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

Prepared for:  
**North American Natural Resources**  
**Autumn Hills Generating Station**  
**SRN N6006**

**ICT Project No.: 2300049**  
**April 27, 2023**





# Report Certification

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

**North American Natural Resources  
Autumn Hills Generating Station  
Zeeland, MI**

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

Report Prepared By:



Andy Rusnak, QSTI  
Technical Manager  
Impact Compliance & Testing, Inc.



## Executive Summary

### NORTH AMERICAN NATURAL RESOURCES AUTUMN HILLS GENERATING STATION LFG FUELED IC ENGINE EMISSION TEST RESULTS

North American Natural Resources (NANR) contracted Impact Compliance & Testing, Inc. (ICT) to conduct a performance demonstration for the determination of nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), volatile organic compounds (VOC), sulfur dioxide (SO<sub>2</sub>), and formaldehyde (HCOH) concentrations and emission rates from one (1) Caterpillar (CAT®) Model No. G3516 gas-fired reciprocating internal combustion engine and electricity generator set (RICE genset) identified as EUENGINE1 operated at the NANR Autumn Hills Generation Station located in Zeeland, Ottawa County, Michigan. The RICE is fueled with landfill gas (LFG) that is produced at the Autumn Hills 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-N6006-2018a and the federal Standards of Performance for Stationary Spark Ignition Internal Combustion Engines (SI-RICE NSPS; 40 CFR Part 60 Subpart JJJJ). The performance testing was conducted April 19, 2023.

The following table presents the CAT® G3516 emissions results from the performance demonstration.

Emission Unit	NO <sub>x</sub> g/bhp-hr	CO g/bhp-hr	VOC g/bhp-hr	HCOH lb/hr	SO <sub>2</sub> lb/hr
EUENGINE1	1.0	1.4	0.10	0.64	0.98
<i>Permit Limit</i>	<i>2.0</i>	<i>3.1</i>	<i>0.41*</i>	<i>1.72</i>	<i>2.96</i>

Note\*: The VOC limit does not include HCOH.

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

Emission Unit	Generator Output (kW)	Engine Output (bhp)	LFG Fuel Use (scfm)	Fuel CH <sub>4</sub> Content (%)
EUENGINE1	800	1,142	318	49.6

The data presented above indicates that EUENGINE1 was tested while the unit operated within 10% of maximum capacity and is in compliance with the emission standards specified in the ROP.



## TABLE OF CONTENTS

<b>1.0 INTRODUCTION.....</b>	<b>6</b>
<b>2.0 SUMMARY OF TEST RESULTS AND OPERATING CONDITIONS .....</b>	<b>7</b>
2.1 Purpose and Objective of the Tests.....	7
2.2 Operating Conditions During the Compliance Tests .....	7
2.3 Summary of Air Pollutant Sampling Results .....	7
<b>3.0 SOURCE AND SAMPLING LOCATION DESCRIPTION.....</b>	<b>9</b>
3.1 General Process Description.....	9
3.2 Rated Capacities and Air Emission Controls .....	9
3.3 Sampling Locations .....	9
<b>4.0 SAMPLING AND ANALYTICAL PROCEDURES.....</b>	<b>10</b>
4.1 Summary of Sampling Methods.....	10
4.2 Exhaust Gas Velocity Determination (USEPA Method 2) .....	11
4.3 Exhaust Gas Molecular Weight Determination (USEPA Method 3A).....	11
4.4 NOx and CO Concentration Measurements (USEPA Methods 7E and 10).....	11
4.5 Measurement of VOC (USEPA Method 25A / ALT-096).....	12
4.6 Measurement of HCOH, SO <sub>2</sub> , and Moisture Content via FTIR (ASTM D6348)....	12
<b>5.0 QA/QC ACTIVITIES.....</b>	<b>14</b>
5.1 Flow Measurement Equipment.....	14
5.2 NOx Converter Efficiency Test .....	14
5.3 Gas Divider Certification (USEPA Method 205).....	14
5.4 Instrumental Analyzer Interference Check.....	14
5.5 Instrument Calibration and System Bias Checks .....	14
5.6 Determination of Exhaust Gas Stratification .....	15
5.7 System Response Time .....	15
5.8 FTIR QA/QC Activities.....	15
<b>6.0 RESULTS .....</b>	<b>17</b>
6.1 Test Results and Allowable Emission Limits.....	17
6.2 Variations from Normal Sampling Procedures or Operating Conditions .....	17

