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AIR EMISSION TEST REPORT FOR THE VERIFICATION OF AIR POLLUTANT EMISSIONS FROM A DIESEL-FUELED COMPRESSION INGITION ENGINE-GENERATOR SET

Prepared for:

A&L Iron and Metal
Gaylord, MI
SRN N7508

ICT Project No.: 2200043
December 19, 2022

IMPACT COMPLIANCE & TESTING

Report Certification

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

A&L Iron and Metals
Gaylord, MI

This report has been reviewed by A&L Iron and Metal (A&L) representatives and approved for submittal to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Air Quality Division (AQD).

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

Impact Compliance & Testing, Inc.

Clay Gaffey
Project Manager

I certify that the facility and emission units were operated at maximum routine operating conditions for the test event. Based on information and belief formed after reasonable inquiry, the statements and information in this report are true, accurate and complete.

Responsible Official Certification:

Brian Miller
Operations Manager
A&L Iron and Metal

Table of Contents

List of Tables

List of Appendices

1.0 Introduction

A&L Iron and Metal (A&L Iron) owns and operates a metal shredding and recycling facility located in Gaylord, Otsego County, Michigan. The facility is powered by a General Electric locomotive diesel compression-ignition engine (CI RICE) that drives an electricity generator. The engine is subject to the emission standards and testing requirements in Title 40 of the Code of Federal Regulations Part 63 Subpart ZZZZ *National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines* (40 CFR Part 63 Subpart ZZZZ) as an existing non-emergency, non-black start CI stationary RICE with a power output greater than 500 horsepower (hp), located at an area source of hazardous air pollutant (HAP) emissions.

Pursuant to 40 CFR Part 63 Subpart ZZZZ, an owner/operator of an existing non-emergency, non-black CI RICE >500 hp at an area source of HAP emissions must:

- Install an oxidation catalyst emission control system.
- Reduce carbon monoxide (CO) emissions by 70% or more, or reduce CO to an outlet concentration of 23 ppmvd at 15% oxygen.

In addition, EGLE Permit to install (PTI) No. 173-08B, issued January 7, 2021, limits emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOC) to the following emission rates:.

- NO_x : 69.4 pounds per hour (lb/hr)
- VOC : 17.4 (lb/hr)

A&L Iron has equipped the existing engine with an oxidation catalyst and is submitting this test report for the verification of its CO destruction efficiency (DE), and NO_X and VOC emission rates. CO Emissions were measured at the inlet and outlet of the catalyst in the exhaust gas stream, while NO_X and VOC emissions were measured in the outlet of the exhaust gas stream.

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 Clay Gaffey and Max Fierro performed the field sampling and measurements October 26 – 27, 2022.

The emission tests consisted of triplicate, one-hour sampling periods to measure inlet and outlet CO, NO_X, and VOC, as non-methane hydrocarbons; NMHC or NMOC concentrations. 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 August 4, 2022, that was reviewed and approved by EGLE-AQD. Ms. Sharon LeBlanc and Mr. Jeremy Howe of EGLE-AQD observed portions of the compliance testing.

Testing was performed in accordance with the proposed operating conditions of the Corrective Actions presented in A&L's response to the Second Violation Notice (dated February 10, 2022), which was provided to EGLE on February 24, 2022.

A copy of the Violation Notice Response is included in Appendix 1.

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

Installation and operation of the existing General Electric Model No. 7FDL16 CI RICE genset is permitted under PTI No. 173-08B. CI RICE genset CO emissions testing was performed as specified in 40 CFR Part 63 Subpart ZZZZ, and NO_X and VOC emissions testing was performed as specified in PTI No. 173-08B.

2.2 Operating Conditions During the Compliance Tests

A&L representatives provided kW readings in 1-minute average increments for each test period, as well as written records in 15-minute intervals. Generator output ranged between 605 and 1,076 kW for each test period. Operating Load (%) was calculated using the maximum rated capacity of the engine of 2,600 kW. The calculated Operating Load ranged between 23% and 41%.

