENGINE#2	C-10812-7
Turbine	EUTURBINE	-

3.2 Rated Capacities and Air Emission Controls

The Waukesha model VHP7042GLD engine generator sets each have a rated design capacity of:

- Engine Power: 1,408 brake horsepower (bhp)
- Electricity Generation: 997 kW

The LFG fueled RICE are not equipped with add-on emission control equipment. The electronic air-to-fuel ratio controller automatically adjusts the air-to-fuel ratio and ignition timing to maintain efficient fuel combustion, which minimizes air pollutant emissions. Exhaust gas is exhausted directly to atmosphere through a noise muffler and horizontal exhaust stack for each engine.

The Solar Centaur model T-4500 turbine has a rated design capacity of:

- Electricity Generation: 3,500 kW

The turbine is not equipped with add-on emission control equipment. Nitrogen oxides (NO_x) emissions are suppressed by the use of a dry low-NO_x combustor. Exhaust gas is exhausted directly to atmosphere through a vertical exhaust stack for the turbine.

3.3 Sampling Locations

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

The Engine No. 1 / EUCENGINE#1 exhaust stack sampling ports are located in a horizontal exhaust duct, located after the engine muffler, with an inner diameter of 13.5 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location at least 0.5 duct diameters upstream and at least 2.0 duct diameters downstream from any flow disturbance.

The Engine No. 2 / EUCENGINE#2 exhaust stack sampling ports are located in a horizontal exhaust duct, located after the engine muffler, with an inner diameter of 13.5 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location at least 0.5 duct diameters upstream and at least 2.0 duct diameters downstream from any flow disturbance.

The turbine (EUTURBINE) exhaust stack sampling ports are located in a vertical exhaust duct, with an inner diameter of 42.0 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location at least 0.5 duct diameters upstream and at least 2.0 duct diameters downstream from any flow disturbance.

All sample port locations satisfy 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

Stack Test Protocols for the air emission testing were 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

USEPA Method 1 [Engines & Turbine]	Exhaust gas velocity measurement locations were determined based on the physical stack arrangement and requirements in USEPA Method 1.
USEPA Method 2 [Engines & Turbine]	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 4 [Engines & Turbine]	Exhaust gas moisture was determined based on the water weight gain in chilled impingers.
USEPA Method 3A [Engines & Turbine]	Exhaust gas O ₂ and CO ₂ content were determined using paramagnetic and infrared instrumental analyzers, respectively.
USEPA Method 7E [Engines & Turbine]	Exhaust gas NO _x concentration was determined using chemiluminescence instrumental analyzers.
USEPA Method 10 [Engines]	Exhaust gas CO concentration was measured using an infrared instrumental analyzer.
USEPA Method 25A / ALT-096 [Engines]	Exhaust gas NMOC (as NMHC) concentration was determined using a flame ionization analyzer equipped with methane separation column.
USEPA Method 26 [Engines]	Exhaust gas HCl concentration was determined using single point (non-isokinetic) sampling and analysis by ion chromatography.
ASTM Method D-5504 & 1945/3588 [Turbine]	Fuel gas sulfur and heat content analysis by gas chromatography and chemiluminescence.

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

The RICE and turbine 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 at 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)

CO₂ and O₂ content in the RICE and turbine exhaust gas streams was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO₂ content of the exhaust was monitored using a Servomex 4900 infrared gas analyzer. The O₂ content of the exhaust was monitored using a Servomex 4900 gas analyzer that uses a paramagnetic sensor.

During each sampling period, a continuous sample of the RICE and turbine exhaust gas streams 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 O₂ and CO₂ concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

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

Appendix 4 provides O₂ and CO₂ 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 and turbine exhaust gases was determined in accordance with USEPA Method 4 using a chilled impinger sampling train. Exhaust gas moisture content was measured as part of the USEPA sampling procedures for HCl for the engines (i.e., not as a separate sampling train), which was performed concurrently with the instrumental analyzer sampling periods. Exhaust gas moisture content measurements for the turbine were also performed concurrently with the instrumental analyzer sampling periods. 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 Concentration Measurements (USEPA Method 7E)

NO_x pollutant concentrations in the RICE and turbine exhaust gas streams were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42i High Level chemiluminescence NO_x analyzer.

Throughout each test period, a continuous sample of the engine or turbine exhaust gas was extracted from the stack using the Teflon® heated sample line and gas conditioning system and delivered to the instrumental analyzer. Instrument response for the 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 instrument was calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias.