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## List of Tables

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2.1	Average operating conditions during the test periods .....	8
2.2	Measured CAT® G3516 air pollutant emission rates (three-test average) .....	8
6.1	Measured exhaust gas conditions and NO <sub>x</sub> , CO, VOC, SO <sub>2</sub> , and HCOH air pollutant emission rates for Engine No. 1 (EUENGINE1).....	18

## List of Appendices

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APPENDIX 1	SAMPLING DIAGRAMS
APPENDIX 2	OPERATING RECORDS
APPENDIX 3	FLOWRATE CALCULATIONS AND DATA SHEETS
APPENDIX 4	CO <sub>2</sub> , O <sub>2</sub> , CO, NO <sub>x</sub> , VOC, SO <sub>2</sub> , AND HCOH CALCULATIONS
APPENDIX 5	INSTRUMENTAL ANALYZER RAW DATA
APPENDIX 6	FTIR RAW DATA
APPENDIX 7	QA/QC RECORDS



## 1.0 Introduction

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NANR operates gas-fired RICE gensets at the Autumn Hills Generating Station in Zeeland, Ottawa County, Michigan. The EGLE-AQD has issued NANR ROP No. MI-ROP-N6006-2018a for operation of the RICE gensets.

Air emission compliance testing was performed pursuant to conditions specified in ROP No. MI-ROP-N6006-2018a and the SI-RICE NSPS; 40 CFR Part 60 Subpart JJJJ. The compliance emission testing was performed on EUENGINE1 (Engine No. 1). Engine No. 1 is required to test for NO<sub>x</sub>, CO, SO<sub>2</sub>, VOC and HCOH every five (5) years (previous testing was conducted 2/21/2018). The test date was delayed because Engine No. 1 was offsite for maintenance on 2/21/2023. This will be reported as a deviation on the semi-annual ROP certification. Emissions testing required by the NSPS Subpart JJJJ must be completed every 8,760 hours (or three (3) years). Previous NSPS Subpart JJJJ testing was completed on 4/12/2022 (at 55,520 operating hours). This test event satisfied both the five (5) year ROP testing requirement and the NSPS Subpart JJJJ testing requirement.

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 Blake Beddow, Andy Rusnak and Max Fierro performed the field sampling and measurements April 19, 2023.

The emission performance tests consisted of triplicate, one-hour sampling periods for NO<sub>x</sub>, CO, VOC, SO<sub>2</sub> and HCOH on Engine No. 1. Exhaust gas velocity, moisture, oxygen (O<sub>2</sub>) content, and carbon dioxide (CO<sub>2</sub>) 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 5, 2023, that was reviewed and approved by EGLE-AQD.

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

Andy Rusnak, QSTI  
Technical Manager  
Impact Compliance & Testing, Inc.  
4180 Keller Rd., Ste. B  
Holt, MI 48842  
(517) 481-3283  
andy.rusnak@impactcandt.com

Mr. Eric Parker  
Environmental Manager  
Kinder Morgan  
6 Desta Dr., Ste. 6000  
Midland, TX 79705  
(432) 230-0956  
Eric\_Parker@kindermorgan.com

## **2.0 Summary of Test Results and Operating Conditions**

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### **2.1 Purpose and Objective of the Tests**

Conditions of ROP No. MI-ROP-N6006-2018a and 40 CFR Part 60, Subpart JJJJ, require NANR to test Engine No. 1 for CO, NO<sub>x</sub>, VOC, SO<sub>2</sub>, and HCOH emissions.

### **2.2 Operating Conditions During the Compliance Tests**

The testing was performed while the NANR engine/generator set was operated at maximum operating conditions. NANR representatives provided kW output in 15-minute increments for each test period.

Landfill Gas (LFG) fuel flowrate (standard cubic feet per minute, scfm) and fuel methane content (%) were also recorded by NANR 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 G3516 generator efficiency (93.9%), and the unit conversion factor for kW to horsepower (0.7457 kW/hp).

$$\text{Engine output (bhp)} = \text{Electricity output (kW)} / (0.939) / (0.7457 \text{ kW/hp})$$

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

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 Engine No. 1 were sampled for three (3) one-hour test periods during the compliance testing performed April 19, 2023.