Catalyst inlet / outlet temperature (°F), catalyst pressure drop (in. H_2O), and diesel fuel consumption (gal/hr) were also recorded by A&L representatives at 15-minute intervals for each test period. Catalyst inlet temperature ranged between 630 and 805 °F, catalyst outlet temperature ranged between 617 and 798 °F, catalyst pressure drop ranged between 0 and 2 "H_2O, and diesel fuel consumption rate ranged between 53 and 54 gal/hr.

Appendix 2 provides operating records provided by A&L representatives for the test periods.

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

2.3 Summary of Air Pollutant Sampling Results

The exhaust gas from the diesel-fueled CI RICE genset is routed to an oxidation catalyst for the control of CO and hydrocarbons in the exhaust gas. In order to determine the CO destruction efficiency, the exhaust gas was sampled prior to the oxidation catalyst (inlet) and after the catalyst (outlet) using instrumental analyzers. The exhaust gas was sampled at the catalyst outlet for NO_X and VOC using instrumental analyzers.

The compliance testing performed October 26 – 27, 2022 consisted of three (3) one-hour test periods during which the catalyst inlet and outlet gas streams were sampled and analyzed simultaneously. During each test period the inlet gas stream was sampled for an equal amount of time at twelve (12) points. The catalyst outlet gas stream is divided into three (3) vertical stacks. The three (3) stacks were sampled simultaneously, using three (3) separate sample probes manifolded into one (1) sample probe, during each one-hour test period.

The test results verify compliance with the 40 CFR Part 63 Subpart ZZZZ emission standard to achieve a CO emission reduction of 70% or more using an oxidation catalyst, and are less than (in compliance with) the NO_X and VOC emissions limitations permitted in PTI 173-08B.

Table 2.2 presents the average measured CO DE, NO_X, and VOC 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 CI RICE operating conditions during the test periods (three-test average)

Emission Unit ID	Operating Hours†	Average Output (kW)	Catalyst Inlet (°F)	Catalyst Outlet (°F)	Pressure Drop Catalyst ("H_2O)	Diesel Usage (gal/hr)
EUGENERATOR	2,089	813	744	734	0.2	53.7

† Engine run hours since last emissions test on October 5, 2021

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

Emission Unit ID	CO Destruction Efficiency (%)	NO_x (lb/hr)	VOC (lb/hr)
EUGENERATOR	80%	29.4	0.10
Permitted Limit	**>70%**	**69.4**	**17.4**

3.0 Source and Sampling Location Description

3.1 General Process Description

The diesel fueled CI RICE genset is a General Electric model 7FDL16 locomotive RICE connected to an electricity generator. The engine has a manufacture date of 1978.

3.2 Rated Capacities, Type and Quantity of Raw Materials Used

The engine has a horsepower rating of approximately 3,506 hp. The generator has a rated maximum output of 2.6 MW. The CI RICE genset typically operates, on average, between 25 and 30% of its rated capacity of 2.6 MW. During the emission testing the three-run average recorded generator output was 813 kW (0.8 MW, 31% capacity).

The CI RICE was tested while firing 100% diesel fuel. The three-run average diesel fuel consumption was 54 gal/hr.

3.3 Emission Control System Description

The exhaust gas from the CI RICE is directed to an EST Diesel Oxidation/VOC Silencer/Converter. The emission control system reduces (oxidizes using a catalyst) CO and other hydrocarbon emissions prior to the release to the ambient air.

The CI RICE exhaust gas provides the heat necessary to initiate the catalytic reaction (an additional heat source is not used to preheat the gas prior to the catalyst).

The temperature at the catalyst inlet and pressure drop across the catalyst were monitored throughout the test periods to verify that the catalyst operating parameters are within the proper ranges as required by 40 CFR Part 63 Subpart ZZZZ. Table 2b to Subpart ZZZZ specifies that for existing CI RICE with a power output greater than 500 HP, the catalyst:

- Must be maintained such that the pressure drop across the catalyst does not change more than 2 inches of water from the pressure drop across the catalyst that was measured during the initial performance test.

