Source Test Report for 2022 Compliance Emissions Testing

Reciprocal Internal Combustion Engines (EUCHP1 and EUCHP3)

City of Grand Rapids – Water Resource Recovery Facility
Grand Rapids, MI

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MONTROSE AIR QUALITY SERVICES

STAC ACCREDITED TO ASTM D7036 ONLY

Review and Certification

All work, calculations, and other activities and tasks performed and presented in this document were carried out by me or under my direction and supervision. I hereby certify that, to the best of my knowledge, Montrose operated in conformance with the requirements of the Montrose Quality Management System and ASTM D7036-04 during this test project.

Signature:	Todd Wessel	**Date:**	08 / 02 / 2022
Name:	Todd Wessel	**Title:**	Client Project Manager

I have reviewed, technically and editorially, details, calculations, results, conclusions, and other appropriate written materials contained herein. I hereby certify that, to the best of my knowledge, the presented material is authentic, accurate, and conforms to the requirements of the Montrose Quality Management System and ASTM D7036-04.

Signature:	robert j lisy jr	**Date:**	08 / 02 / 2022
Name:	Robert J. Lisy, Jr.	**Title:**	Reporting Hub Manager

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1.0 Introduction

1.1 Summary of Test Program

City of Grand Rapids - Water Resource Recovery Facility (WRRF) (State Registration No.: B1729) contracted Montrose Air Quality Services, LLC (Montrose) to perform a compliance test program on the Reciprocal Internal Combustion Engine (RICE) EUCHP1 and RICE EUCHP3 at the City of Grand Rapids WRRF located in Grand Rapids, Michigan. Testing was performed on June 7, 2022, for the purpose of satisfying the emission testing requirements pursuant to Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit-to-Install (PTI) No. 37-19B and 40 CFR Part 60 Subpart JJJJ.

The specific objectives were to:

- Verify the emissions of nitrogen oxides (NO_X), carbon monoxide (CO), formaldehyde (CH_2O), and non-methane non-ethane organic compounds (NMEOC) at the exhaust stacks serving EUCHP1 and EUCHP3
- Conduct the test program with a focus on safety

Montrose performed the tests to measure the emission parameters listed in Table 1-1.

Table 1-1
Summary of Test Program

Test Date(s)	Unit ID/ Source Name	Activity/Parameters	Test Methods	No. of Runs	Duration (Minutes)
6/7/2022	EUCHP1	Velocity/Volumetric Flow Rate	EPA 1 & 2	3	14-20
6/7/2022	EUCHP1	O_2	EPA 3A	3	60
6/7/2022	EUCHP1	THC	EPA 25A	3	60
6/7/2022	EUCHP1	CO_2, Moisture, NO_X, CO, CH_4, C_2H_6, CH_2O	EPA 320	3	60
6/7/2022	EUCHP3	Velocity/Volumetric Flow Rate	EPA 1 & 2	3	10-13
6/7/2022	EUCHP3	O_2	EPA 3A	3	60
6/7/2022	EUCHP3	THC	EPA 25A	3	60
6/7/2022	EUCHP3	CO_2, Moisture, NO_X, CO, CH_4, C_2H_6, CH_2O	EPA 320	3	60

To simplify this report, a list of Units and Abbreviations is included in Appendix D.1. Throughout this report, chemical nomenclature, acronyms, and reporting units are not defined. Please refer to the list for specific details.

This report presents the test results and supporting data, descriptions of the testing procedures, descriptions of the facility and sampling locations, and a summary of the quality assurance procedures used by Montrose. The average emission test results are summarized

and compared to their respective permit limits in Tables 1-2 and 1-3. Detailed results for individual test runs can be found in Section 4.0. All supporting data can be found in the appendices.

The testing was conducted by the Montrose personnel listed in Table 1-4. The tests were conducted according to the test plan (protocol) dated June 1, 2022 that was submitted to EGLE.

Table 1-2
Summary of Average Compliance Results – EUCHP1

June 7, 2022

Parameter/Units	Average Results	40 CFR Part 60 Subpart JJJJ Emission Limits	PTI 37-19B Emission Limits
Nitrogen Oxides (NO_x)			
ppmvd @ 15% O_2	45	82	--
g/hp-hr	0.52	1.0	0.55
Carbon Monoxide (CO)			
ppmvd @ 15% O_2	4.1	270	--
g/hp-hr	0.029	2.0	0.44
Formaldehyde (CH_2O)			
lb/hr	0.025	--	0.056
Non-Methane/Non-Ethane Organic Compounds, as Propane (NMEOC)*			
ppmvd @ 15% O_2	0.0	60	--
g/hp-hr	0.0	0.7	--
NMEOC (includes CH_2O)*			
g/hp-hr	0.0	--	0.105

* NMEOC concentrations were negative and are assigned a value of zero. See Section 4.2 for details.

Table 1-3
Summary of Average Compliance Results – EUCHP3

June 7, 2022

Parameter/Units	Average Results	40 CFR Part 60 Subpart JJJJ Emission Limits	PTI 37-19B Emission Limits
Nitrogen Oxides (NO_x)			
ppmvd @ 15% O_2	40	82	--
g/hp-hr	0.47	1.0	0.55
Carbon Monoxide (CO)			
ppmvd @ 15% O_2	2.1	270	--
g/hp-hr	0.015	2.0	0.44
Formaldehyde (CH_2O)			
lb/hr	0.022	--	0.056
Non-Methane/Non-Ethane Organic Compounds, as Propane (NMEOC)*			
ppmvd @ 15% O_2	0.0	60	--
g/hp-hr	0.0	0.7	--
NMEOC (includes CH_2O)*			
g/hp-hr	0.0	--	0.105

* NMEOC concentrations were negative and are assigned a value of zero. See Section 4.2 for details.

1.2 Key Personnel

A list of project participants is included below:

Facility Information

Source Location:	City of Grand Rapids – Water Resource Recovery Facility 1300 Market Ave. SW Grand Rapids, MI 49503	
Project Contact:	Todd Williams	William Kaiser
Role:	Industrial Pretreatment Program Inspector	Wastewater Plant Superintendent
Company:	City of Grand Rapids WRRF	City of Grand Rapids WRRF
Telephone:	616-456-3213	616-456-3214
Email:	twilliams@grcity.us	wkaiser@grcity.us

Agency Information

Regulatory Agency:	EGLE
Agency Contact:	Karen Kajiya-Mills
Telephone:	517-335-3122
Email:	Kajiya-millsk@michigan.gov

Testing Company Information

Testing Firm:	Montrose Air Quality Services, LLC	
Contact:	John Nestor	Todd Wessel
Title:	District Manager	Client Project Manager
Telephone:	248-548-8070	248-548-8070
Email:	jonestor@montrose-env.com	twessel@montrose-env.com

Laboratory Information

Laboratory:	Prism Analytical Technologies
City, State:	Mount Pleasant, Michigan
Method:	EPA 320

Test personnel and observers are summarized in Table 1-4.

Table 1-4
Test Personnel and Observers

Name	Affiliation	Role/Responsibility
Todd Wessel	Montrose	Client Project Manager, QI
David Koponen	Montrose	Field Technician
James Carey	Prism	FTIR Analyst
Todd Williams	City of Grand Rapids WRRF	Observer
Trever Drost	EGLE	Observer
Kaitlyn DeVries	EGLE	Observer/Client Liaison/Test Coordinator

2.0 Plant and Sampling Location Descriptions

2.1 Process Description, Operation, and Control Equipment

During the compliance emissions test event the facility operated two combined heat and power RICE engines (EUCHP1 and EUCHP3) manufactured by Jenbacher, each with a nominal rating of 1.411 MW (12.07 MMBTU/hr or 1937 bhp), used for electricity generation and heat for a heat loop for the digestor tanks and incidental building heat. Each engine is equipped with an oxidation catalyst for control of CO, VOC, and CH_2O.

2.2 Flue Gas Sampling Locations

Information regarding the sampling locations is presented in Table 2-1.

Table 2-1
Sampling Locations

Sampling Location	Stack Inside Diameter (in.)	Distance from Nearest Disturbance		Number of Traverse Points
		Downstream EPA "B" (in./dia.)	Upstream EPA "A" (in./dia.)	
EUCHP1 Exhaust Stack	15.0	30.0 / 2.0	12.0 / 0.8	Flow: 16 (8/port) Gaseous: 1
EUCHP3 Exhaust Stack	15.0	30.0 / 2.0	12.0 / 0.8	Flow: 16 (8/port) Gaseous: 1

Sample locations were verified in the field to conform to EPA Method 1. Acceptable cyclonic flow conditions were confirmed prior to testing using EPA Method 1, Section 11.4. See Appendix A.1 for more information.

2.3 Operating Conditions and Process Data

Emission tests were performed while EUCHP1 and EUCHP3 and air pollution control devices were operating at the conditions required by the permit. EUCHP1 and EUCHP3 were tested when operating normally.

Plant personnel were responsible for establishing the test conditions and collecting all applicable unit-operating data. The process data that was provided is presented in Appendix B. Data collected includes the following parameters:

- Natural gas used, scf
- Power generated, kW
- DTE pipeline gas value position, open/closed
- Jenbacher spec sheet

3.0 Sampling and Analytical Procedures

3.1 Test Methods

The test methods for this test program have been presented in Table 1-1. Additional information regarding specific applications or modifications to standard procedures is presented below.

3.1.1 EPA Method 1, Sample and Velocity Traverses for Stationary Sources

EPA Method 1 is used to assure that representative measurements of volumetric flow rate are obtained by dividing the cross-section of the stack or duct into equal areas, and then locating a traverse point within each of the equal areas. Acceptable sample locations must be located at least two stack or duct equivalent diameters downstream from a flow disturbance and one-half equivalent diameter upstream from a flow disturbance.