Table 2.2 presents the average measured CO, NO<sub>x</sub>, VOC, SO<sub>2</sub>, and HCOH emission rates for each engine (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
Generator output (kW)	800
Engine output (bhp)	1,142
Engine LFG fuel use (scfm)	318
LFG methane content (%)	49.7

**Table 2.2 Measured CAT® G3516 air pollutant emission rates (three-test average)**

	CO	NO <sub>x</sub>	VOC	HCOH	SO <sub>2</sub>
Emission Unit	(g/bhp-hr)	(g/bhp-hr)	(g/bhp-hr)	(lb/hr)	(lb/hr)
EUENGINE1	1.4	1.0	0.10	0.64	0.98
<b>Permit Limit</b>	<b>3.1</b>	<b>2.0</b>	<b>0.41*</b>	<b>1.72</b>	<b>2.96</b>

Note\*: The VOC limit does not include HCOH.

## 3.0 Source and Sampling Location Description

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### 3.1 General Process Description

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

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

### 3.2 Rated Capacities and Air Emission Controls

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

The engine is equipped with an air-to-fuel ratio (AFR) controller that automatically blends the appropriate ratio of combustion air and treated LFG fuel.

The RICE is 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 a noise muffler and vertical exhaust stack.

### 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 exhaust stack sampling ports for Engine No. 1 is located in an individual exhaust duct (horizontal section of the stack before the noise muffler) with an inner diameter of 10.0 inches. The duct is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 34.5 inches (3.5 duct diameters) upstream and 293 inches (29.3 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

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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

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 <sub>2</sub> and CO <sub>2</sub> content was determined using paramagnetic and infrared instrumental analyzers, respectively.
USEPA Method 7E	Exhaust gas NO <sub>x</sub> 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.
ASTM D6348	Exhaust gas HCOH, SO <sub>2</sub> , and moisture content were measured using a Fourier transform infrared spectroscopy (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<sub>2</sub> and O<sub>2</sub> content in the RICE exhaust gas stream were measured continuously throughout each test period in accordance with USEPA Method 3A. The CO<sub>2</sub> content of the exhaust was monitored using a M&C GenTwo infrared gas analyzer. The O<sub>2</sub> content of the exhaust was monitored using a M&C GenTwo 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<sub>2</sub> and CO<sub>2</sub> 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<sub>2</sub> and CO<sub>2</sub> calculation sheets. Raw instrument response data are provided in Appendix 5.

## 4.4 NO<sub>x</sub> and CO Concentration Measurements (USEPA Methods 7E and 10)

NO<sub>x</sub> and CO pollutant concentrations in each RICE exhaust gas stream were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42i High Level chemiluminescence NO<sub>x</sub> analyzer and a M&C GenTwo 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<sub>x</sub> calculation sheets. Raw instrument response data are provided in Appendix 5.

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

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

The USEPA Office of Air Quality Planning and Standards (OAQPS) has issued 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 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.

#### **4.6 Measurement of HCOH, SO<sub>2</sub>, and Moisture Content via FTIR (ASTM D6348)**

HCOH and SO<sub>2</sub> concentrations, and moisture content in the RICE exhaust gas stream 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, sulfur hexafluoride, and sulfur dioxide 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<sup>-1</sup> resolution. Instrument response was recorded using MG2000 data acquisition software.

Appendix 4 provides HCOH and SO<sub>2</sub> 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.



## 5.0 QA/QC Activities

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### 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 NO<sub>x</sub> Converter Efficiency Test

The NO<sub>2</sub> – NO conversion efficiency of the TEI Model 42i analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO<sub>2</sub> was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO<sub>2</sub> – NO converter uses a catalyst at high temperatures to convert the NO<sub>2</sub> to NO for measurement. The conversion efficiency of the instrumental analyzer will be deemed acceptable if the measured NO<sub>x</sub> concentration is at least 90% of the expected value (within 10%).

The NO<sub>2</sub> – NO conversion efficiency test satisfied the USEPA Method 7E criteria (measured NO<sub>x</sub> concentration was 100.4% 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<sub>x</sub>, CO, O<sub>2</sub>, and CO<sub>2</sub> have had an interference response test performed prior to their use in the field, pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e., gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 2.5% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

### 5.5 Instrument Calibration and System Bias Checks

At the beginning of each day of the testing program, initial three-point instrument calibrations were performed for the NO<sub>x</sub>, CO, CO<sub>2</sub>, and O<sub>2</sub> 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<sub>2</sub>, O<sub>2</sub>, NO<sub>x</sub>, 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.

## **5.6 Determination of Exhaust Gas Stratification**

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

The recorded concentration data for the RICE exhaust stack indicated that the measured CO, NO<sub>x</sub>, O<sub>2</sub> and CO<sub>2</sub> 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 the RICE exhaust stack.

