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AIR EMISSION TEST REPORT FOR THE VERIFICATION OF AIR POLLUTANT EMISSIONS FROM RENEWABLE NATURAL GAS PLANT WASTE GAS THERMAL OXIDIZER

Prepared for:

Emerald RNG, LLC

Facility SRN: N2688

Test Date: 2/13/2024

ICT Project No.: 2400063

March 29, 2024

IMPACT
COMPLIANCE & TESTING

Report Certification

AIR EMISSION TEST REPORT
FOR THE
VERIFICATION OF AIR POLLUTANT EMISSIONS
FROM
RENEWABLE NATURAL GAS PLANT
WASTE GAS THERMAL OXIDIZER

Emerald RNG LLC
Northville, Michigan

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

Impact Compliance & Testing, Inc.

Blake Beddow
Sr. Project Manager

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1.0 Introduction

Emerald RNG, LLC (Emerald) operates a renewable natural gas (RNG) plant and associated waste gas thermal oxidizer (TOX) at the Arbor Hills Landfill in Northville, Washtenaw County, Michigan. The TOX is fueled by waste gas from the process and supplemented with natural gas.

Permit to Install (PTI) No. 67-23A has been issued to Emerald for the operation of their RNG facility. PTI 67-23A requires Emerald to verify NOx, and CO emission rates and operating parameter boundaries for the TOX emissions control within 180 days after commencement of initial startup.

> *1. Within 180 days after commencement of initial start-up, the permittee shall verify NOx and CO emission rates and operating parameter boundaries for EURNGTOX by testing at the owner's expense, in accordance with Department requirements. Testing shall be performed using an approved EPA Method listed in the table below.*

Additionally, the requirements of the municipal solid waste landfill new source performance standard (MSW NSPS) specify in 40 CFR §60.762 that:

> *Route all the collected gas to a control system that complies with the requirements in either paragraph (b)(2)(iii)(A), (B), or (C) of this section.*
>
> *(B) A control system designed and operated to reduce NMOC by 98 weight-percent, or, when an enclosed combustion device is used for control, to either reduce NMOC by 98 weight percent or reduce the outlet NMOC concentration to less than 20 parts per million by volume, dry basis as hexane at 3 percent oxygen.*

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 Andrew Eisenberg and Blake Beddow performed the field sampling and measurements on February 13, 2024.

Air emission compliance testing was performed pursuant to the stack test protocol submitted to the Michigan Department of Environment, Great Lakes, and Energy, Air Quality Division (EGLE-AQD) on January 12, 2024.

The TOX emission performance tests consisted of triplicate, one-hour sampling periods for nitrogen oxides (NOx), carbon monoxide (CO), and non-methane organic compounds (NMOC). 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.

Testing was performed using procedures specified in the Test Plan dated January 12, 2024, that was reviewed and approved by the State of Michigan Department of Environment, Great Lakes, and Energy – Air Quality Division (EGLE-AQD). Mr. Andrew Riley and Ms. Diane Kavanaugh Vetort of EGLE-AQD observed portions of the compliance testing.

Questions regarding this 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

Emissions testing was conducted to verify compliance with the CO and NO_x pollutant emission rates described in PTI 67-23A issued by EGLE-AQD. NMOC pollutant emission rates were verified to comply with 40 CFR 60.762(b)(2)(iii)(B).

2.2 Operating Conditions During the Compliance Tests

The testing was performed while the TOX was operated at normal operating conditions. The TOX operating temperature, waste gas flowrate, supplemental gas flowrate, and waste gas methane content were recorded in 15-minute increments for each test period.

Appendix 2 provides operating records taken during the test periods.

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

2.3 Summary of Air Pollutant Sampling Results

The gases exhausted from EURNGTOX were sampled for three (3) one-hour test periods during the compliance testing performed February 13, 2024.

Table 2.2 presents the average measured CO, NO_X, and NMOC emission rates for the TOX (average of the three test periods).

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

Table 2.1 Average TOX operating conditions during the test periods

Emission Unit	TOX Temp. (°F)	Waste Gas Flow (scfm)	Supp. Fuel Use (scfm)	Waste Gas CH_4 (%)	Calculated Heat Input (MMBtu/hr)
EURNGTOX	1,748	2,759	228	13.6	36.7

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

Emission Unit	NO_x Emissions (lb/hr)	NO_x Emissions (lb/MMBtu)	CO Emissions (lb/hr)	CO Emissions (lb/MMBtu)	NMOC Emissions (ppmvd C_6 @ 3% O_2)
EURNGTOX	0.82	0.02	3.77	0.10	0.01
Emissions Limits	**-**	***0.06***	**-**	***0.20***	***20***

3.0 Source and Sampling Location Description

3.1 General Process Description

Landfill gas (LFG) containing methane is generated in the Landfill from the anaerobic decomposition of disposed waste materials. The LFG is collected using a system of wells (gas collection system). The collected gas is directed to the Emerald gas conditioning facility to produce RNG. The final RNG product gas is injected into a nearby natural gas pipeline and used in place of fossil fuel-derived natural gas.