- Inlet temperature must be maintained between 450 and 1350°F.

3.4 Sampling Locations

A continuous sample of the CI RICE exhaust gas was obtained from the inlet and the outlet of the emission control catalyst. The oxidation catalyst inlet sample location is a rectangular plenum at the engine exhaust that is approximately 13.5 inches by 28 inches.

This sampling location does not meet USEPA Method 1 requirements. Therefore, sampling was performed using a 12 point-grid across the rectangular cross section pursuant to Section 8.1.2 of USEPA Method 7E and Table 1-1 to USEPA Method 1. The sample points were configured in a 4-by-3 grid.

The catalyst outlet was sampled concurrently with the inlet. The catalyst exhaust gas is released to atmosphere by three (3) separate exhaust stacks. The three (3) stacks were sampled simultaneously using three (3) separate sample probes manifolded into one (1) sample probe during each one-hour test period.

Appendix 3 provides diagrams of the sampling locations.

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

USEPA Method 1	Exhaust gas sampling locations were determined based on the physical stack arrangement and requirements in USEPA Method 1.
USEPA Method 3A	Exhaust gas O_2 content was determined using paramagnetic analyzers.
USEPA Method 4	Exhaust gas moisture was determined based on the water weight gain in chilled impingers.
USEPA Method 7E	Exhaust gas NO_X concentration was determined using chemiluminescence instrumental analyzers.
USEPA Method 10	Exhaust gas CO concentration was measured using an infrared instrumental analyzer.
USEPA Method 19	Exhaust gas flowrate was calculated by using the fuel F-Factor for diesel fuel (fuel oil).
USEPA Method 25A / ALT-096	Exhaust gas VOC (as NMHC) concentration was determined using a flame ionization analyzer equipped with methane separation column.

4.2 O_2 and CO Concentration Measurements (USEPA Methods 3A and 10)

The CO concentration at the inlet and outlet of catalyst in the RICE exhaust gas stream was measured continuously throughout each one-hour test period in accordance with USEPA Method 10. O_2 content of the exhaust gas outlet was measured continuously throughout each one-hour test period in accordance with USEPA Method 3A. The CO concentration at the catalyst inlet was measured using a Thermo Environmental Instruments (TEI) Model 48i non-dispersive infrared (NDIR) analyzer. The CO concentration at the catalyst outlet was measured using a California Analytical Instruments (CAI) Model Model ZRF NDIR analyzer. A Servomex Model 4900 oxygen analyzer with a paramagnetic sensor was used to measure the O_2 content of the exhaust gas stream (it is assumed that the oxygen content of the catalyst inlet and outlet gas streams remains constant). After the test, the O_2 analyzer was used to collect 30-minutes of data from the catalyst inlet to demonstrate that the concentration is similar to the outlet concentration.

Instrument response for each analyzer was recorded on an ESC Model 8816 data logging 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 period, instrument calibration was verified using appropriate calibration gases to determine accuracy and system bias (described in Section 5.1 of this document).

Appendix 4 provides CO and O_2 calculation sheets. Raw instrument response data (one-minute averages) are provided in Appendix 5.

4.3 Exhaust Gas Moisture Content (USEPA Method 4)

Moisture content was determined in accordance with USEPA Method 4 using a chilled impinger sampling train. Exhaust gas moisture content measurements were 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.

Appendix 4 provides field data sheets and calculations.

4.4 NO_X Concentration Measurements (USEPA Method 7E)

NO_X pollutant concentrations in the RICE 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 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 NO_X calculation sheets. Raw instrument response data (one-minute averages) are provided in Appendix 5.