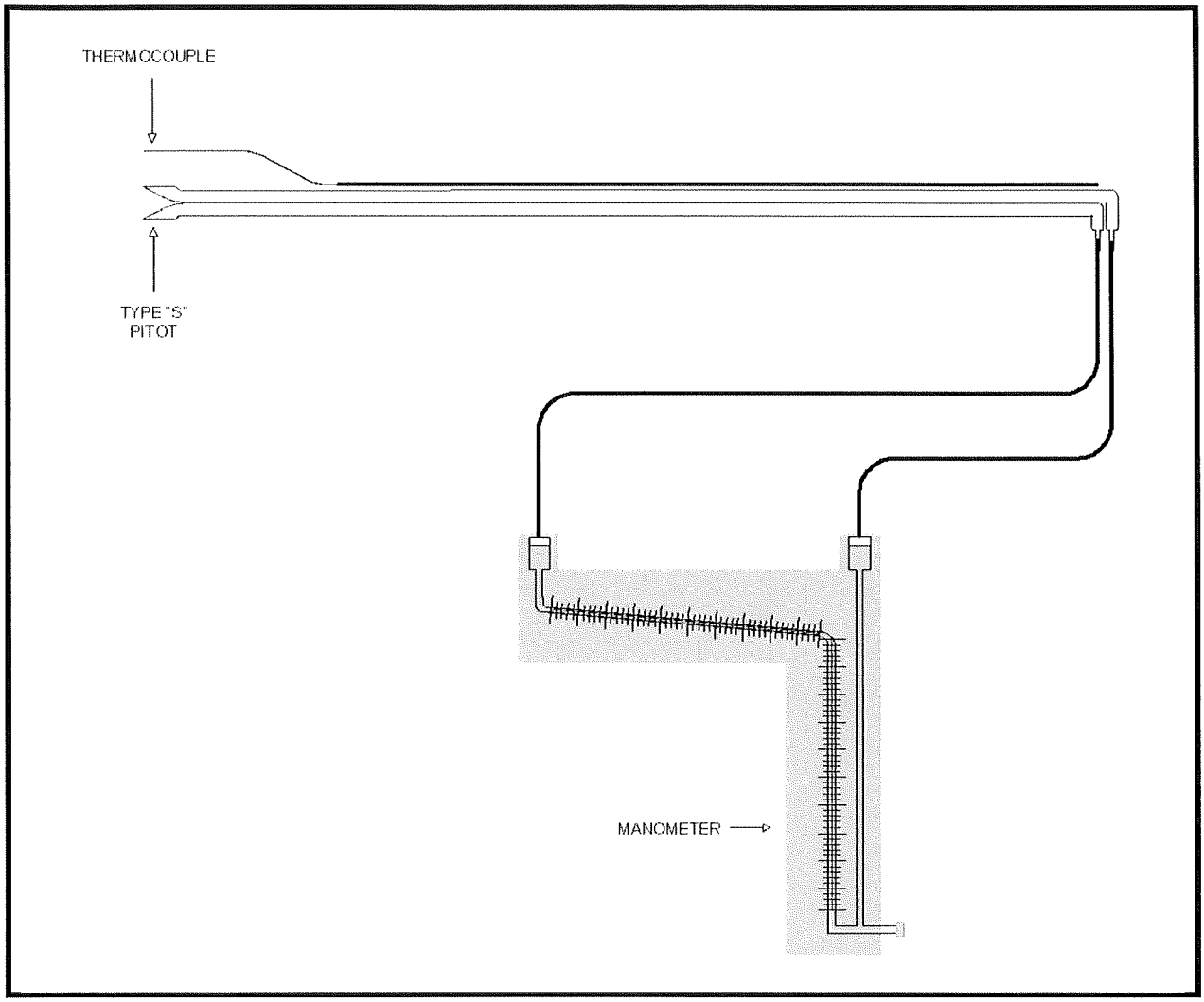
The sample port and traverse point locations are detailed in Appendix A.

3.1.2 EPA Method 2, Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)

EPA Method 2 is used to measure the gas velocity using an S-type pitot tube connected to a pressure measurement device, and to measure the gas temperature using a calibrated thermocouple connected to a thermocouple indicator. Typically, Type S (Staußcheibe) pitot tubes conforming to the geometric specifications in the test method are used, along with an inclined manometer. The measurements are made at traverse points specified by EPA Method 1.

The typical sampling system is detailed in Figure 3-1.

Figure 3-1
EPA Method 2 Sampling Train



3.1.3 EPA Method 3A, Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)

EPA Method 3A is an instrumental test method used to measure the concentration of O_2 and CO_2 in stack gas. The effluent gas is continuously or intermittently sampled and conveyed to analyzers that measure the concentration of O_2 and CO_2. The performance requirements of the method must be met to validate data.

The typical sampling system is detailed in Figure 3-2.

3.1.4 EPA Method 25A, Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer

EPA Method 25A is an instrumental test method used to measure the concentration of THC in stack gas. A gas sample is extracted from the source through a heated sample line and glass fiber filter to a flame ionization analyzer (FIA). Results are reported as volume concentration equivalents of the calibration gas or as carbon equivalents.

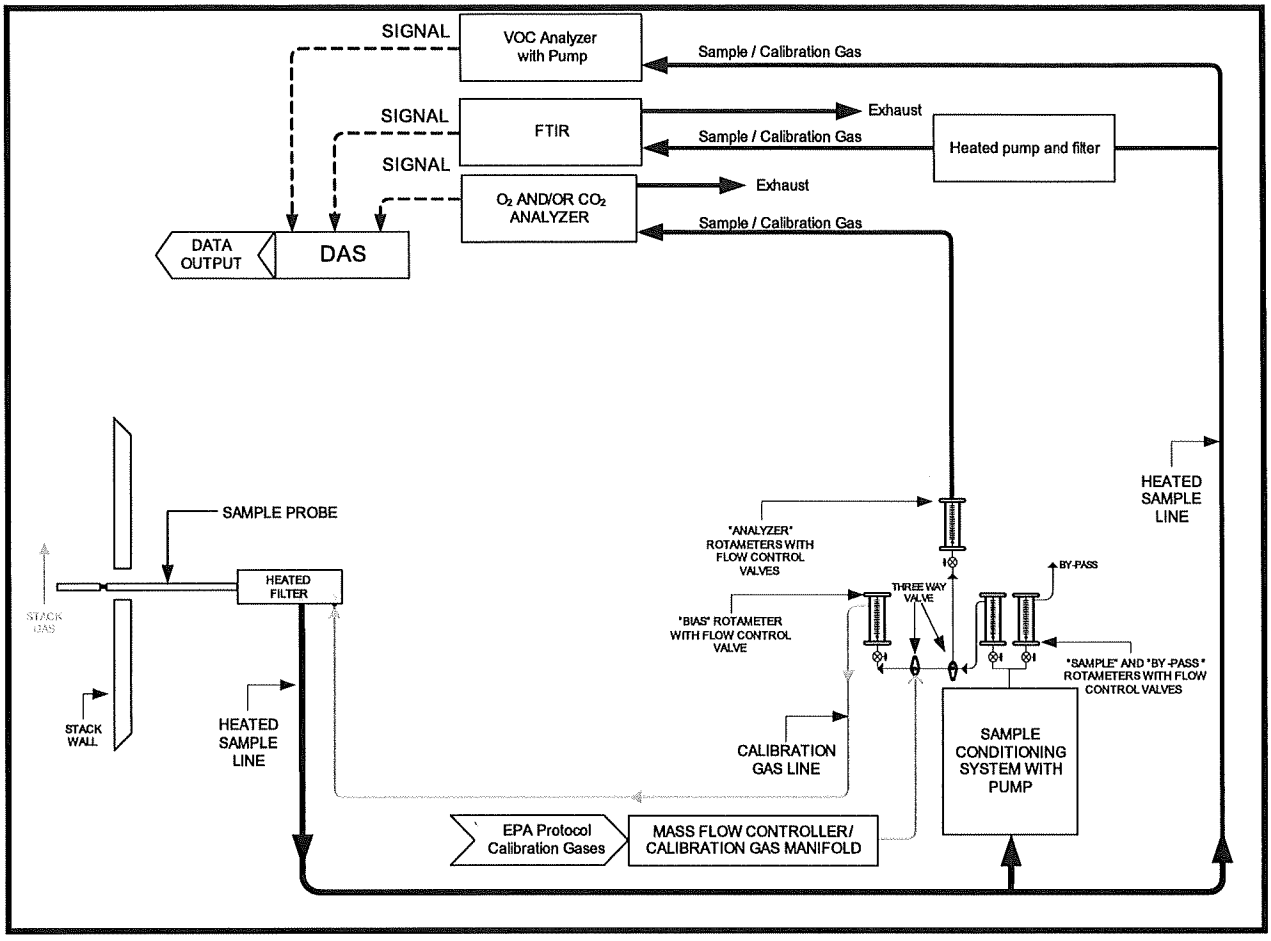
The typical sampling system is detailed in Figure 3-2.

3.1.5 EPA Method 320, Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive FTIR Spectroscopy

EPA Method 320 is an instrumental test method used to measure specific analyte concentrations for which EPA reference spectra have been developed or prepared. Extractive emission measurements are performed using FTIR spectroscopy. The FTIR analyzer is composed of a spectrometer and detector, a high optical throughput sampling cell, analysis software, and a quantitative spectral library. The analyzer collects high resolution spectra in the mid infrared spectral region (400 to 4,000 cm-1), which are analyzed using the quantitative spectral library. This provides an accurate, highly sensitive measurement of gases and vapors.

The typical sampling system is detailed in Figure 3-2.

Figure 3-2
EPA Method 3A (O_2), 25A, and 320 (CO_2, NO_x, CO, and CH_2O)



3.2 Process Test Methods

The test plan did not require that process samples be collected during this test program; therefore, no process sample data are presented in this test report.