## **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 FTIR QA/QC Activities**

At the beginning of each day a calibration transfer standard (CTS, ethylene gas), analyte of interest (acetaldehyde, sulfur hexafluoride, and sulfur dioxide) 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 and sulfur dioxide 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 (NO<sub>2</sub> – NO conversion efficiency test 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

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### 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.

Engine No. 1 has the following allowable emission limits specified in ROP No. MI-ROP-N6006-2018a. The limits specified in the ROP are equal to or more stringent than the limits specified in the SI-RICE NSPS; 40 CFR Part 60 Subpart JJJJ:

Emission Unit ID	CO Limits	NOx Limits	VOC Limits	SO <sub>2</sub> Limits	HCOH Limits
EUENGINE1	3.1 g/bhp-hr	2.0 g/bhp-hr	0.41 g/bhp-hr*	2.96 lb/hr	1.72 lb/hr

Note\*: This VOC limit does not include HCOH.

The results of the Engine No. 1 performance testing demonstrate compliance with the emission limits specified in ROP No. MI-ROP-N6006-2018a and the SI-RICE NSPS; 40 CFR Part 60 Subpart JJJJ.

### 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.

During the third test run the wire connecting the oxygen analyzer to the data logger fell off of the connection on the data logger and data was not logged for the final 17 minutes of the test run. The test three oxygen average is based on 43 minutes of data that was recorded and is consistent with the averages that were measured for Test Period Nos. 1 and 2.

**Table 6.1 Measured exhaust gas conditions and NO<sub>x</sub>, CO, VOC, SO<sub>2</sub>, and HCOH air pollutant emission rates for Engine No. 1 (EUENGINE1)**

Test No.	1	2	3	Three Test
Test date	4/19/2023	4/19/2023	4/19/2023	Average
Test period (24-hr clock)	914-1014	1030-1130	1147-1247	
Generator output (kW)	801	801	798	800
Engine output (bhp)	1,144	1,144	1,139	1,142
LFG flowrate (scfm)	318	317	318	318
LFG methane content (%)	49.5	49.5	49.7	49.6
<u>Exhaust Gas Composition</u>				
CO <sub>2</sub> content (% vol)	13.2	13.1	13.2	13.1
O <sub>2</sub> content (% vol)	6.88	6.83	6.74	6.81
Moisture (% vol)	13.0	13.0	13.1	13.0
Exhaust gas temperature (°F)	873	872	872	872
Exhaust gas flowrate (dscfm)	2,486	2,376	2,372	2,411
Exhaust gas flowrate (scfm)	2,856	2,730	2,729	2,772
<u>Nitrogen Oxides</u>				
NO <sub>x</sub> conc. (ppmvd)	144	146	168	153
NO <sub>x</sub> emissions (g/bhp-hr)	1.0	1.0	1.1	1.0
Permit limit (g/bhp-hr)	-	-	-	2.0
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	328	326	333	329
CO emissions (g/bhp-hr)	1.4	1.3	1.4	1.4
Permit limit (g/bhp-hr)	-	-	-	3.1
<u>Volatile Organic Compounds</u>				
VOC conc. (ppmv C <sub>3</sub> )	13.3	13.3	13.4	13.4
VOC emissions (g/bhp-hr)	0.10	0.10	0.10	0.10
Permit limit (g/bhp-hr)	-	-	-	0.41
<u>Formaldehyde</u>				
HCOH conc. (ppmv)	49.5	49.5	50.1	49.7
HCOH emissions (lb/hr)	0.66	0.63	0.64	0.64
Permit limit (lb/hr)	-	-	-	1.72
<u>Sulfur Dioxide</u>				
SO <sub>2</sub> conc. (ppmv)	35.2	35.3	35.4	35.3
SO <sub>2</sub> emissions (lb/hr)	1.00	0.96	0.97	0.98
Permit limit (lb/hr)	-	-	-	2.96