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

4.6 CO Concentration Measurements (USEPA Method 10)

CO pollutant concentrations in the RICE exhaust gas streams were determined using a TEI 48i 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 analyzer. Instrument response for the 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 instrument was calibrated using upscale calibration and zero gas to determine analyzer calibration error and system bias.

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

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

The VOC emission rate for each RICE 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 RICE (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 NMHC 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.

4.8 HCl Emission Sampling (USEPA Method 26)

HCl concentrations in the RICE exhaust gas streams were determined using a modified version of USEPA Method 26 (see section 4.9 of this document). A sample of the exhaust gas was drawn from the exhaust stack at a constant rate (i.e., non-isokinetic rate) using a glass lined probe and a quartz filter. The gas sample was bubbled through chilled impingers containing 0.1 normality sulfuric acid (0.1N H₂SO₄). The NaOH fraction of the Method 26 sampling train was not used since halogen (Cl₂) concentrations were not included in the analysis.

The wetted portions of the sampling train were constructed of glass.

At the end of each one-hour test period, the impinger solutions and rinses were recovered and labeled. Following completion of the compliance test event, the samples were transferred (shipped) to a third-party laboratory (Enthalpy Analytical in Durham, North Carolina) for HCl analysis by ion chromatography (IC) analysis in accordance with USEPA Method 26.

Appendix 4 provides HCl calculation sheets. Appendix 6 provides a copy of the HCl laboratory report.

4.9 Test Method Exception (USEPA Method 26)

A modified version of USEPA Method 26 was used to measure HCl for each RICE.

Standard Greenberg-Smith (G-S) and modified G-S impingers were used instead of midget impingers for the sampling train.

A calibrated dry gas meter was used to measure the total sample volume.

These were the same procedures that were performed during a similar RICE compliance test event, that occurred in May 2024 at a different facility in Michigan.

4.10 Turbine Fuel Gas Analysis (ASTM D-5504 & 1945/3588)

Two (2) samples of treated LFG used as fuel for the turbine were analyzed for sulfur content and heat content. Sulfur dioxide (SO₂) emission calculations were performed based on the conversion of sulfur to SO₂. The two (2) samples of the treated LFG were collected during the turbine test event (July 25, 2024) using evacuated, sillonite-coated Summa Canisters. The sample tubing was connected to the fuel header at a location after the treatment system and gas blower. The sample canister vacuum was recorded before and after sampling and verified by the laboratory upon receipt.

The gas samples were analyzed by AtmAA, Inc. (Calabasas, CA) for gross heating value by ASTM D1945/3588 and sulfur bearing compounds by ASTM D-5504.

The analytical results for the fuel gas were used to determine the potential SO₂ emission rate in pounds per million British thermal units (lb/MMBtu) using the following equation:

$$(\text{Total S in LFG, ppmv}) \times (64 \text{ lb/lb-mol}) / (385 \text{ scf/lb-mol}) / (\text{Heat content, Btu/scf}) = \text{lb/MMBtu}$$

Appendix 4 provides the SO₂ emission rate calculations based on analysis of the gas sample. Appendix 7 provides a copy of the laboratory analytical report for the treated LFG samples.

5.0 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 (pyrometer, Pitot tube, and scale) were calibrated to specifications in the sampling methods.

5.2 NO_x Converter Efficiency Test

The NO₂ – NO conversion efficiency of the Model 42i analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO₂ was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO₂ – NO converter uses a catalyst at high temperatures to convert the NO₂ to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO_x concentration is at least 90% of the expected value (within 10%).

The NO₂ – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO_x concentration was 100.8% of the expected value).

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, O₂, and CO₂ 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 the 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 RICE testing program, initial three-point instrument calibrations were performed for the NO_x, CO, CO₂, and O₂ analyzers by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the upscale calibration gas and zero gas into the sampling system (at the base of the stainless-steel sampling probe prior to the particulate filter and Teflon® heated sample line) and determining the instrument response against the initial instrument calibration readings.

At the beginning of each RICE 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 used for RICE testing were calibrated with USEPA Protocol 1 certified concentrations of CO₂, O₂, NO_x, and CO in nitrogen and zeroed using hydrocarbon free nitrogen. The NMHC (NMOC) 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.