4.0 Test Discussion and Results

4.1 Field Test Deviations and Exceptions

No field deviations or exceptions from the test plan or test methods occurred during this test program.

4.2 Presentation of Results

The average results are compared to the permit limits in Tables 1-2 and 1-3. The results of individual compliance test runs performed are presented in Tables 4-1 and 4-2. Emissions are reported in units consistent with those in the applicable regulations or requirements. Additional information is included in the appendices as presented in the Table of Contents.

The CH_4/C_2H_6 correction of THC concentration values measured at the EUCHP1 and EUCHP3 exhaust stacks resulted in negative values. As a result, the CH_4/C_2H_6-corrected THC (NMEOC) displayed in Tables 1-2, 1-3, 4-1, and 4-2 have been assigned a value of zero.

Table 4-1
NO_X, CO, CH_2O, and NMEOC Emissions Results – EUCHP1

Parameter/Units	Run 1	Run 2	Run 3	Average
Date	6/7/2022	6/7/2022	6/7/2022	--
Time	13:25-14:25	14:38-15:38	15:55-16:55	--
Process Data*				
Brake HP, bhp	1,744.8	1,743.5	1,744.8	1,744.4
Sampling & Flue Gas Parameters				
O_2, % volume dry	10.2	10.2	10.3	10.2
CO_2, % volume dry	6.04	6.02	6.00	6.02
flue gas temperature, °F	732.3	737.1	737.6	735.7
moisture content, % volume	11.3	11.2	11.1	11.2
volumetric flow rate, dscfm	3,426	3,337	3,364	3,375
Nitrogen Oxides (NO_X)				
ppmvd	81.11	81.95	83.23	82.10
ppmvd @ 15% O_2	44.76	45.22	45.93	45.30
lb/hr (as NO_2)	1.99	1.96	2.01	1.99
g/bhp-hr	0.52	0.51	0.52	0.52
Carbon Monoxide (CO)				
ppmvd	7.45	7.45	7.50	7.47
ppmvd @ 15% O_2	4.11	4.13	4.16	4.13
lb/hr	0.11	0.11	0.11	0.11
g/bhp-hr	0.029	0.028	0.029	0.029
Formaldehyde (CH_2O)				
ppmvd	1.60	1.62	1.62	1.61
ppmvd @ 15% O_2	0.88	0.89	0.89	0.89
lb/hr	0.026	0.025	0.025	0.025
g/bhp-hr	0.00667	0.00658	0.00662	0.00662
Total Hydrocarbon (THC)				
ppmvd, as propane	424.6	426.3	426.6	425.8
Methane (CH_4)				
ppmvd	1,096	1,092	1,089	1,092
ppmvd, as propane†	456.8	455.0	453.7	455.2

Parameter/Units	Run 1	Run 2	Run 3	Average
Ethane (C_2H_6)				
ppmvd	60.48	60.81	61.05	60.78
ppmvd, as propane†	40.32	40.54	40.70	40.52
Non-methane/Non-Ethane Organic Compounds (NMEOC) ‡				
ppmvd	0.0	0.0	0.0	0.0
ppmvd @ 15% O_2	0.0	0.0	0.0	0.0
lb/hr	0.0	0.0	0.0	0.0
g/bhp-hr	0.0	0.0	0.0	0.0
g/bhp-hr (includes CH_2O)	0.0	0.0	0.0	0.0

* Process data provided by City of Grand Rapids – Water Resource Recovery Facility personnel.

† Concentrations are determined by the pollutant / propane response factor.

‡ NMEOC concentrations were negative and are assigned a value of zero.

Table 4-2
NO_X, CO, CH_2O, and NMEOC Emissions Results – EUCHP3

Parameter/Units	Run 1	Run 2	Run 3	Average
Date	6/7/2022	6/7/2022	6/7/2022	--
Time	8:37-9:37	9:51-10:51	11:05-12:05	--
Process Data				
Brake HP, bhp	1746.2	1743.5	1743.5	1744.4
Sampling & Flue Gas Parameters				
O_2, % volume dry	10.34	10.33	10.33	10.33
CO_2, % volume dry	5.96	5.97	5.96	5.96
flue gas temperature, °F	740.9	754.0	767.5	754.1
moisture content, % volume	11.2	11.2	11.2	11.2
volumetric flow rate, dscfm	3,404	3,468	3,482	3,452
Nitrogen Oxides (NO_X)				
ppmvd	71.85	72.75	72.85	72.48
ppmvd @ 15% O_2	40.12	40.63	40.69	40.48
lb/hr (as NO_2)	1.75	1.81	1.82	1.79
g/bhp-hr	0.46	0.47	0.47	0.47
Carbon Monoxide (CO)				
ppmvd	3.72	3.75	3.80	3.76
ppmvd @ 15% O_2	2.08	2.09	2.12	2.10
lb/hr	0.055	0.057	0.058	0.057
g/bhp-hr	0.0143	0.0148	0.0150	0.0147
Formaldehyde (CH_2O)				
ppmvd	1.30	1.32	1.39	1.33
ppmvd @ 15% O_2	0.72	0.74	0.77	0.74
lb/hr	0.021	0.021	0.023	0.022
g/bhp-hr	0.0054	0.0056	0.0059	0.0056
Total Hydrocarbon (THC)				
ppmvd, as propane	461.40	457.37	457.42	458.73
Methane (CH_4)				
ppmvd	1,169.7	1,169.4	1,167.3	1,168.8
ppmvd, as propane†	487.4	487.3	486.4	487.0

Parameter/Units	Run 1	Run 2	Run 3	Average
Ethane (C_2H_6)				
ppmvd	66.03	65.99	65.88	65.97
ppmvd, as propane†	44.02	43.99	43.92	43.98
Non-methane/Non-Ethane Organic Compounds (NMEOC) ‡				
ppmvd	0.0	0.0	0.0	0.0
ppmvd @ 15% O_2	0.0	0.0	0.0	0.0
lb/hr	0.0	0.0	0.0	0.0
g/bhp-hr	0.0	0.0	0.0	0.0
g/bhp-hr (includes CH_2O)	0.0	0.0	0.0	0.0

* Process data provided by City of Grand Rapids – Water Resource Recovery Facility personnel.

† Concentrations are determined by the pollutant / propane response factor.

‡ NMEOC concentrations were negative and are assigned a value of zero.

5.0 Internal QA/QC Activities

5.1 QA/QC Audits

EPA Method 3A calibration audits were all within the measurement system performance specifications for the calibration drift checks, system calibration bias checks, and calibration error checks.

EPA Method 25A FIA calibration audits were within the measurement system performance specifications for the calibration drift checks and calibration error checks.

An EPA Method 205 field evaluation of the calibration gas dilution system was conducted. The dilution accuracy and precision QA specifications were met.

The EPA Method 320 performance parameters measured included signal to noise tests, noise equivalent absorbance (NEA), detector linearity, background spectra, potential interferents, and cell and system leakage. Quality assurance procedures included baseline measurement with ultra-high purity nitrogen, measurement of a calibration transfer standard (~100 ppm ethylene), direct analyte calibration measurements, and measurements to determine baseline shift. SF_6 was also used as a tracer gas in the calibration gases to evaluate dilution ratios and verify the sample delivery system integrity. A dynamic matrix spike was performed using SF_6 as a tracer gas. The method QA/QC criteria were met.

5.2 QA/QC Discussion

All QA/QC criteria were met during this test program.