The non-methane components in the incoming LFG, and a small amount of methane, are sent to a waste gas stream that is directed to a TOX (enclosed flare) for the destruction of methane and other hydrocarbons.

3.2 Air Emission Controls

The TOX acts as the device used to control emissions associated with the waste gas stream that is produced by the RNG plant.

3.3 Sampling Locations

The TOX exhaust gas is released to the atmosphere through a dedicated vertical exhaust stack with a vertical release point.

The TOX exhaust stack sampling ports are located at a vertical portion of the stack with an inner diameter of 84 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 44 inches (0.5 duct diameters) upstream and greater than 300 inches (>3.6 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.

4.0 Sampling and Analytical Procedures

The 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_2 and CO_2 content was determined using paramagnetic and infrared instrumental analyzers, respectively.
USEPA Method 4	Exhaust gas moisture was determined based on the water weight gain in chilled impingers.
USEPA Method 7E	Exhaust gas NOx concentration was determined using chemiluminescence instrumental analyzers.
USEPA Method 10	Exhaust gas CO concentration was measured using an infrared instrumental analyzer
USEPA Method 25A / ALT-097	Exhaust gas NMOC (as NMHC) concentration was determined using a flame ionization analyzer equipped with methane separation column.

4.2 Exhaust Gas Velocity Determination (USEPA Method 2)

The TOX exhaust stack gas velocities and volumetric flow rates were determined using USEPA Method 2 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 the sampling location was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each velocity traverse point with the planes of the face openings of the Pitot tube perpendicular to the stack cross-sectional plane. The Pitot tube was then rotated to determine the null angle (rotational angle as measured from the perpendicular, or reference, position at which the differential pressure is equal to zero).

Appendix 3 provides exhaust gas flowrate calculations and field data sheets.

4.3 Exhaust Gas Molecular Weight Determination (USEPA Method 3A)

CO_2 and O_2 content in the TOX exhaust gas stream was measured continuously throughout each test period in accordance with USEPA Method 3A. The CO_2 content of the exhaust was monitored using a California Analytical Fuji Model ZRF infrared gas analyzer. The O_2 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 TOX exhaust gas stream was extracted from the stack using a stainless-steel probe connected to a Teflon® heated sample line. The sampled gas was conditioned by removing moisture prior to being introduced to the analyzers; therefore, measurement of O_2 and CO_2 concentrations correspond to standard dry gas conditions. Instrument response data were recorded using an ESC Model 8816 data acquisition system that monitored the analog output of the instrumental analyzers continuously and logged data as one-minute averages.

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

Appendix 4 provides O_2 and CO_2 calculation sheets. Raw instrument response data are provided in Appendix 5.

4.4 NO_X, and CO Concentration Measurements (USEPA Methods 7E & 10)

NO_X, and CO pollutant concentrations in the TOX exhaust gas streams were determined using a Thermo Environmental Instruments, Inc. (TEI) Model 42i High-Level chemiluminescence NO_X analyzer and a TEI Model 48i infrared CO analyzer.

Throughout each test period, a continuous sample of the TOX 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 and CO calculation sheets. Raw instrument response data are provided in Appendix 5.

4.5 Measurement of NMOC (USEPA Method 25A / ALT-097)

The NMOC emission rate was determined by measuring the nonmethane hydrocarbon (NMHC) concentration in the TOX exhaust gas. NMOC 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 NMOC 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.

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, NMOC 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 NMOC calculation sheets. Raw instrument response data for the NMHC analyzer is provided in Appendix 5.

5.0 QA/QC Activities

5.1 Flow Measurement Equipment

Prior to arriving onsite, 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.

The absence of cyclonic flow for each sampling location was verified using an S-type Pitot tube and oil manometer. The Pitot tube was positioned at each of the velocity traverse points 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).

5.2 NO_X Converter Efficiency Test

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 (measured NO_X concentration was 100.3% 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, O_2 and CO_2 have had an interference response test preformed prior to their use in the field, pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e., gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 2.5% of the span for all

measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

5.5 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_X, CO, CO_2 and O_2 analyzers by injecting calibration gas directly into the inlet sample port for each instrument. System bias checks were performed prior to and at the conclusion of each sampling period by introducing the upscale calibration gas and zero gas into the sampling system (at the base of the stainless-steel sampling probe prior to the particulate filter and Teflon® heated sample line) and determining the instrument response against the initial instrument calibration readings.

