RECEIVED
JUN 17 2022
AIR QUALITY DIVISION

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

Prepared for:

Energy Developments Lansing, LLC
SRN N5997

ICT Project No.: 2100178
June 14, 2022

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

EDL Lansing, LLC Facility
Lansing, Michigan

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

Impact Compliance and Testing, Inc.

Andy Rusnak, QSTI
Technical Manager

Executive Summary

ENERGY DEVELOPMENTS LANSING, LLC
RNG PLANT WASTE GAS TOX
EMISSION TEST RESULTS

Energy Developments Lansing, LLC (EDL) contracted Impact Compliance & Testing, Inc. (ICT) to conduct a performance demonstration for the determination of nitrogen oxides (NO_x) and carbon monoxide (CO) concentrations and emission rates from a thermal oxidizer (TOX) used to control waste gas from the EDL renewable natural gas (RNG) facility located at the Granger Wood Street Landfill in Lansing, Clinton County, Michigan.

The Michigan Department of Environment, Great Lakes, and Energy-Air Quality Division (EGLE-AQD) Permit to Install (PTI) No. 178-19 requires that emission testing be performed on the RNG plant TOX within 180 days of startup. Initial performance testing was conducted on February 22, 2022. During the initial test event the TOX heat input was not able to be calculated and therefore compliance with the NO_x and CO lb/MMBtu emission limits could not be demonstrated. EGLE approved an extension to the 180-day testing requirement to allow for a new supplemental natural gas flowmeter to be installed at the facility. Additional testing was conducted on June 8, 2022 to demonstrate compliance with the NO_x and CO lb/MMBtu emission limits. This report presents the June 8, 2022 results.

The following tables present the results from the performance demonstration.

Emission Unit	NO_x Emissions (lb/MMBtu)	NO_x Emissions (lb/hr)	NO_x Emissions (TpY)*	CO Emissions (lb/MMBtu)	CO Emissions (lb/hr)	CO Emissions (TpY)*
EUTOX	0.032	0.44	1.93	0.06	0.85	3.73
Permit Limits	***0.060***	-	***6.40***	***0.20***	-	***21.3***

* - calculated value based on 8,760 hours operation per year

Emission Unit	TOX Temp.* (°F)	Waste Gas Flow (scfm)	Waste Gas CH_4 (%)	Nat. Gas Fuel Use (scfm)
EUTOX	1,599	1,257	7.70	127

* - measured at the top temperature probe

The data presented above indicates that EUTOX is in compliance with the lb/MMBtu and TpY emission standards specified in PTI No. 178-19 for NO_x and CO.

Table of Contents

List of Tables

List of Appendices

1.0 Introduction

Energy Developments Lansing, LLC (EDL) operates a renewable natural gas (RNG) plant and associated waste gas thermal oxidizer (TOX) at the Granger Wood Street Landfill in Lansing, Clinton County, Michigan. The TOX is fueled by waste gas from the process and supplemented with natural gas.

The Michigan Department of Environment, Great Lakes and Energy – Air Quality Division (EGLE-AQD) has issued EDL Permit to Install (PTI) No. 178-19 for operation of the RNG facility, which consists of:

- EUCONDSYS - Landfill gas conditioning system using a membrane filtering technology to condition landfill gas into renewable natural gas (RNG) by removing hydrogen sulfide (H_2S), volatile organic compounds (VOCs), carbon dioxide (CO_2), nitrogen (N_2), and oxygen (O_2).; and

- EUTOX - A 2,000 standard cubic feet per minute (scfm) thermal oxidizer (enclosed flare) used for destruction of waste gas (components removed during the conditioning of the gas and off-spec RNG).

Air emission compliance testing was performed pursuant to PTI No. 178-19. Conditions of the PTI for EUTOX state:

1. *Within 180 days after commencement of initial start-up, the permittee shall verify NO_x, CO, and SO_2 emission rates and operating parameter boundaries for EUTOX by testing at the owner's expense, in accordance with Department requirements.*

Initial compliance testing was performed on February 22, 2022. The initial test event was performed within 180 days after commencement of initial start-up. During the initial test event the supplemental natural gas flowrate to EUTOX was not able to be measured and a corresponding heat input rate could not be calculated. Compliance with the NO_x and CO lb/MMBtu emission limits could not be determined during the initial compliance testing. EDL requested an extension of the 180-day testing requirement to allow for replacement of the supplemental natural gas flowmeter. EGLE approved the test extension request. EDL installed a new supplemental natural gas flowmeter and a subsequent compliance test was performed on June 8, 2022 to demonstrate compliance with the CO and NO_x lb/MMBtu emission limits.