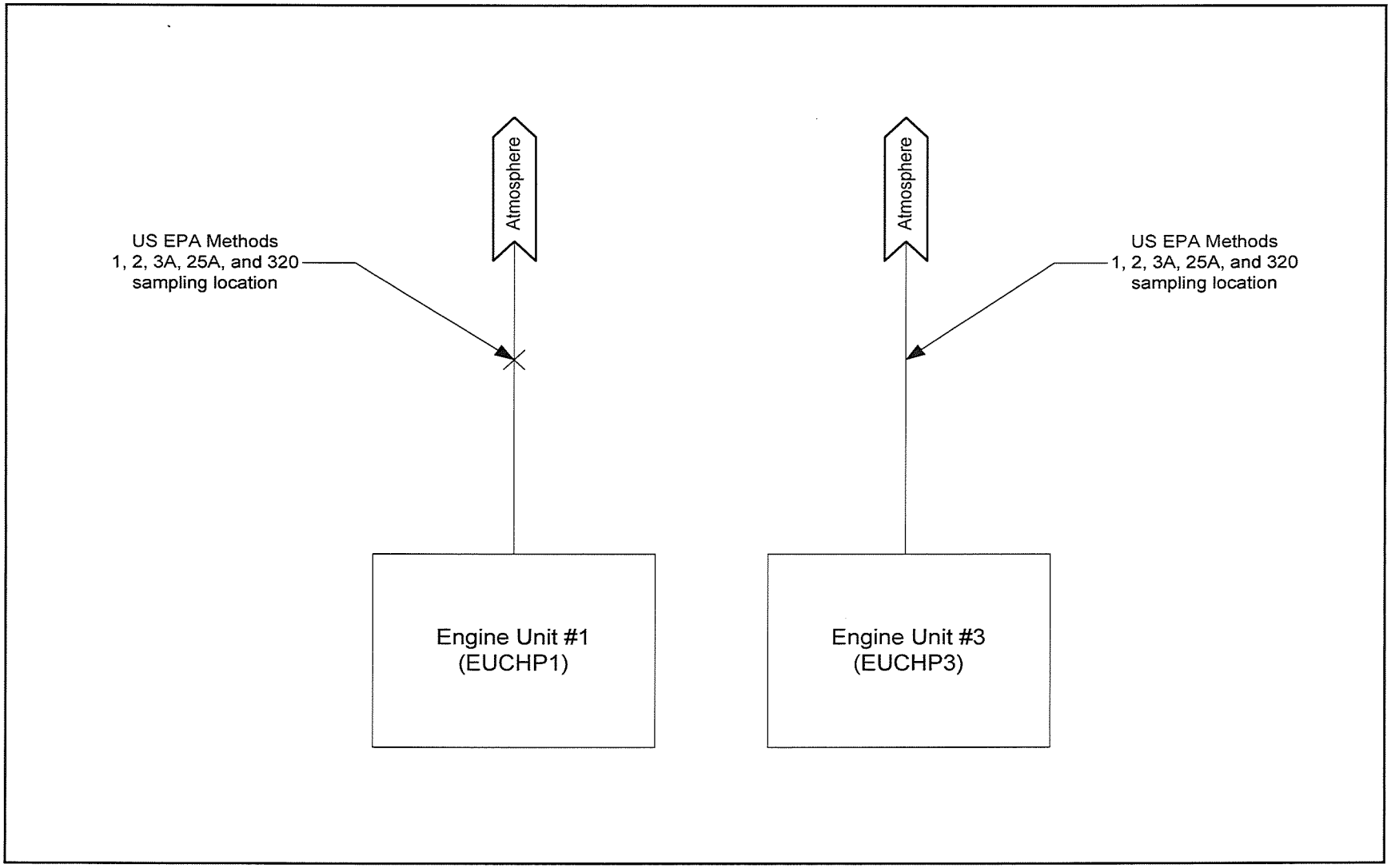
5.3 Quality Statement

Montrose is qualified to conduct this test program and has established a quality management system that led to accreditation with ASTM Standard D7036-04 (Standard Practice for Competence of Air Emission Testing Bodies). Montrose participates in annual functional assessments for conformance with D7036-04 which are conducted by the American Association for Laboratory Accreditation (A2LA). All testing performed by Montrose is supervised on site by at least one Qualified Individual (QI) as defined in D7036-04 Section 8.3.2. Data quality objectives for estimating measurement uncertainty within the documented limits in the test methods are met by using approved test protocols for each project as defined in D7036-04 Sections 7.2.1 and 12.10. Additional quality assurance information is included in the report appendices. The content of this report is modeled after the EPA Emission Measurement Center Guideline Document (GD-043).

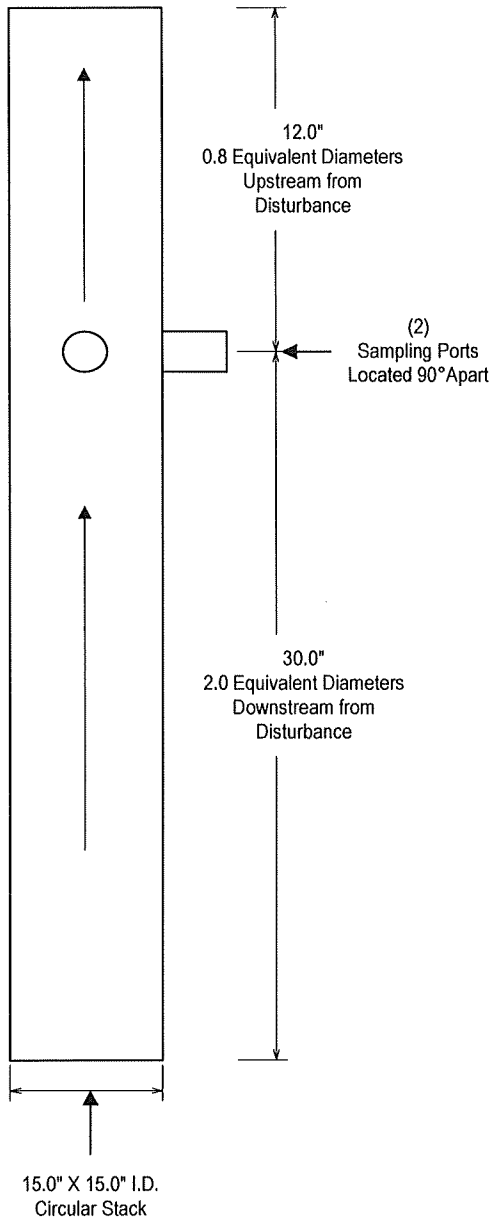
Appendix A
Field Data and Calculations

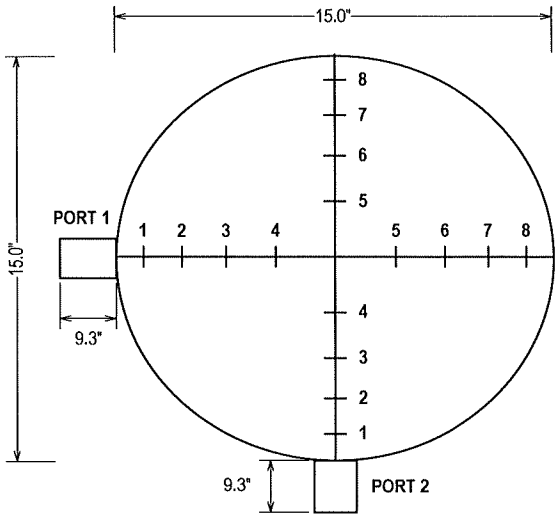
Appendix A.1
Sampling Locations

EUCHP1 AND EUCHP3 PROCESS AND SAMPLING LOCATION SCHEMATIC



EUCHP1 EXHAUST TRAVERSE POINT LOCATION DRAWING

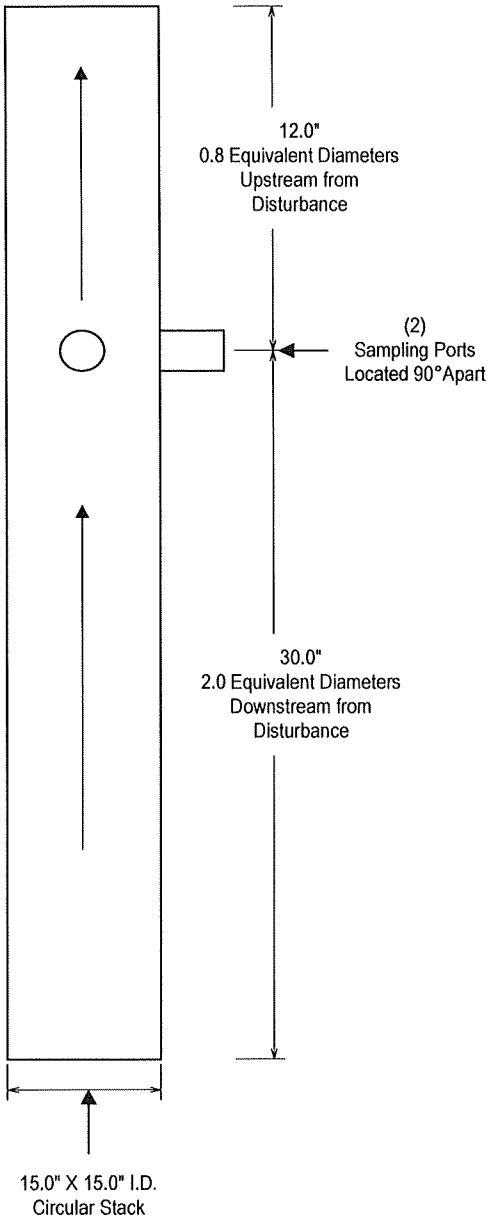


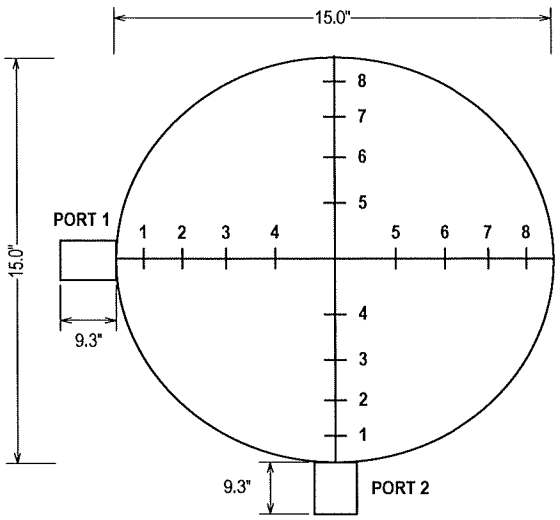


Point	% of Stack Depth	Distance from Inside Wall (in.) PORT 1	Distance from Inside Wall (in.) PORT 2
1*	3.2	0.5	0.5
2	10.5	1.6	1.6
3	19.4	2.9	2.9
4	32.3	4.8	4.8
5	67.7	10.2	10.2
6	80.6	12.1	12.1
7	89.5	13.4	13.4
8*	96.8	14.5	14.5

* Points adjusted per US EPA Method 1, Section 11.1.3.4

EUCHP3 EXHAUST TRAVERSE POINT LOCATION DRAWING





Point	% of Stack Depth	Distance from Inside Wall (in.) PORT 1	Distance from Inside Wall (in.) PORT 2
1*	3.2	0.5	0.5
2	10.5	1.6	1.6
3	19.4	2.9	2.9
4	32.3	4.8	4.8
5	67.7	10.2	10.2
6	80.6	12.1	12.1
7	89.5	13.4	13.4
8*	96.8	14.5	14.5

* Points adjusted per US EPA Method 1, Section 11.1.3.4

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Appendix A.2
EUCHP1 Data Sheets