4.5 VOC Concentration Measurements (USEPA Method 25A / Alt 096)

The VOC emission rate was determined by measuring the nonmethane hydrocarbon (NMHC or NMOC) 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 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 Fuel F-Factor (USEPA Method 19)

During operation the shredder has the potential to produce an unsafe area and prohibits stack testing personnel from accessing the stack to perform exhaust gas velocity measurements via USEPA Method 2. Therefore, the CI RICE exhaust flowrate was calculated using procedures and equations presented in USEPA Method 19.

The fuel F-Factor (F_d) for diesel fuel (9,190 dscf/MMBtu), a default diesel fuel heat content of 18,660 Btu/lb and fuel density of 7.2 lb/gal were used in conjunction with the following USEPA Method 19 calculation to determine CI RICE exhaust flowrate.

Q_{dry} = (MMBtu/hr) * F_d * (20.9) / (20.9 - %O_2) / (60 min/hr)

Where:

Q_{dry} = dry exhaust gas flow rate (dscfm)
MMBtu/hr = calculated heat input
F_d = F-Factor for diesel fuel
%O_2 = measured exhaust gas oxygen content

Appendix 4 provides F-Factor calculation sheets.

5.0 QA/QC Activities

5.1 Instrument Calibration and System Bias Checks

At the beginning of each day, initial three-point instrument calibrations were performed 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 appropriate 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 verifying the instrument response against the initial instrument calibration readings.

The instrument analyzers were calibrated with USEPA Protocol 1 certified concentrations in nitrogen or air and zeroed using nitrogen or air. A STEC ten-step gas divider was used (as needed) to obtain intermediate calibration gas concentrations.

5.2 Sampling System Response Time Determination

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.

The TEI Model 55i analyzer exhibited the longest system response time at 100 seconds. Results of the response time determinations were recorded on field data sheets. For each test period, test data were collected once the sample probe was in position for at least twice the maximum system response time.

5.3 Gas Divider Certification (USEPA Method 205)

The STEC 10-step gas divider was used in the field to obtain appropriate calibration span gases. The 10-step 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 gas divider delivers calibration gas values of 0 to 100% in (10% increments) of the USEPA Protocol 1 calibration gas that is introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 were followed prior to use of the 10-step 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 NO_x Converter Efficiency Test (USEPA Method 7E)

The NO_2 – NO conversion efficiency of the Model 42i analyzer was verified prior to the testing program. A USEPA Protocol 1 certified concentration of NO_2 was injected directly into the analyzer, following the initial three-point calibration, to verify the analyzer's conversion efficiency. The analyzer's NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. The conversion efficiency of the analyzer is deemed acceptable if the measured NO_x concentration is within 90% of the expected value.

The NO_2 – NO conversion efficiency test satisfied the USEPA Method 7E criteria.

5.5 Determination of Exhaust Gas Stratification

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

The recorded concentration data for each catalyst exhaust stack indicated that the measured O_2, CO_2, and NO_X concentrations did not vary by more than 5% of the mean across the stack diameters. Therefore, the CI RICE exhaust gas was considered to be unstratified in each stack and the compliance test sampling was performed at a single sampling location within each exhaust stack of the CI RICE.

The catalyst inlet sampling location did not meet the USEPA Method 1 spacing requirements. Therefore, it was treated as a stratified stack using a 12 point-grid across the rectangular cross section pursuant to Section 8.1.2 of USEPA Method 7E and Table 1-1 to USEPA Method 1.

5.6 Meter Box Calibrations

The dry gas meter sampling console used for moisture 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.

Appendix 6 presents test equipment quality assurance data (NO_2 – 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 Test Results

6.1 Results Summary and Allowable Emission Limits

Table 6.1 presents the operating data and air pollutant emission measurement results for each one-hour test period.

Catalyst CO DE was calculated by comparing the average measured CO concentration at the catalyst outlet to the average measured CO concentration at the catalyst inlet.

Destruction Efficiency, DE = $((C_{CO\text{-}in} / C_{CO\text{-}out}) / C_{CO\text{-}in}) \times 100$

The measured CO reduction across the catalyst averaged 80% across the three (3) one-hour test runs. This is greater than (in compliance with) the 40 CFR Part 63 Subpart ZZZZ emission standard that requires the catalyst emission control system achieve a CO emission reduction of at least 70%.