The instruments were calibrated with USEPA Protocol 1 certified concentrations of CO_2, O_2, NO_X, and CO in nitrogen and zeroed using hydrocarbon free nitrogen. The NMHC (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.

5.6 Methane / Non-Methane Separation Efficiency

The most recent demonstration of methane to non-methane organic compound separation when using an analyzer equipped with an internal gas chromatograph (GC) was performed on site. No major components of the TEI 55i analyzer were replaced after the separation study.

After independently calibrating the TEI 55i analyzer using a certified methane calibration gas and a certified non-methane hydrocarbon calibration gas (propane), the analyzer was challenged with a certified blend gas containing 11.03 ppmv propane and 995.1 ppmv methane. The analyzer response was 10.64 ppm propane and 1017 ppm methane, which verified accurate separation and measurement of the methane and non-methane analytes.

5.7 Determination of Exhaust Gas Stratification

A stratification test was performed for the TOX 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 TOX exhaust stack indicated that the measured NO_X concentrations did not vary by more than 5% of the mean across the stack diameter. Therefore, the TOX exhaust gas was unstratified and the compliance test sampling was performed at a single sampling location within the TOX exhaust stack.

6.0 Results

6.1 Test Results and Allowable Emission Limits

TOX operating data and air pollutant emission measurement results for each one-hour test period are presented in Table No. 6.1.

EU014 has the following allowable emission limits specified in the permit application:

- 0.20 lb/MMbtu for CO;
- 0.06 lb/MMBtu for NO_x;
- 20 ppmvd as hexane corrected to 3% oxygen for NMOC

Based on the recorded data the measured air pollutant concentrations and emission rates for EURNGTOX are less than the allowable emission limits specified in the permit application.

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 TOX was operated at the normal routine operating conditions on the testing day and no variations from normal operating conditions occurred during the TOX test periods.

Each one-run average CO concentration during testing was below the calibrated span of the CO instrument (less than 100.2 ppmvd), as required by USEPA Method 7E section 3.4, which is referenced in USEPA Method 10. However, there were occasional CO spikes above the calibrated span during the test periods.

As an additional measure to show sampling system and instrument accuracy above span, a high span CO calibration gas with a concentration of 1,504 ppm was introduced to the sampling system at a divider cut of 70%. The expected concentration was 1,053 ppm and the system response concentration was 1,057 ppm at 13:18. The system response was within the bias allowances specified in USEPA Method 10/7E.