TEST DATA

Number of Test Runs	3			
Traverse Points	16			
	Run 1	**Run 2**	**Run 3**	**Average**
Stack Cross-Sectional Diameter 1 **(circular)** (in)	15.0	15.0	15.0	15.0
Stack Cross-Sectional Diameter 2 **(circular)** (in)	15.0	15.0	15.0	15.0
Pitot Tube Coefficient (Cp)	0.84	0.84	0.84	0.84
Barometric Pressure at Ground Level (Pbar) (in Hg)	29.84	29.84	29.84	29.84
Elevation Difference Between Ground Level and Meter Box Locations (ft)	0	0	0	0
Elevation Difference Between Ground Level and Sampling Locations (ft)	37	37	37	37
Percent by Volume Moisture as Measured in Stack Gas (%H2O)	11.29	11.17	11.07	11.18
Air Percent by Volume Oxygen in Stack Gas (%-dry)	10.21	10.24	10.26	10.24
Air Percent by Volume Carbon Dioxide in Stack Gas (%-dry)	6.04	6.02	6.00	6.02
Air Percent by Volume Nitrogen in Stack Gas (%-dry)	**83.75**	**83.74**	**83.73**	83.74
Average Pitot Rotation Angle	1.4			
Brake Horsepower (bhp)	1744.8	1743.5	1744.8	1744.4
Test Run Start Time (hrmin)	6/7/2022 13:25	6/7/2022 14:38	6/7/2022 15:55	
Test Run Stop Time (hrmin)	6/7/2022 14:25	6/7/2022 15:38	6/7/2022 16:55	

DETAILED RESULTS

Stack Gas Conditions	**Run 1**	**Run 2**	**Run 3**	**Average**
Stack Cross-Sectional Area (A) (ft2)	1.23	1.23	1.23	1.23
Barometric Pressure at Sampling Location (in Hg)	29.80	29.80	29.80	29.80
Dry Molecular Weight of Stack Gas (Md) (lb/lb-mole)	29.38	29.37	29.37	29.37
Wet Molecular Weight of Stack Gas (Ms) (lb/lb-mole)	28.09	28.10	28.11	28.10
Average Absolute Stack Gas Pressure (Ps) (in Hg)	29.68	29.68	29.68	29.68
Average Stack Gas Static Pressure (ps) (in H2O)	-1.70	-1.70	-1.70	-1.70
Average Stack Gas Temperature (ts) (°F)	732.3	737.1	737.6	735.7
Average Stack Gas Temperature (Ts) (°R)	1,192.3	1,197.1	1,197.6	1,195.7
Average Stack Gas Velocity (Vs) (ft/sec)	119.48	116.69	117.54	117.90
Average Stack Gas Velocity (Vs) (ft/min)	7,169	7,001	7,052	7,074
Wet Volumetric Stack Gas Flow at Actual Conditions (Qaw) (acfm)	8,797	8,592	8,654	8,681
Wet Volumetric Stack Gas Flow at Standard Conditions (scfm)	3,862	3,757	3,782	3,800
Dry Volumetric Stack Gas Flow at Standard Conditions (Qstd) (dscfm)	3,426	3,337	3,364	3,375
Percent by Volume Moisture as measured in Stack Gas (%H2O)	11.29	11.17	11.07	11.18

	Run 1	**Run 2**	**Run 3**	**Average**
Dry Mole Fraction of Flue Gas (Mfd)	0.887	0.888	0.889	0.888
Average Velocity Pressure (Delta P) (in H2O)	1.96	1.86	1.88	1.90
Average Square Root of Delta P	1.39	1.36	1.37	1.37

MEASURED DATA FROM TEST RUNS

Point Count	Run #	Pitot Delta P (in H2O)	Square Root of Delta P	Stack Pressure (in H2O)	Stack Temp (°F)
1	1	1.70	1.304	-1.7	736
2	1	1.80	1.342		737
3	1	1.90	1.378		738
4	1	2.30	1.517		740
5	1	2.30	1.517		739
6	1	1.90	1.378		737
7	1	1.80	1.342		720
8	1	1.70	1.304		720
9	1	1.70	1.304		741
10	1	1.80	1.342		742
11	1	2.30	1.517		743
12	1	2.80	1.673		744
13	1	2.80	1.673		744
14	1	1.70	1.304		736
15	1	1.40	1.183		700
16	1	1.40	1.183		700
17	2	1.70	1.304	-1.7	742
18	2	1.90	1.378		742
19	2	2.10	1.449		742
20	2	2.30	1.517		743
21	2	1.70	1.304		737
22	2	1.40	1.183		737
23	2	1.30	1.140		725
24	2	1.20	1.095		725
25	2	1.70	1.304		742
26	2	1.90	1.378		742
27	2	1.90	1.378		742
28	2	2.00	1.414		743
29	2	2.50	1.581		741
30	2	2.20	1.483		730
31	2	2.00	1.414		730
32	2	1.90	1.378		730
33	3	1.70	1.304	-1.7	742
34	3	1.90	1.378		741
35	3	2.10	1.449		742
36	3	2.40	1.549		743
37	3	1.90	1.378		741
38	3	1.60	1.265		741
39	3	1.50	1.225		730
40	3	1.40	1.183		730
41	3	1.80	1.342		740
42	3	1.90	1.378		740
43	3	2.00	1.414		741
44	3	2.30	1.517		741
45	3	2.35	1.533		740
46	3	2.00	1.414		730
47	3	1.70	1.304		730
48	3	1.50	1.225		730

TEST DATA - EPA Method 3A (O_2)

Number of Concentration Runs: 3

Analyzer Calibration

	Run 1	Run 2	Run 3	Average
Actual Concentration of the Mid-Level Calibration Gas (%)	10.19	10.19	10.19	10.190
Actual Concentration of the High-Level Calibration Gas (%)	20.00	20.00	20.00	20.00
Analyzer Span During Test Run (%)	20.00	20.00	20.00	20.00
Calibration Gas QA	**GOOD**	**GOOD**	**GOOD**	
Analyzer Calibration Response for Zero Gas (%)	0.02	0.02	0.02	0.02
Analyzer Calibration Response for Mid-Level Gas (%)	10.23	10.23	10.23	10.23
Analyzer Calibration Response for High Level Gas (%)	20.07	20.07	20.07	20.07
Initial System Calibration Response for Zero Gas (%)	0.02	0.03	0.03	0.03
Initial System Calibration Response for Upscale Gas (%)	10.22	10.24	10.24	10.23
Final System Calibration Response for Zero Gas (%)	0.03	0.03	0.03	0.03
Final System Calibration Response for Upscale Gas (%)	10.24	10.24	10.24	10.24

Analyzer Calibration QA

	Run 1	Run 2	Run 3	Average
Initial System Calibration Bias for Zero Gas (% of Span)	0.03	0.10	0.06	0.06
Initial System Calibration Bias for Upscale Gas (% of Span)	-0.05	0.02	0.01	-0.01
Final System Calibration Bias for Zero Gas (% of Span)	0.10	0.06	0.08	0.08
Final System Calibration Bias for Upscale Gas (% of Span)	0.02	0.01	0.05	0.03
System Drift for Zero Gas (% of Span)	0.07	-0.03	0.02	0.02
System Drift for Upscale Gas (% of Span)	0.07	-0.02	0.04	0.03
Analyzer Calibration Error for Zero Gas (% of Span)	0.08	0.08	0.08	0.08
Analyzer Calibration Error for Mid-Level Gas (% of Span)	0.22	0.22	0.22	0.22
Analyzer Calibration Error for High-Level Gas (% of Span)	0.33	0.33	0.33	0.33

CONCENTRATION CALCULATIONS - DRY SYSTEM

Calculate the Average Effluent Oxygen O_2 Concentration

	Run 1	Run 2	Run 3	Average
Average O_2 Concentration Indicated by Gas Analyzer, dry basis (%-dry)	10.25	10.29	10.31	10.28
Average of Initial and Final System Calibration Bias Check Responses for the Zero Gas (%)	0.027	0.031	0.029	0.029
Average of Initial and Final System Calibration Bias Check Responses for the Upscale Calibration Gas (%)	10.232	10.237	10.240	10.236
Average Effluent O_2 Concentration, dry basis (%-dry)	10.208	10.241	10.262	10.237

TEST DATA - EPA Method 25A

Number of Concentration Runs: 3

Analyzer Calibration

	Run 1	Run 2	Run 3	Average
Actual Concentration of the Low-Level Calibration Gas (ppmv)	300.00	300.00	300.00	300.00
Actual Concentration of the Mid-Level Calibration Gas (ppmv)	500.00	500.00	500.00	500.00
Actual Concentration of the High-Level Calibration Gas (ppmv)	850.00	850.00	850.00	850.00
Analyzer Span During Test Run (ppmv)	1000.00	1000.00	1000.00	1000.00
Calibration Gas QA	**GOOD**	**GOOD**	**GOOD**	
Average Effluent TGO Concentration at MDL (ppmvw)	20.00	20.00	20.00	20.00
Initial Analyzer Calibration Response for Zero Gas (ppmv)	0.22	0.22	0.22	0.22
Initial Analyzer Calibration Response for Low-Level Gas (ppmv)	299.87	299.87	299.87	299.87
Initial Analyzer Calibration Response for Mid-Level Gas (ppmv)	498.49	498.49	498.49	498.49
Initial Analyzer Calibration Response for High Level Gas (ppmv)	851.37	851.37	851.37	851.37
Initial Analyzer Calibration Response for Zero Gas (ppm)	0.36	0.37	0.19	0.31
Inital Analyzer Calibration Response for Mid-Level Gas (ppm)	499.63	494.94	499.25	497.94
Final Analyzer Calibration Response for Zero Gas (ppm)	0.37	0.19	0.16	0.24
Final Analyzer Calibration Response for Mid-Level Gas (ppm)	494.94	499.25	499.77	497.99