At the beginning of each day of the turbine testing program, initial three-point instrument calibrations were performed for the NO_x, CO₂, and O₂ analyzers by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the upscale calibration gas and zero gas into the sampling system (at the base of the stainless-steel sampling probe prior to the particulate filter and Teflon® heated sample line) and determining the instrument response against the initial instrument calibration readings.

The instruments used for turbine testing were calibrated with USEPA Protocol 1 certified concentrations of CO₂, O₂, and NO_x in nitrogen and zeroed using hydrocarbon free nitrogen. 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 stacks indicated that the measured O₂ and CO₂ 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.

A stratification test was performed for the turbine exhaust stack. The stainless-steel sample probe was positioned at sixteen (16) sample points inside the turbine exhaust stack (eight

(8) points per sample port). 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 turbine exhaust stack indicated that the measured O₂ concentrations satisfied requirements in 40 CFR, Part 60, Subpart KKKK, Section 60.4400 for use of a single sampling location.

Therefore, the turbine exhaust gas compliance test sampling was performed at one (1) sampling location within the turbine exhaust stack (centroid), for each test period.

5.7 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.

5.8 Meter Box Calibrations

The dry gas meter sampling console used for moisture and HCl testing 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 metering console was calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

5.9 HCl Recovery and Analysis

All recovered Method 26 impinger solutions and rinses were stored in appropriate HDPE bottles with Teflon® lined caps. The liquid level on each bottle was marked with a permanent marker and the caps were securely sealed with tape, prior to shipment. A blank solution was prepared using 0.1 N H₂SO₄ and the high-purity deionized (DI) water used for recovery and analyzed by the laboratory with the sample train solutions. QA/QC procedures used by the laboratory are included in the final report provided by Enthalpy Analytical.

Appendix 8 presents test equipment quality assurance data (NO₂ – NO conversion efficiency test data, instrument calibration and system bias check records, calibration gas certifications, interference test results, meter box calibration records, 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 6.2.

Engine Nos. 1 & 2 / EUCENGINE#1 & EUCENGINE#2 each have the following allowable emission limits specified in MI-ROP-P0222-2023:

- 7.33 pounds per hour (lb/hr) and 2.30 grams per brake horsepower hour (g/bhp-hr) for CO;
- 2.93 lb/hr and 0.90 g/bhp-hr for NO_x;
- 0.81 lb/hr and 0.25 g/bhp-hr for VOC; and
- 0.60 lb/hr for HCl.

The measured air pollutant emission rates for Engine Nos. 1 & 2 / EUCENGINE#1 & EUCENGINE#2 are less than the allowable limits specified in MI-ROP-P0222-2023.

Turbine operating data and air pollutant emission measurement results for each one-hour test period are presented in Table 6.3.

6.2 Results of LFG Fuel Analysis

On the day of the turbine test event (July 25, 2024), the treated LFG used as fuel for the turbine was:

- Sampled using evacuated, silonite-coated Summa Canisters and shipped to a third-party laboratory for analysis of sulfur-bearing compounds.
- Sampled using evacuated, silonite-coated Summa Canisters and shipped to a third-party laboratory for analysis of heat input.

The laboratory reported an average H₂S content of 263 ppmv for the Summa Canister samples with a calculated average total reduced sulfur (TRS) content of 269 ppmv. The laboratory reported an average heat content of 552 Btu/scf.

Turbine LFG fuel sulfur content results are presented in Table 6.4.

6.3 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 Protocols. The engine-generator sets were operated within 10% of maximum output (997 kW generator output for Waukesha model VHP7042GLD RICE) throughout the compliance testing. The turbine was operated within 25% of maximum output (3,500 kW generator output for Solar Centaur model T-4500 turbine) throughout the compliance testing.

Test No. 2 for Engine No. 1 was paused twice (26-minutes and 20-minutes) due to two (2) unexpected engine shutdowns occurring during the test. C&C Energy representatives resolved the engine shutdown issue and Engine No. 1 returned to full load, then after the

sampling probe had been in place for at least twice the greatest system response time, Test No. 2 resumed until a total of at least 60-minutes of test data was measured and recorded.

No variations from normal operating conditions occurred during the turbine test periods.