The TOX emission performance retest consisted of triplicate, one-hour sampling periods for NO_x and CO. Exhaust gas velocity, moisture, O_2 content, and CO_2 content were determined for each test period to calculate pollutant mass emission rates.

The compliance testing presented in this report was performed by ICT, a Michigan-based environmental consulting and testing company. ICT representatives Max Fierro and Andrew Rusnak performed the field sampling and measurements June 8, 2022.

The exhaust gas sampling and analysis was performed using procedures specified in the Test Plan provided to EGLE representatives on May 6, 2022. The test plan was reviewed and approved by the EGLE-AQD.

EDL and the landfill have also been issued Renewable Operating Permit (ROP) No. MI-ROP-N5997-2020 for the operation of their facilities (however, the RNG plant has not been incorporated into the ROP as of the testing date).

Questions regarding this emission test report should be directed to:

Andy Rusnak, QSTI
Technical Manager
Impact Compliance and Testing, Inc.
4180 Keller Rd., Ste. B
Holt, MI 48842
Ph: (517) 268-0043
andy.rusnak@impactcandt.com

Ms. Courtney Truett
Environmental Compliance Systems Advisor for North America
Energy Developments
P.O. Box 15217
Lansing, MI 48901
(615) 290-4553
Courtney.truett@edlenergy.com

2.0 Summary of Test Results and Operating Conditions

2.1 Purpose and Objective of the Tests

Conditions of PTI No. 178-19 requires EDL to test EUTOX for CO, NO_x and SO_2 emissions. Initial compliance testing to demonstrate compliance with the CO, NO_x and SO_2 mass emission rates (lb/hr and TpY) was completed on February 22, 2022. The purpose of the June 8, 2022 was to demonstrate compliance with the CO and NO_x lb/MMBtu emission limits.

2.2 Operating Conditions During the Compliance Tests

The testing was performed while the TOX was operated at the routine operating conditions. The rated capacity for the TOX is 24.4 MMBtu/hr and it is designed to treat up to 2,000 scfm of waste gas. The TOX operating temperature, waste gas flowrate, waste gas methane content and supplemental natural gas flowrate were recorded by EDL in 10-second increments for each test period.

The TOX heat input was calculated by adding the heat input contributions from the residual methane contained in the waste gas stream to the heat input contribution from the supplemental natural gas stream. A default higher heating value for methane of 1,010 Btu/ft³ was used in the following calculation:

$$H_{TOX} = (Q_{waste} * CH_{4waste} + Q_{NG}) * 1010 \text{ Btu/ft}^3 * 60 \text{ min/hr} / 10^6$$

Where: H_{TOX} = Heat Input of TOX (MMBtu/hr)
Q_{waste} = Waste gas flowrate to TOX (ft^3/min)
CH_{4waste} = Methane content of waste gas stream (%)
Q_{NG} = Natural gas flowrate to TOX (ft^3/min)

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 EUTOX were sampled for three (3) one-hour test periods during the compliance testing performed June 8, 2022.

Table 2.2 presents the average measured CO and NO_x emission rates for the TOX (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 TOX operating conditions during the test periods

Emission Unit	TOX Temp.* (°F)	Waste Gas Flow (scfm)	Waste Gas CH_4 (%)	Nat. Gas Fuel Use (scfm)	TOX Heat Input (MMBtu/hr)
EUTOX	1,599	1,257	7.70	127	13.6

* - measured at the top temperature probe

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

Emission Unit	NO_x Emissions			CO Emissions		
	(lb/MMBtu)	(lb/hr)	(TpY)*	(lb/MMBtu)	(lb/hr)	(TpY)*
EUTOX	0.032	0.44	1.9	0.06	0.85	3.7
Permit Limits	***0.060***	**-**	***6.4***	***0.20***	**-**	***21.3***

* - calculated value based on 8,760 hour per year of operation

3.0 Source and Sampling Location Description

3.1 General Process Description

Granger (the landfill owner / operator) operates an active LFG collection and control system. Most of the collected gas is directed to the EDL gas conditioning facility to produce RNG. The final RNG product gas is injected into a nearby natural gas pipeline and used by consumers in place of fossil fuel-derived natural gas.

The non-methane components in the incoming LFG, and a small amount of methane, are rejected to a waste gas stream that is directed to a 2,000 standard cubic feet per minute (scfm) TOX (enclosed flare) for the destruction of methane and other hydrocarbons.

3.2 Rated Capacities and Air Emission Controls

The TOX is the device used to control emissions associated with the waste gas stream that the RNG plant produces.