Analyzer Calibration QA

	Run 1	Run 2	Run 3	Average
Analyzer Span During Test Run (ppmv as Carbon)	3000	3000	3000	3000
Zero Drift (% of Span)	0.00	-0.02	0.00	-0.01
Calibration Drift for Mid-Level Cal. Gas (% of Span)	-0.47	0.43	0.05	0.00
Calibration Error for Low-Level Gas (% of Cal. Gas Tag Value)	0.04	0.04	0.04	0.04
Calibration Error for Mid-Level Gas (% of Cal. Gas Tag Value)	0.30	0.30	0.30	0.30

DETAILED RESULTS

Emission Results

	Run 1	Run 2	Run 3	Average
Average THC Mass Emission Rate as Propane, (lb/hr)	10.0	9.8	9.9	9.9
Average THC Mass Emission Rate as Propane, (g/bhp-hr, dry)	2.60	2.54	2.56	2.57
NMEOC Mass Emission Rate as Propane, (lb/hr)	-1.7	-1.6	-1.6	-1.62
NMEOC Mass Emission Rate as Propane, (g/bhp-hr, dry)	-0.44	-0.41	-0.41	-0.42

CONCENTRATION CALCULATIONS

Average Effluent Total Hydrocarbons (THC) Concentration	Run 1	Run 2	Run 3	Average
Cmeas = Average Organic Concentration as Measured by Gas Analyzer (ppmvw as propane)	374.67	376.58	379.02	376.76
Average of Initial and Final System Calibration Bias Check Responses for the Zero Gas (ppmv)	0.36	0.28	0.18	0.27
Average of Initial and Final System Calibration Bias Check Responses for the Upscale Calibration Gas (ppmv)	497.28	497.09	499.51	497.96
Corrected Total Hydrocarbons Dry Concentration Measured as Propane (ppmvw as propane)	376.63	378.71	379.35	378.23
Corrected Total Hydrocarbons Dry Concentration Measured as Propane (ppmvd as propane)	424.56	426.33	426.57	425.82

Methane Corrections	Run 1	Run 2	Run 3	Average
ENTER METHANE CONCENTRATION FROM FTIR (ppmvd as methane)	1096.25	1092.09	1088.78	1092.37
Methane:Propane Response Factor	2.40	2.40	2.40	2.40
Corrected Methane Concentration (ppmvd as propane)	456.77	455.04	453.66	455.15

Ethane Corrections	Run 1	Run 2	Run 3	Average
ENTER ETHANE CONCENTRATION FROM FTIR (ppmvd as ethane)	60.48	60.81	61.05	60.78
Ethane:Propane Response Factor	1.50	1.50	1.50	1.50
Corrected Ethane Concentration (ppmvd as propane)	40.32	40.54	40.70	40.52
Methane/Ethane Corrected TGO Concentration (ppmvd as propane)	**-72.53**	**-69.24**	**-67.79**	-69.85

Oxygen Corrected Total Hydrocarbons Concentration	Run 1	Run 2	Run 3	Average
Correction for Oxygen (Enter % Oxygen)	15.0	15.0	15.0	15.0
Average Effluent THC Concentration Corrected to 15% Oxygen (ppmvd as propane)	234.3	236.0	236.6	235.6
Average Effluent NMEOC Concentration Corrected to 15% Oxygen (ppmvd as propane)	-40.0	-38.3	-37.6	-38.6

Maximum Effluent Total Hydrocarbons (THC) Concentration	Run 1	Run 2	Run 3	Average
Cmeas = Maximum Organic Concentration as Measured by Gas Analyzer, wet basis (ppmv as Propane)	380.75	384.54	384.87	383.39

TEST DATA - EPA Method 320

Testing Data

Number of Concentration Runs: 3

EMISSIONS	Run 1	Run 2	Run 3	Average
Carbon Monoxide Emissions (lb/hr)	0.111	0.108	0.110	0.110
Nitrogen Oxides Emissions (lb/hr)	1.991	1.959	2.006	1.985
Formaldehyde Emissions (lb/hr)	0.026	0.025	0.025	0.025
Carbon Monoxide Emissions (g/bhp-hr, dry)	0.029	0.028	0.029	0.029
Nitrogen Oxides Emissions (g/bhp-hr, dry)	0.517	0.510	0.521	0.516
Formaldehyde Emissions (g/bhp-hr, dry)	0.0067	0.0066	0.0066	0.0066

CONCENTRATIONS	Run 1	Run 2	Run 3	Average
Moisture Content (%)	11.29	11.17	11.07	11.2
Carbon Dioxide Concentration (%-Wet)	5.36	5.35	5.34	5.4
Carbon Monoxide Concentration (ppmvw)	6.61	6.62	6.67	6.6
Nitrogen Oxides Concentration (ppmvw)	71.95	72.80	74.02	72.9
Methane Concentration (ppmvw)	972.48	970.10	968.25	970.3
Ethane Concentration (ppmvw)	53.65	54.02	54.29	54.0
Formaldehyde Concentration (ppmvw)	1.42	1.44	1.44	1.43
Carbon Dioxide Concentration (%-Dry)	6.04	6.02	6.00	6.02
Carbon Monoxide Concentration (ppmvd)	7.45	7.45	7.50	7.47
Nitrogen Oxides Concentration (ppmvd)	81.1	82.0	83.2	82.1
Methane (ppmvd)	1096.2	1092.1	1088.8	1092.4
Ethane (ppmvd)	60.5	60.8	61.0	60.8
Formaldehyde (ppmvd)	1.601	1.621	1.619	1.614

MOLECULAR WEIGHTS	Run 1	Run 2	Run 3	Average
Carbon Monoxide (g/g-mole)	28.01	28.01	28.01	28.01
Nitrogen Oxides (g/g-mole)	46.01	46.01	46.01	46.01
Methane (g/g-mole)	16.04	16.04	16.04	16.04
Ethane (g/g-mole)	30.07	30.07	30.07	30.07
Formaldehyde (g/g-mole)	30.031	30.031	30.031	30.031

OXYGEN CORRECTED CONCENTRATIONS	Run 1	Run 2	Run 3	Average
Correction for Oxygen (Enter % Oxygen)	15.00	15.00	15.00	15.00
Average Effluent CO Concentration Corrected to 15% Oxygen (ppmvd)	4.11	4.13	4.16	4.13
Average Effluent NO_X Concentration Corrected to 15% Oxygen (ppmvd)	44.76	45.22	45.93	45.30
Average Effluent CH_2O Concentration Corrected to 15% Oxygen (ppmvd)	0.88	0.89	0.89	0.89

US EPA Method 1 Traverse Point Determination

Relative Port Location	1.0	2.0
From Far Wall to Outside of Port (in.)	24.25	24.25
Nipple Length or Wall Thickness (in.)	9.25	9.25
Port Protrusion Length (opt) (in.)	0.00	0.00
Depth of Stack or Duct (in.)	15.00	15.00
Stack or Duct Type	Circular	
Port Hole Inner Diameter (in.)		
Stack or Duct Width (If Rectangular) (in.)		
Stack Outer Circumference (in.)		
Number of Ports Traversed	2	
Elevation of Meter Box from Sea Level (ft)	607	
Elevation of Ports from Sea Level (ft)	637	
Stack Build-up (in.)	0.0	
Stack Cross-Sectional Diameter 1 (in)	15.0	
Stack Cross-Sectional Diameter 2 (in)	15.0	

Note:

Add nipple protrusion length to Point 1 only.
Actual nipple length = (length - protrusion)

Relocate to a distance equal to the inside diameter of the nozzle being used or to the above minimum distances, whichever is larger.

This Stack having a diameter of less than or equal to 24-inches shall have not traverse points located within 0.5-inches of the stack wall.

'Pt. Adj.' denotes that the traverse point has been adjusted to 0.5-inch from the stack wall.

"Vertical" or "Horizontal" Flow	Vertical
Direction of Flow	Up
"Velocity" or "Isokinetic" Traverse	Velocity

Port Distance Upstream from Flow Disturbance (in.)	12.0
Diameters Upstream from Flow Disturbance (³ 0.5 De)	0.8
Minimum Traverse Points Needed for a Velocity Traverse *	16
Minimum Traverse Points Needed for a Isokinetic Traverse *	24

Port Distance Downstream from Flow Disturbance (in.)	30.0
Diameters Downstream from Flow Disturbance (³ 2.0 De)	2.0
Minimum Traverse Points Needed for a Velocity Traverse *	16
Minimum Traverse Points Needed for a Isokinetic Traverse *	24

Minimum Traverse Points per Method 1	16
Number of Traverse Points for this Circular Stack or Duct	16
Point Overide	
Duct Area - in^2	176.71
Duct Area - ft^2	1.2272

New Method 1 verified on 6/7/2022 by: TW

	Port	Point	% of Duct Depth	Dist. From Inside Wall (Decimal)	Dist. From Outside Wall (Decimal)
Pt. Adj	1	1	3.2	0.5	9.8
	1	2	10.5	1.6	10.8
	1	3	19.4	2.9	12.2
	1	4	32.3	4.8	14.1
	1	5	67.7	10.2	19.4
	1	6	80.6	12.1	21.3
	1	7	89.5	13.4	22.7
Pt. Adj	1	8	96.8	14.5	23.8
Pt. Adj	2	1	3.2	0.5	9.8
	2	2	10.5	1.6	10.8
	2	3	19.4	2.9	12.2
	2	4	32.3	4.8	14.1
	2	5	67.7	10.2	19.4
	2	6	80.6	12.1	21.3
	2	7	89.5	13.4	22.7
Pt. Adj	2	8	96.8	14.5	23.8

MAQS

USEPA METHOD 2 GAS VELOCITY TRAVERSE
AND VOLUMETRIC FLOWRATE DATA SHEET

Client GRWRR
Sampling Location Unit #1
Run Number: 1
Date 6/7/22 Time 13:30 - 13:50
Port and Stack 24.25 in.
Port 9.25 in.
Nipple Protrusion 0 in.
Stack Diameter 15 in.
Bar. Pressure 29.64 in Hg
Static Pressure -1.7 in H_2O
Moisture % 11.2
% CO2 5.37 % CO 0
% O2 10.2 % N2 84.43