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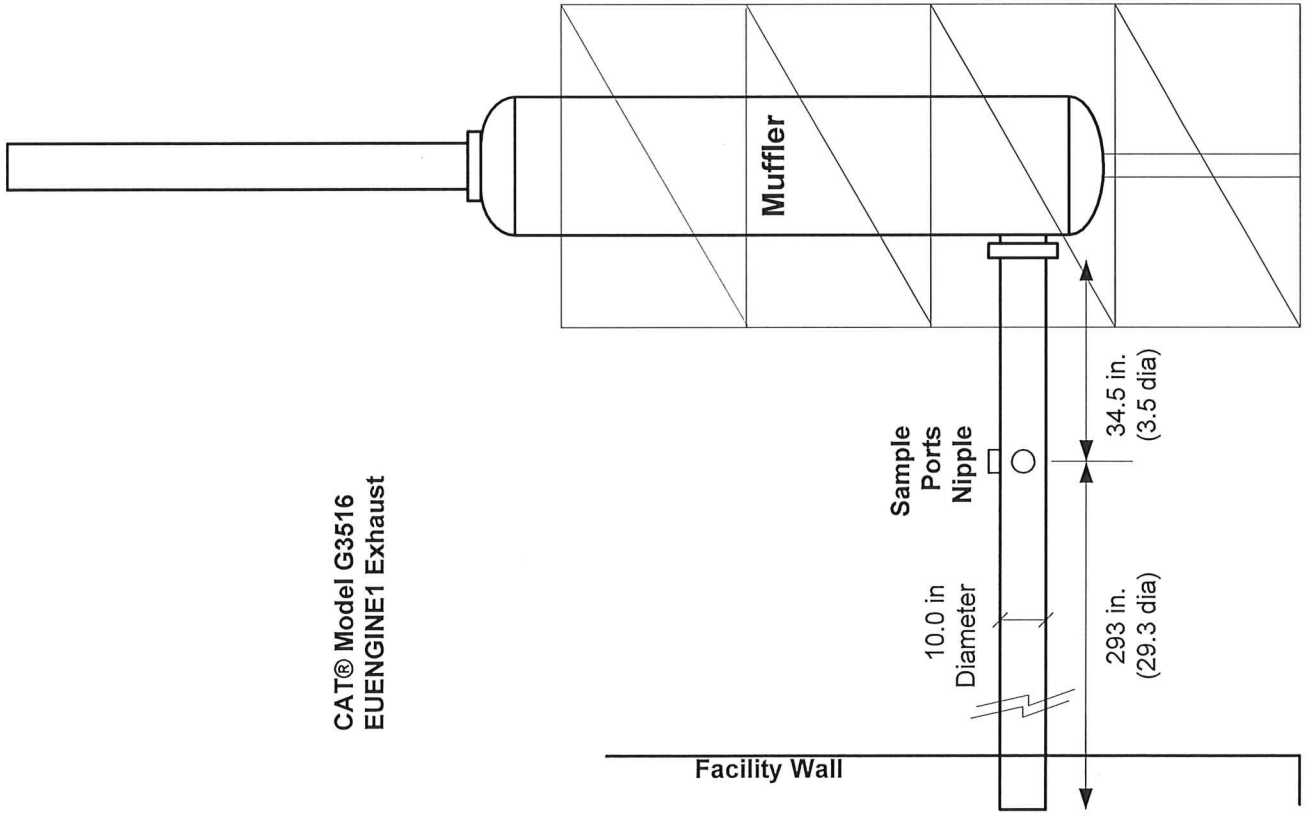
**APPENDIX 1**

- RICE Engine Sample Port Diagram

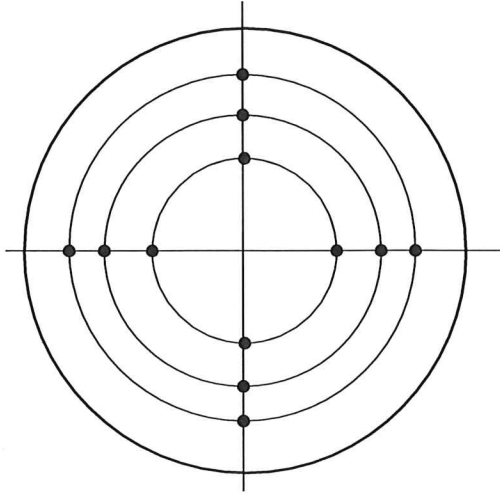




CAT® Model G3516  
EUENGINE1 Exhaust



Exhaust Stack  
Cross-Section  
with Traverse  
Points



Velocity sample locations as  
measured from stack wall

Pt. #	in.
1	0.50
2	1.46
3	2.96
4	7.04
5	8.54
6	9.50

4/21/23 ALR

**NANR Autumn Hills Generating Station  
Exhaust Sample Location, CAT® G3516 ICE**

Scale None	Sheet 1 of 1	Impact Comp. & Testing, Inc. Dwg. No. NANR-AH-1
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