The TOX has a rated design capacity of:

- Waste Gas Capacity: 2,000 ft^3/min
- Heat Input: 24.4 MMBtu/hr

3.3 Sampling Locations

The EUTOX exhaust gases are released to the atmosphere through a dedicated vertical exhaust stack with a vertical release point.

The EUTOX exhaust stack sampling ports are located in a vertical portion of the stack with an inner diameter of 56 inches. The stack is equipped with two (2) sample ports, opposed 90°, that provide a sampling location 36 inches (0.6 duct diameters) upstream and 324 inches (5.8 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

A test protocol for the air emission testing was reviewed and approved by the 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 NO_x concentration was determined using chemiluminescence instrumental analyzers.
USEPA Method 10	Exhaust gas CO concentration was measured using an infrared instrumental analyzer

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 Fuji 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 and 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 Fuji Model ZRF 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 CO and NO_x calculation sheets. Raw instrument response data are 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 93.9% 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. 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 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 considered to be 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.

EUTOX has the following allowable emission limits specified in PTI No. 178-19:

- 0.20 lb/MMBtu and 21.3 TpY for CO; and
- 0.060 lb/MMBtu and 6.4 TpY for NO_X.

Based on the recorded data the measured air pollutant concentrations and emission rates for EUTOX are less than the allowable lb/MMBtu and TpY limits specified in PTI No. 178-19.

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 with the exceptions noted below. The TOX was operated at the normal routine operating conditions for the amount of gas that was available to be processed on the testing day and no variations from normal operating conditions occurred during the TOX test periods.

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

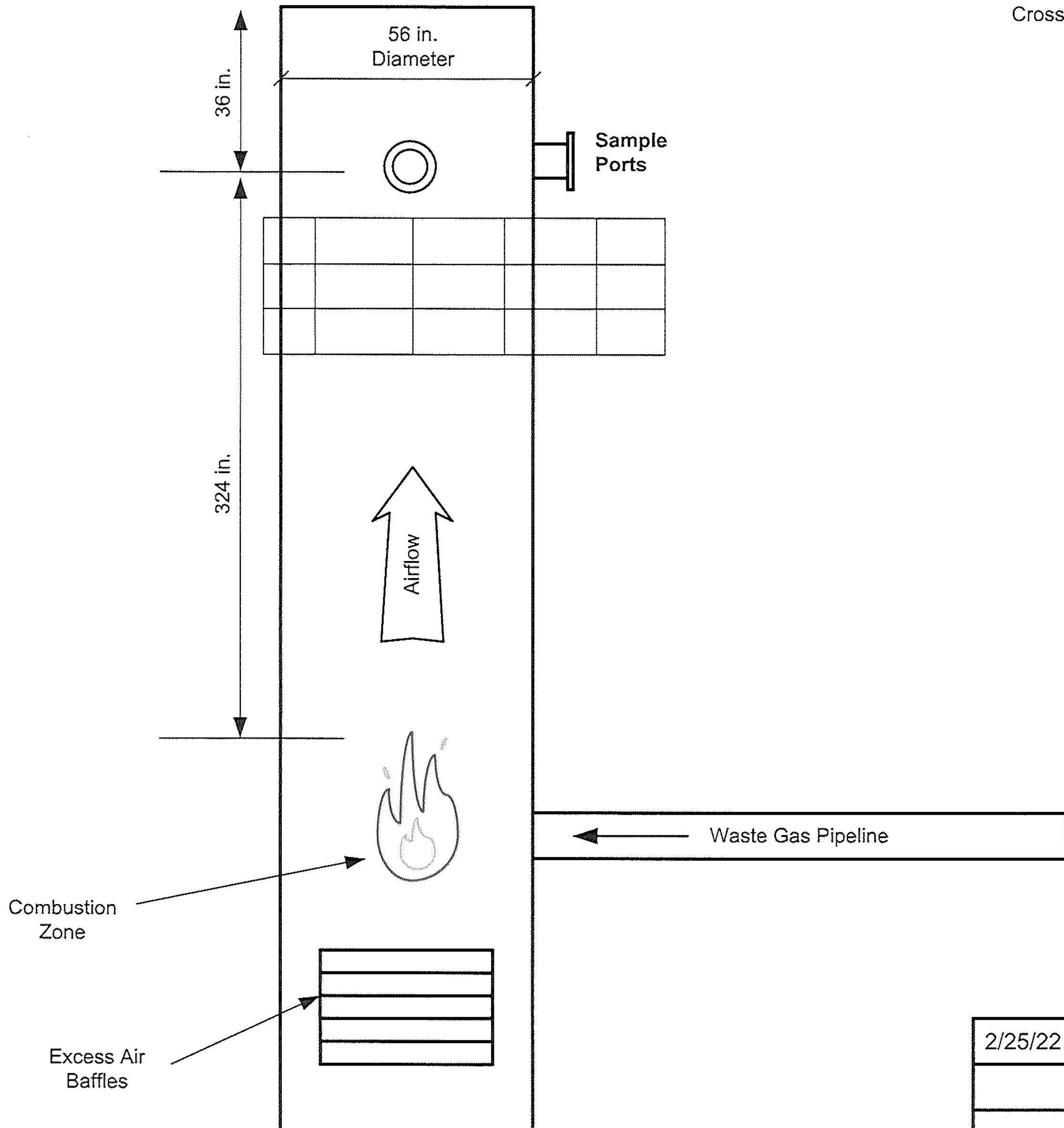
Test No. Test date Test period (24-hr clock)	1 6/8/22 731-831	2 6/8/22 850-950	3 6/8/22 1010-1110	Three Test Average
Top Temperature (°F)	1,599	1,599	1,600	1,599
Middle Temperature (°F)	1,743	1,744	1,742	1,743
Bottom Temperature (°F)	1,721	1,732	1,732	1,728
Waste gas flowrate (scfm)	1,222	1,277	1,273	1,257
Waste gas CH_4 content (%)	7.75	7.62	7.74	7.70
Supplemental natural gas flowrate (scfm)	130	127	126	127
Calculated TOX heat input (MMBtu/hr)	13.6	13.6	13.6	13.6
<u>Exhaust Gas Composition</u>				
CO_2 content (% vol)	28.6	28.8	29.2	28.8
O_2 content (% vol)	6.25	6.17	6.21	6.21
Moisture (% vol)	8.1	8.4	9.2	8.6
Exhaust gas flowrate (dscfm)	5,448	5,533	4,721	5,234
<u>Nitrogen Oxides</u>				
NO_x conc. (ppmvd)	11.6	11.9	11.7	11.7
NO_x emissions (lb/hr)	0.45	0.47	0.40	0.44
NO_x emissions (TpY)*	2.0	2.1	1.7	1.9
Permit Limit (TpY)	-	-	-	*6.4*
NO_x emissions (lb/MMBtu)	0.033	0.035	0.029	0.032
Permit Limit (lb/MMBtu)	-	-	-	*0.060*
<u>Carbon Monoxide</u>				
CO conc. (ppmvd)	31.8	40.5	39.7	37.3
CO emissions (lb/hr)	0.76	0.98	0.82	0.85
CO emissions (TpY)*	3.3	4.3	3.6	3.7
Permit Limit (TpY)	-	-	-	*21.3*
CO emissions (lb/MMBtu)*	0.06	0.07	0.06	0.06
Permit Limit (lb/MMBtu)	-	-	-	*0.20*