Stack Diagram

Weather conditions:

Operators TW DK Manometer ID: MB12
Pitot Tube number 6'C Umbilical ID: #7
Pitot Tube factor, Cp 0.84 Pitot Line ID: 1A
Site Elevation 607 ft. Upstream 12 in.
Port Height 30 ft. Downstream 30 in.
Leak Check- Positive: Pre: ☑ @ 7 Post: ☑ @ 6.5 Negative: Pre: ☐ @ 8 Post: ☑ @ 7

% of Stack Diameter	Point Distance (in.)	Traverse Point Number	Velocity Head (ΔP) in H2O	Stack Temp °F	Null Angle (zero ΔP angle)	Flow Angle Ø (90° from null angle)
		1	1.7	736		
		2	1.8	737		
		3	1.9	738		
		4	2.3	740		
		5	2.3	739		
		6	1.9	737		
		7	1.8	720		
		8	1.7	700		
		1	1.7	741		+3
		2	1.8	742		0
		3	2.3	743		0
		4	2.8	744		+2
		5	2.8	744		0
		6	1.7	736		0
		7	1.4	720		+5
		8	1.4	700		0

MAQS

USEPA METHOD 2 GAS VELOCITY TRAVERSE
AND VOLUMETRIC FLOWRATE DATA SHEET

Client: GRWRR
Sampling Location: Unit #1
Run Number: 2
Date: 6/7/22 Time: 14:46 - 15:00
Port and Stack: 24.25 in.
Port: 9.25 in.
Nipple Protrusion: 0 in.
Stack Diameter: 15 in.
Bar. Pressure: 29.85 in Hg
Static Pressure: -1.7 in H_2O
Moisture %: 11.2
% CO2: 5.37 % CO:
% O2: 10.25 % N2: 84.38

Stack Diagram

Weather conditions:

Operators: TW DK Manometer ID: MB12
Pitot Tube number: 6'C Umbilical ID: #7
Pitot Tube factor, Cp: 0.84 Pitot Line ID: 1A
Site Elevation: 607 ft. Upstream: 12 in.
Port Height: 30 ft. Downstream: 30 in.
Leak Check- Positive: Pre: ☑ @ 7 Post: ☐ @ 6.5 Negative: Pre: ☑ @ 5 Post: ☑ @ 7

% of Stack Diameter	Point Distance (in.)	Traverse Point Number	Velocity Head (ΔP) in H2O	Stack Temp °F	Null Angle (zero ΔP angle)	Flow Angle Ø (90° from null angle)
		1	1.7	742		0
		2	1.9	742		0
		3	2.1	742		+2
		4	2.3	743		0
		5	1.7	737		+2
		6	1.4	737		0
		7	1.3	725		+5
		8	1.2	725		-3
		1	1.7	742		
		2	1.9	742		
		3	1.9	742		
		4	2.0	743		
		5	2.5	741		
		6	2.2	730		
		7	2.0	730		
		8	1.9	730		

MAQS

USEPA METHOD 2 GAS VELOCITY TRAVERSE
AND VOLUMETRIC FLOWRATE DATA SHEET

Client: GRWRC
Sampling Location: Unit #1
Run Number: 3
Date: 6/7/22 Time: 16:20 - 16:35
Port and Stack: 24.25 in.
Port: 9.25 in.
Nipple Protrusion: 0 in.
Stack Diameter: 15 in.
Bar. Pressure: 29.86 in Hg
Static Pressure: -1.7 in H_2O
Moisture %: 11.07
% CO2: 5.3 % CO: 0
% O2: 10.3 % N2: 84.4

Stack Diagram

Weather conditions:

Operators: TW DK Manometer ID: UB12
Pitot Tube number: 61C Umbilical ID: #7
Pitot Tube factor, Cp: 0.84 Pitot Line ID: 1A
Site Elevation: 607 ft. Port Height: 30 ft.
Upstream: 12 in. Downstream: 30 in.
Leak Check- Positive: Pre: ☑ @ 7 Post: ☑ @ 6.5 Negative: Pre: ☐ @ 8 Post: ☑ @ 7

% of Stack Diameter	Point Distance (in.)	Traverse Point Number	Velocity Head (ΔP) in H2O	Stack Temp °F	Null Angle (zero ΔP angle)	Flow Angle Ø (90° from null angle)
		1	1.7	742		
		2	1.9	741		
		3	2.1	742		
		4	2.4	743		
		5	1.9	741		
		6	1.6	741		
		7	1.5	730		
		8	1.4	730		
		1	1.8	740		
		2	1.9	740		
		3	2.0	741		
		4	2.3	741		
		5	2.35	740		
		6	2.0	730		
		7	1.7	730		
		8	1.5	730		

Montrose AQS CEM Calibration Field Data Sheet

Client GRAND RAPIDS
Date 6/7/22
Analyzer #'s 2, 41

Operator TW
Sampling Location Unit # 3

Range					
Cylinder Values					
Time	Pollutant VOC	Pollutant O2	Pollutant	Pollutant	Pollutant
7:37		20.06			
7:39:30		10.23			
7:42		0.01			
7:55:30	90.75				
7:58:30	0.4	10.17			
8:03	0.35	0.03			
8:19	851				
8:21	497				
8:22:30	299.4				
8:25	0.52				
8:30	500.5				
8:32:30	0.68	0.08			
8:37	417	10.32			
9:40:30	0.46	0.01			
9:43	500.1	20.9			
9:45:30	0.83	10.2			
9:51	407	10.35			
10:54	0.5	0.02			
10:57	498	20.9			
10:59:30	0.6	10.22			
11:05	413	10.35			
12:09	0.61	0.03			

Environics # yes / no

Notes: Run/Cal Info & File Name

- O2 Cal Error ✓
- "
- O2 Cal Error
- BIAS ✓
- BIAS ✓
- 850 propane
- 500 propane
- 300 propane
- ZERO
- 500 propane
- ZERO
- START Run #1 (Unit #3)
- START Run #2 (Unit #3)
- START Run #3 (Unit #3)

Cylinder Serial Numbers

20% O_2 = CC469833
10.19% O_2 = CC153070
~~90~~, 89.58 = ALM012402
500.6 propane = CC160162
498.0 propane = CC20[illegible]

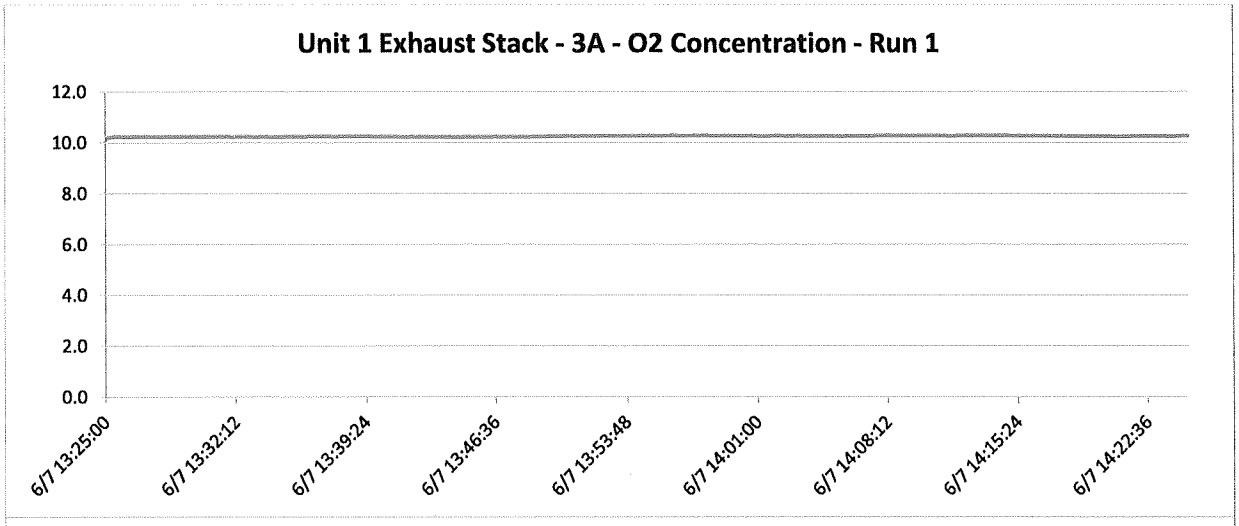
Montrose AQS CEM Calibration Field Data Sheet

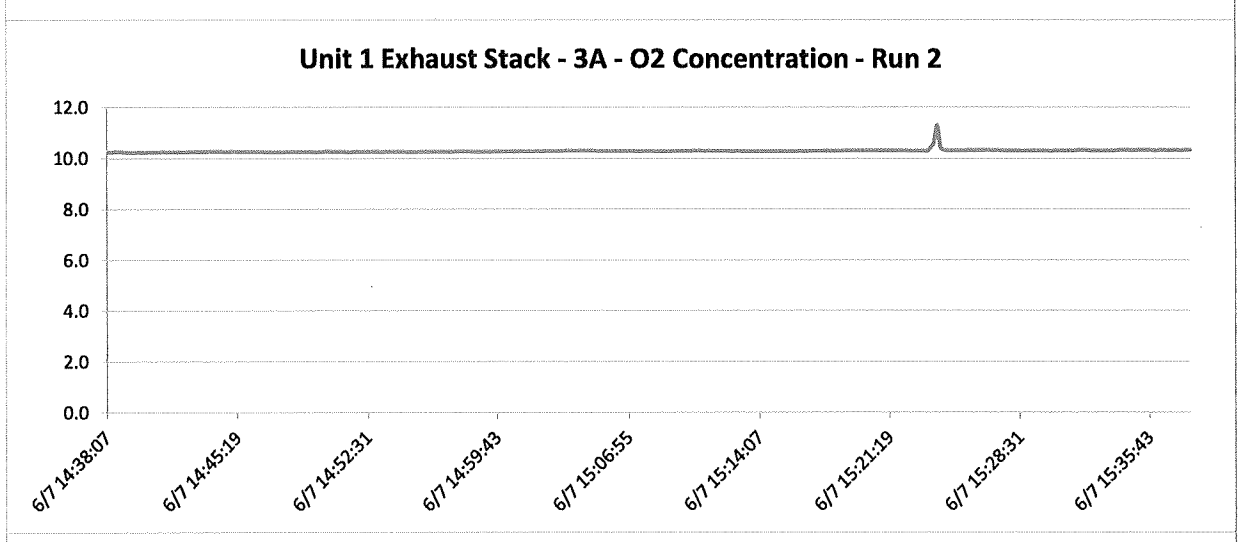
Client GRWRR
Date 6/7/22
Analyzer #'s 2, 41