Table 6.1 Measured exhaust gas conditions and air pollutant emission rates for Engine No. 1 (EUCENGINE#1)

Test No.	1	2	3	
Test date	7/23/2024	7/23/2024	7/23/2024	Three Test
Test period (24-hr clock)	1441-1541	1605-17:51*	1812-1912	Average
Fuel flowrate (scfm)	312	313	313	313
Generator output (kW)	923	905	897	908
Engine output (bhp)	1,303	1,279	1,267	1,283
LFG methane content (%)	57.3	56.8	57.6	57.2
<u>Exhaust Gas Composition</u>				
CO ₂ content (% vol)	11.2	11.3	11.2	11.2
O ₂ content (% vol)	8.85	8.88	8.91	8.88
Moisture (% vol)	13.6	12.5	13.0	13.0
Exhaust gas temperature (°F)	730	736	728	731
Exhaust gas flowrate (dscfm)	2,683	2,779	2,826	2,762
Exhaust gas flowrate (scfm)	3,104	3,174	3,247	3,175
<u>Nitrogen Oxides</u>				
NO _x conc. (ppmvd)	59.8	48.5	40.6	49.6
NO _x emissions (lb/hr)	1.15	0.97	0.82	0.98
NO _x permit limit (lb/hr)	-	-	-	2.93
NO _x emissions (g/bhp-hr)	0.40	0.34	0.29	0.35
NO _x permit limit (g/bhp-hr)	-	-	-	0.90
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	487	499	493	493
CO emissions (lb/hr)	5.70	6.05	6.09	5.95
CO permit limit (lb/hr)	-	-	-	7.33
CO emissions (g/bhp-hr)	1.99	2.15	2.18	2.10
CO permit limit (g/bhp-hr)	-	-	-	2.30
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	18.5	21.1	21.2	20.3
VOC emissions (lb/hr)	0.39	0.46	0.47	0.44
VOC permit limit (lb/hr)	-	-	-	0.81
VOC emissions (g/bhp-hr)	0.14	0.16	0.17	0.16
VOC permit limit (g/bhp-hr)	-	-	-	0.25
<u>Hydrogen Chloride</u>				
HCl catch weight (µg)	1,266	1,195	1,229	1,230
HCl conc. (ppmvd)	0.68	0.65	0.68	0.67
HCl emissions (lb/hr)	0.01	0.01	0.01	0.01
HCl permit limit (lb/hr)	-	-	-	0.60

*Note: Test No. 2 was paused twice (1614-1639 & 1650-1709) due to two (2) unexpected engine shutdowns.

Table 6.2 Measured exhaust gas conditions and air pollutant emission rates for Engine No. 2 (EUCENGINE#2)

Test No.	1	2	3	
Test date	7/23/2024	7/23/2024	7/23/2024	Three Test
Test period (24-hr clock)	0917-1017	1046-1146	1209-1309	Average
Fuel flowrate (scfm)	316	313	309	313
Generator output (kW)	962	960	954	959
Engine output (bhp)	1,359	1,355	1,348	1,354
LFG methane content (%)	55.0	55.4	55.4	55.3
<u>Exhaust Gas Composition</u>				
CO ₂ content (% vol)	11.3	11.2	11.2	11.2
O ₂ content (% vol)	8.85	8.90	8.89	8.88
Moisture (% vol)	13.2	12.9	12.9	13.0
Exhaust gas temperature (°F)	710	711	701	707
Exhaust gas flowrate (dscfm)	2,879	2,847	2,827	2,851
Exhaust gas flowrate (scfm)	3,315	3,269	3,247	3,277
<u>Nitrogen Oxides</u>				
NO _x conc. (ppmvd)	91.2	93.9	100	95.1
NO _x emissions (lb/hr)	1.88	1.92	2.03	1.94
NO _x permit limit (lb/hr)	-	-	-	2.93
NO _x emissions (g/bhp-hr)	0.63	0.64	0.68	0.65
NO _x permit limit (g/bhp-hr)	-	-	-	0.90
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	497	495	504	499
CO emissions (lb/hr)	6.24	6.15	6.22	6.21
CO permit limit (lb/hr)	-	-	-	7.33
CO emissions (g/bhp-hr)	2.08	2.06	2.09	2.08
CO permit limit (g/bhp-hr)	-	-	-	2.30
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv)	14.3	14.2	13.9	14.1
VOC emissions (lb/hr)	0.33	0.32	0.31	0.32
VOC permit limit (lb/hr)	-	-	-	0.81
VOC emissions (g/bhp-hr)	0.11	0.11	0.10	0.11
VOC permit limit (g/bhp-hr)	-	-	-	0.25
<u>Hydrogen Chloride</u>				
HCl catch weight (µg)	1,380	1,529	1,266	1,392
HCl conc. (ppmvd)	0.73	0.82	0.69	0.75
HCl emissions (lb/hr)	0.01	0.01	0.01	0.01
HCl permit limit (lb/hr)	-	-	-	0.60