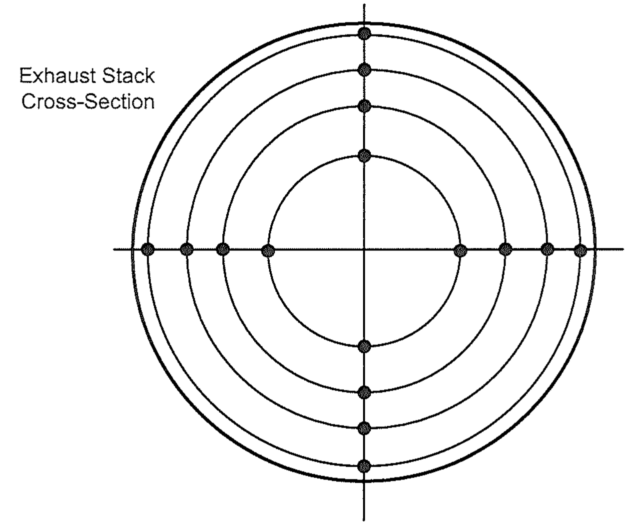
* - calculated value based on 8,760 operating hours per year

APPENDIX 1

- TOX Sample Port Diagram

Impact Compliance Testing, Inc.





Velocity sample locations as measured from stack wall

Pt. #	in.
1	1.8
2	5.9
3	10.9
4	18.0
5	37.9
6	45.1
7	50.1
8	54.2

2/25/22 ALR	**EDL Wood Rd. RNG Facility** **Thermal Oxidizer Exhaust Sample Location**		
	Scale None	Sheet 1 of 1	ICT Dwg No.: EDL-Wood