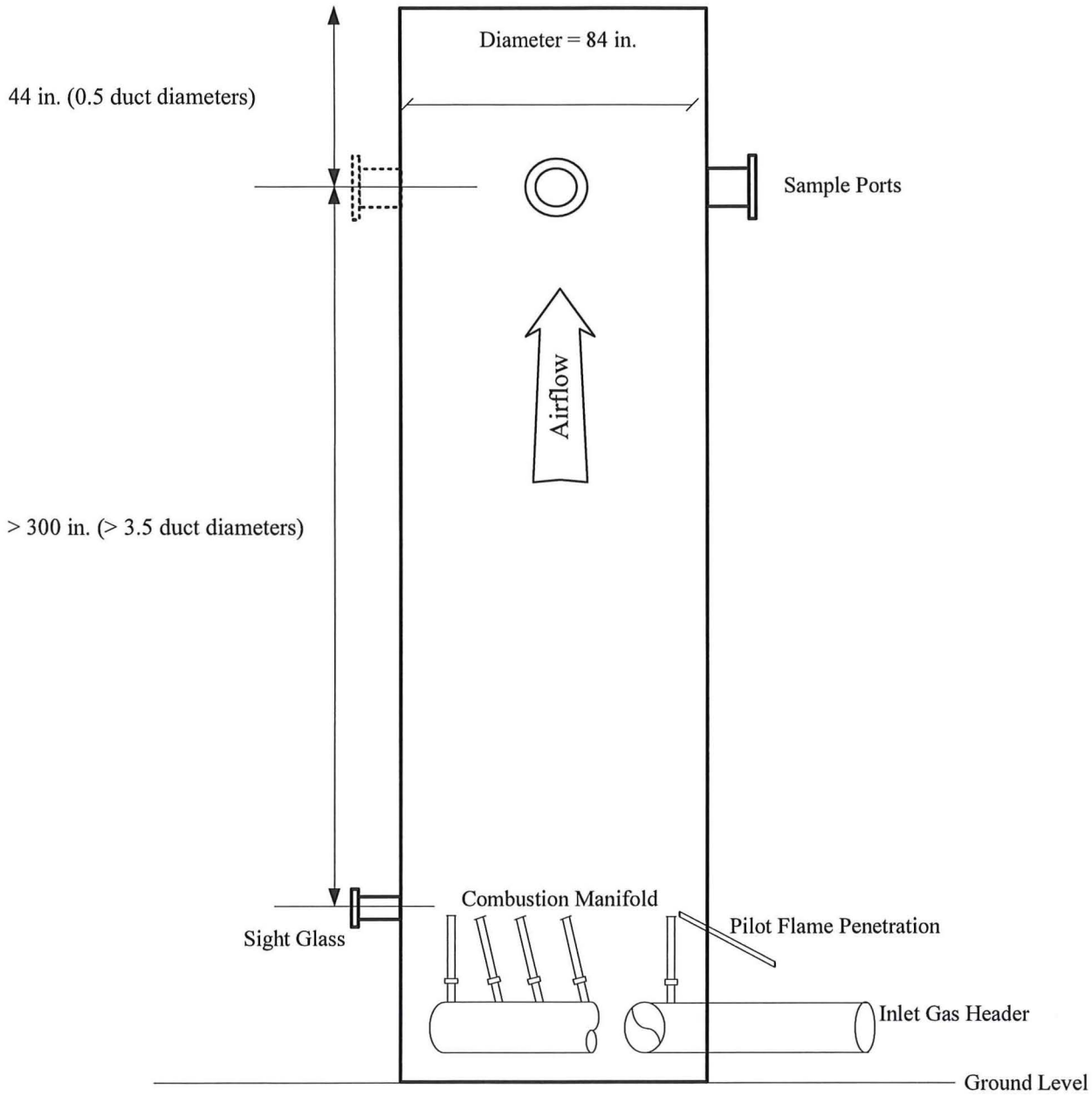
Table 6.1 Measured exhaust gas conditions and air pollutant emission rates for the TOX (EURNGTOX)

Test No. Test date Test period (24-hr clock) (EST)	1 2/13/2024 1030-1130	2 2/13/2024 1200-1300	3 2/13/2024 1345-1445	Three Test Average
TOX Temperature (°F)	1,757	1,727	1,761	1,748
Waste gas flowrate (scfm)	3,014	2,788	2,473	2,759
Waste gas CH_4 content (%)	12.5	14.6	13.7	13.6
Supplemental fuel use (scfm)	223	239	223	228
Heat Input (MMBtu/hr)	36.3	39.3	34.5	36.7
Exhaust Gas Composition				
CO_2 content (% vol)	19.1	18.0	21.2	19.4
O_2 content (% vol)	9.58	10.2	9.80	9.86
Moisture (% vol)	8.53	8.54	8.69	8.59
Exhaust gas flowrate (dscfm)	17,981	15,432	15,427	16,280
Nitrogen Oxides				
NO_X conc. (ppmvd)	6.68	6.90	7.55	7.04
NO_X emissions (lb/hr)	0.86	0.76	0.84	0.82
NO_X emissions (lb/MMBtu)	0.02	0.02	0.02	0.02
Emission Limit (lb/MMBtu)	-	-	-	*0.06*
Carbon Monoxide				
CO conc. (ppmvd)	64.9	76.3	16.2	52.5
CO emissions (lb/hr)	5.09	5.14	1.09	3.77
CO emissions (lb/MMBtu)	0.14	0.13	0.03	0.10
Emission Limit (lb/MMBtu)	-	-	-	*0.20*
Non-Methane Organic Compounds				
NMOC conc. (ppmv, as C_3H_8)	0.02	0.02	0.00	0.01
NMOC conc. (ppmv, as hexane)	0.01	0.01	0.00	0.01
NMOC conc. (ppmvd C_6)	0.01	0.01	0.00	0.01
NMOC conc. (ppmvd C_6 @ 3% O_2)	0.01	0.02	0.00	0.01
Emission Limit (ppmvd C_6 @ 3% O_2)	-	-	-	*20*

APPENDIX 1

- TOX Sample Port Diagram

EURNGTOX (Thermal Oxidizer, TOX)



Thermal Oxidizer Sampling and Measurement Locations

3/21/2024	**Emerald RNG LLC EURNGTOX (TOX)** **Exhaust Sample Location**		
	Scale None	Sheet 1 of 1	IMPACT COMPLIANCE & TESTING