Table 6.3 Measured exhaust gas conditions and air pollutant emission rates for the Turbine (EUTURBINE)

Test No.	1	2	3	
Test date	7/25/2024	7/25/2024	7/25/2024	Three Test
Test period (24-hr clock)	0800-0900	0920-1020	1045-1145	Average
Fuel flowrate (scfm)	1,245	1,231	1,220	1,232
Turbine output (kW)	2,768	2,719	2,695	2,727
Turbine output (MW)	2.77	2.72	2.69	2.73
LFG methane content (%)	56.0	55.6	55.7	55.8
<u>Exhaust Gas Composition</u>				
CO ₂ content (% vol)	4.44	4.42	4.40	4.42
O ₂ content (% vol)	16.5	16.4	16.5	16.5
Moisture (% vol)	5.3	4.0	7.3	5.5
Exhaust gas temperature (°F)	853	858	859	857
Exhaust gas flowrate (dscfm)	29,547	30,262	29,583	29,797
Exhaust gas flowrate (scfm)	31,195	31,511	31,915	31,540
<u>Nitrogen Oxides</u>				
NO _x conc. (ppmvd)	23.6	23.4	23.8	23.6
NO _x emissions (lb/hr)	5.00	5.07	5.04	5.04
NO _x emissions (lb/MWh)	1.81	1.86	1.87	1.85
NO _x permit limit (lb/MWh)	-	-	-	5.5
<u>Sulfur Dioxide</u>				
	<u>CC1</u>		<u>CC2</u>	<u>Average</u>
Sulfur conc. (ppmv)	256		282	269
SO ₂ emissions (lb/hr)	3.15		3.47	3.31
SO ₂ emissions (lb/MMcf)	43		47	45
Fuel heat content (Btu/scf)	554		550	552
SO ₂ emissions (lb/MMBtu)	0.08		0.09	0.08
Permit / NSPS Limit (lb/MMBtu)	-		-	0.15

Table 6.4 Summary of Turbine LFG Fuel Sulfur Content Analyses

Canister No.	1	2	Average
<u>ASTM-D5504</u>			
Lab result (ppm H ₂ S)	250	275	263
Lab result ¹ (ppm TRS)	256	282	269
<u>ASTM-D1945/3588</u>			
Lab result (Btu/scf)	554	550	552