The measured NOx and VOC emission rates were 29.4 lb/hr and 0.10 lb/hr respectively. This is less than (in compliance with) the PTI No. 173-08B emission limits of 69.4 lb/hr for NOx and 17.4 lb/hr for VOC.

Engine operating data and air pollutant emission measurement results for each one-hour test period are presented in Table 6.1.

6.2 Variations from Normal Sampling Procedures or Operating Conditions

The testing for all pollutants was performed in accordance with USEPA methods and the approved test protocol.

The CI RICE exhaust gas flowrate was calculated by using the fuel F-Factor for diesel fuel (fuel oil) in USEPA Method 19 instead of measuring exhaust pressure by USEPA Method 2. This is because of the dangerous sampling location conditions (possibility of scrap metal ejecting from the shredder) that did not allow for ICT representatives to be present at the sampling location while the metal shredder was running.

Based on the configuration of the exhaust, a review of previous test data and the operation of the catalyst it was assumed that the inlet and outlet O_2 concentrations would be identical. Therefore, outlet O_2 concentrations were used as the inlet concentrations for the test program. A 30-minute O_2 concentration verification was performed on the inlet after the test runs were completed. This procedure was approved by Mr. Jeremy Howe on-site on October 26, 2022.

Test run 3 was delayed multiple times on October 26, 2022 and was eventually abandoned due to process breakdowns. The run was repeated on October 27, 2022, to complete the test program. Data for the abandoned run is included in Appendix 5.

Table 6.1. Measured pollutant concentrations and destruction efficiency for the CI RICE catalyst inlet and exhaust gas streams

Test Number Test Date Test Period (24-hr)	1 10/26/22 0805-0905	3 10/26/22 0955-1112	4 10/27/22 0810-0913	Three Test Average
Genset Operating Parameters				
Generator output (kW)	734	840	867	813
Operating Load (%)	28.2	32.3	33.3	31.3
Diesel Fuel Usage (gal/hr)	53.6	53.6	54.0	53.7
Catalyst Data				
Inlet Temperature (°F)	728	744	758	744
Outlet Temperature (°F)	725	732	744	734
Pressure Drop (in. H_2O)	0.0	0.6	0.0	0.2
Exhaust Gas Measurements (Inlet)				
Oxygen content (%vol, dry)[1]	13.2	12.7	13.1	13.0
CO concentration (ppmvd)	586	535	389	504
CO concentration (ppmvd 15% O_2)	447	383	294	374
Exhaust Gas Measurements (Outlet)				
Oxygen content (%vol, dry)	13.2	12.7	13.1	13.0
CO concentration (ppmvd)	110	110	86.4	102
CO concentration (ppmvd 15% O_2)	86.3	78.4	65.2	75.7
NOx concentration (ppmvd)	1,296	1,405	1,532	1,411
VOC concentration (ppmv as C_3)	4.24	5.81	4.68	4.91
Exhaust gas flowrate (dscfm)	2,978	2,796	2,971	2,915
Exhaust gas flowrate (scfm)	3,184	2,957	3,169	3,103
Catalyst CO Destruction Efficiency				
Calculated CO DE (%)	81	80	78	80
Emission Standard (%)[2]	--	--	--	*70*
Nitrogen Oxides				
NOx emissions (lb/hr)	27.6	28.1	32.5	29.4
NOx permit limit (lb/hr)	--	--	--	*69.4*
Volatile Organic Compounds				
VOC emissions (lb/hr)	0.09	0.12	0.10	0.10
VOC permit limit (lb/hr)	--	--	--	*17.4*

Notes
1. Inlet O_2 concentration assumed to be equal to measured exhaust O_2 concentration.
2. 40 CFR Part 63 Subpart ZZZZ emission standard requires that the CI RICE emission control catalyst achieve a CO emission reduction of 70% or greater.