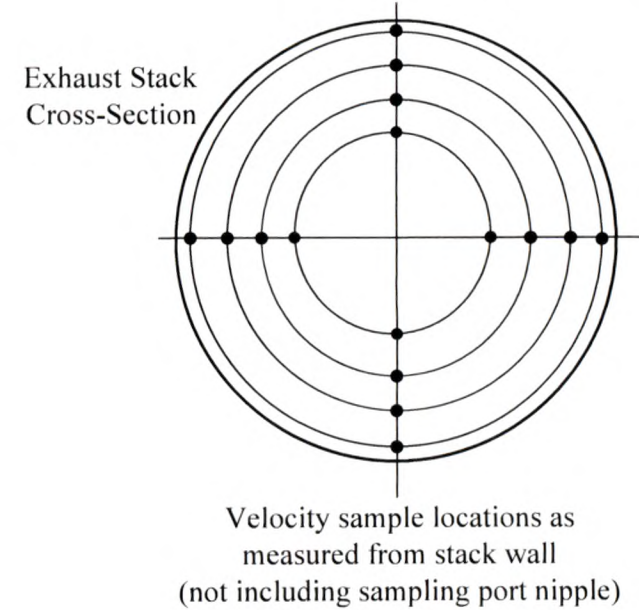
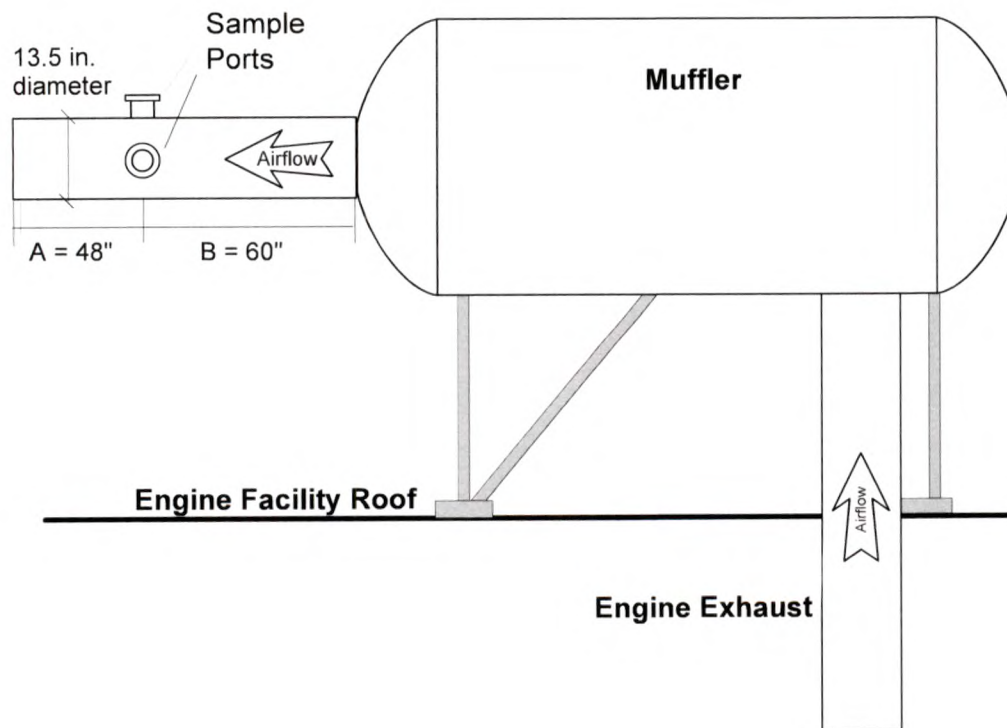
Notes:

1. TRS concentration based on the total of all sulfur-bearing compounds detected in the sample. See laboratory report in Appendix 7.

APPENDIX 1

- Sample Port Diagrams

EUICENGINE#1



Pt. #	in.
1	0.50
2	1.42
3	2.62
4	4.35
5	9.14
6	10.88
7	12.08
8	13.00

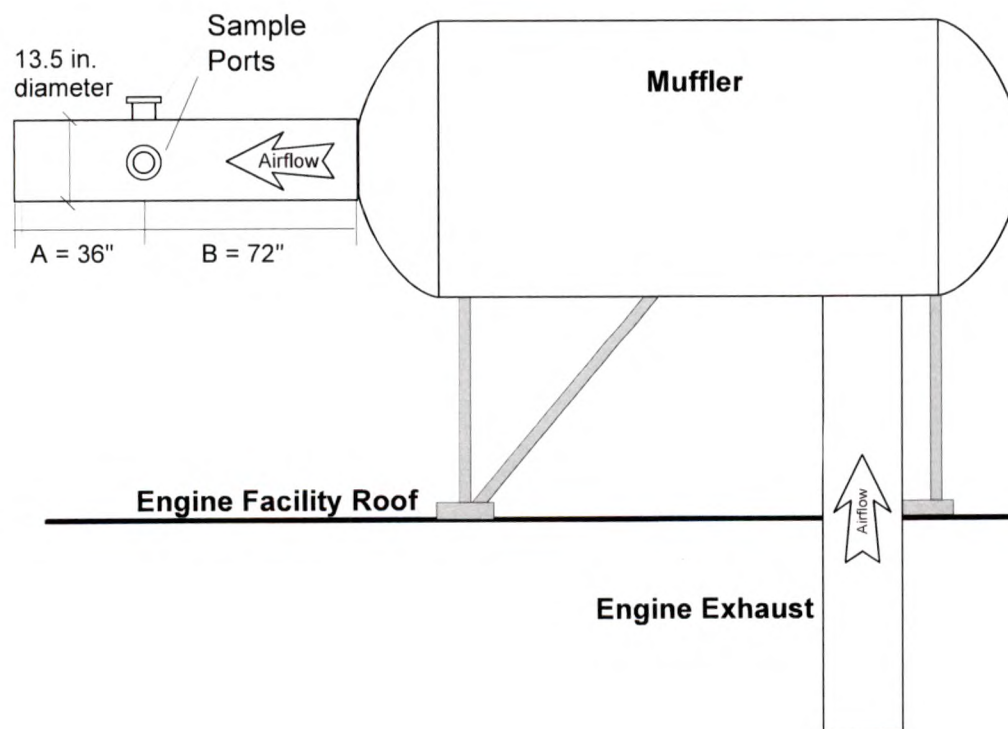
C & C Energy, LLC
Exhaust Sample Location, RICE

Scale
None

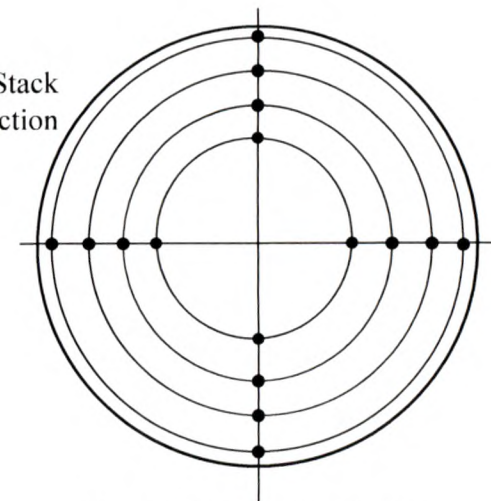
Sheet
1 of 1



EUICENGINE#2



Exhaust Stack Cross-Section



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

Pt. #	in.
1	0.50
2	1.42
3	2.62
4	4.35
5	9.14
6	10.88
7	12.08
8	13.00

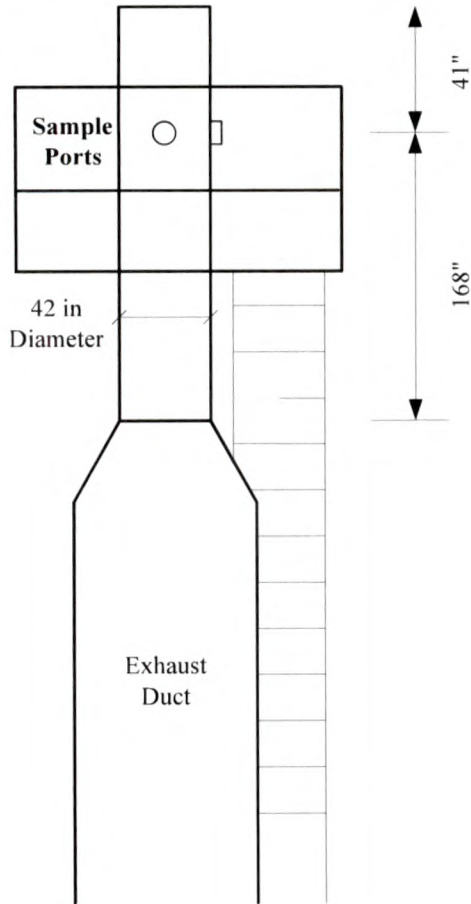
C & C Energy, LLC
Exhaust Sample Location, RICE

Scale
None

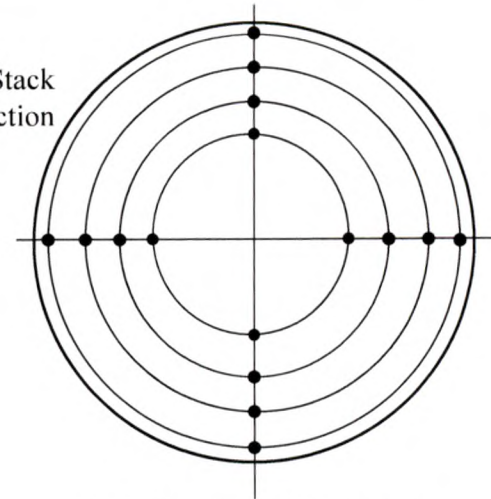
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1 of 1



EUTURBINE



Exhaust Stack Cross-Section



Velocity sample locations as measured from stack wall (not including 6" sampling port nipple)

Pt. #	in.
1	1.34
2	4.41
3	8.15
4	13.52
5	28.43
6	33.85
7	37.59
8	40.66

8/2/18	C&C Energy, LLC		
	Exhaust Sampling Location – EUTURBINE		
	Scale	Sheet	
	None	1 of 1	