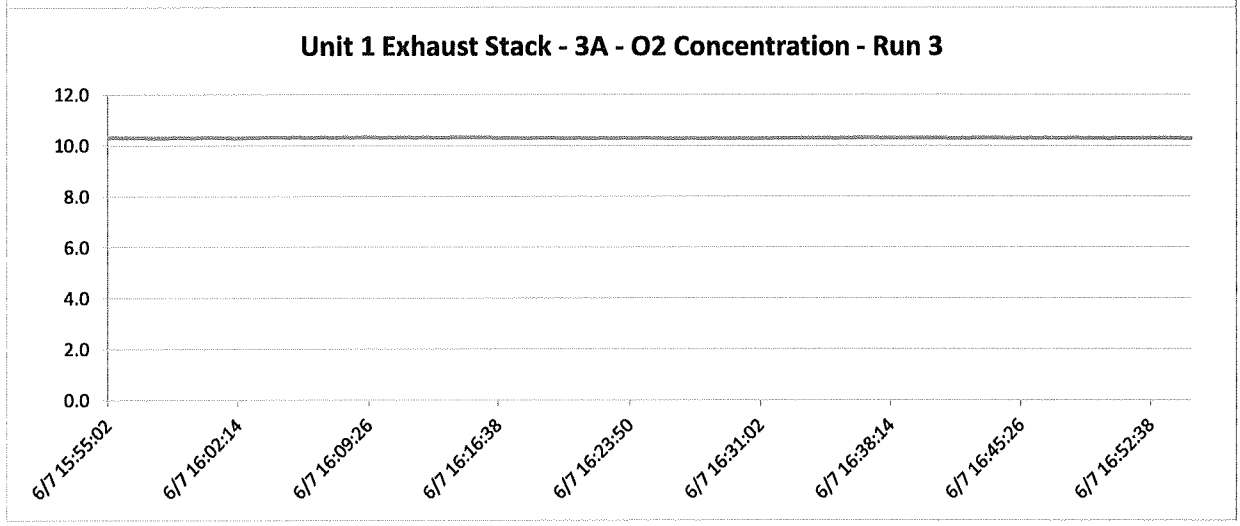
Operator NO D/C
Sampling Location Unit #1

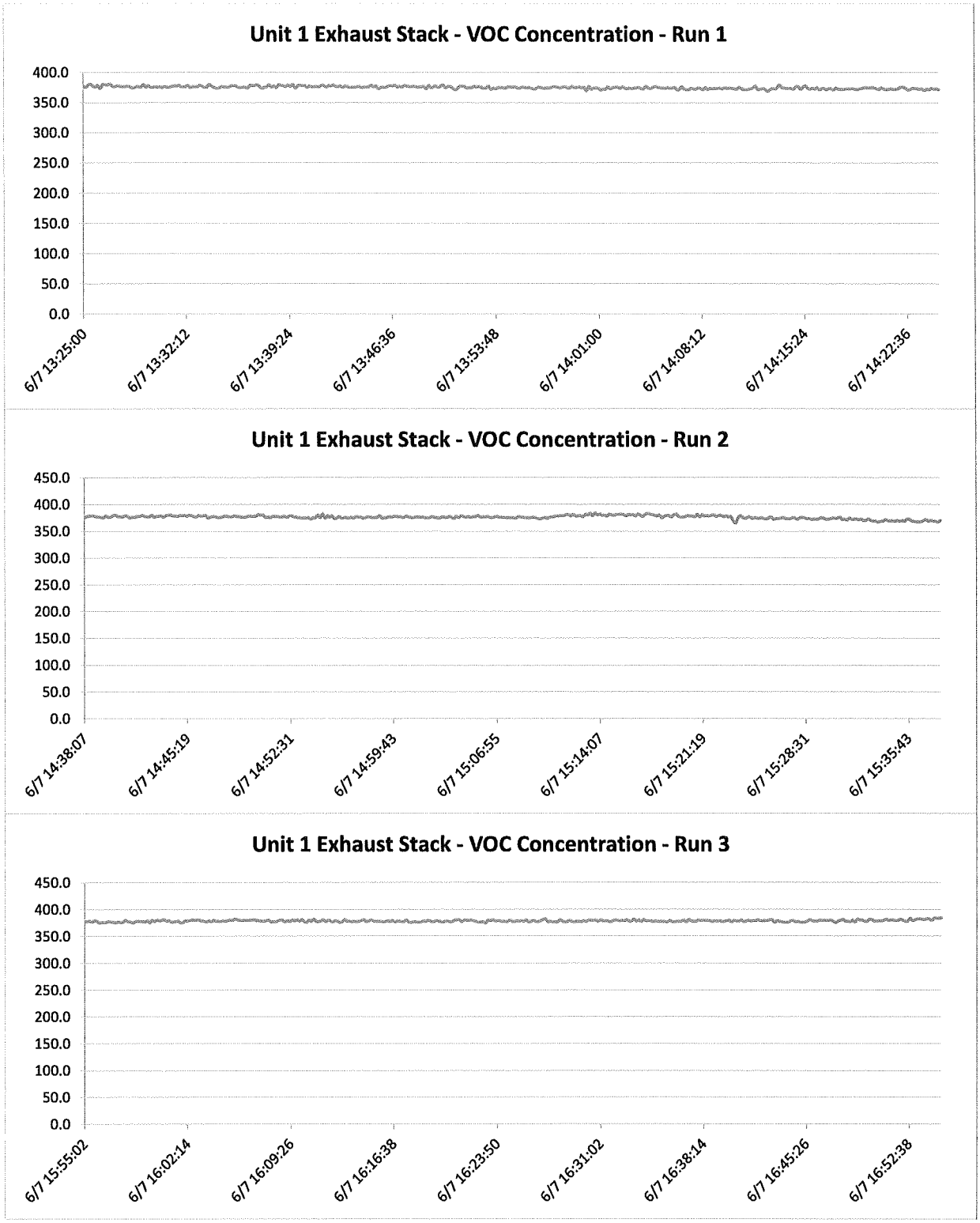
Range						
Cylinder Values						Environics # yes / no
Time	Pollutant	Pollutant	Pollutant	Pollutant	Pollutant	Notes: Run/Cal Info & File Name
12:11:30	499	20.9				
12:14	0.5	10.2				
13:26	378	10.2				START Run #4 (Run #1 Unit)
14:28	0.41	0.03				
14:30	495	20.9				
14:33	0.46	10.24				
14:38	380	10.26				START Run #5 (Run #2 Unit #1)
15:11:30	0.5	0.03				
15:45	499	20.9				
15:48	0.28	10.24				
15:55	376	10.3				START Run #6 (Run 3 Unit #1)
16:59	0.2	0.03				
17:01	498	20.9				
17:04	0.2	10.2				

Cylinder Serial Numbers


Unit 1 Exhaust Stack - 3A - O2 Concentration - Run 1
12.0
10.0
8.0
6.0
4.0
2.0
0.0
6/7 13:25:00
6/7 13:32:12
6/7 13:39:24
6/7 13:46:36
6/7 13:53:48
6/7 14:01:00
6/7 14:08:12
6/7 14:15:24
6/7 14:22:36


Unit 1 Exhaust Stack - 3A - O2 Concentration - Run 2
12.0
10.0
8.0
6.0
4.0
2.0
0.0
6/7 14:38:07
6/7 14:45:19
6/7 14:52:31
6/7 14:59:43
6/7 15:06:55
6/7 15:14:07
6/7 15:21:19
6/7 15:28:31
6/7 15:35:43


Unit 1 Exhaust Stack - 3A - O2 Concentration - Run 3
12.0
10.0
8.0
6.0
4.0
2.0
0.0
6/7 15:55:02
6/7 16:02:14
6/7 16:09:26
6/7 16:16:38
6/7 16:23:50
6/7 16:31:02
6/7 16:38:14
6/7 16:45:26
6/7 16:52:38


Unit 1 Exhaust Stack - VOC Concentration - Run 1
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
6/7 13:25:00
6/7 13:32:12
6/7 13:39:24
6/7 13:46:36
6/7 13:53:48
6/7 14:01:00
6/7 14:08:12
6/7 14:15:24
6/7 14:22:36
Unit 1 Exhaust Stack - VOC Concentration - Run 2
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
6/7 14:38:07
6/7 14:45:19
6/7 14:52:31
6/7 14:59:43
6/7 15:06:55
6/7 15:14:07
6/7 15:21:19
6/7 15:28:31
6/7 15:35:43
Unit 1 Exhaust Stack - VOC Concentration - Run 3
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
6/7 15:55:02
6/7 16:02:14
6/7 16:09:26
6/7 16:16:38
6/7 16:23:50
6/7 16:31:02
6/7 16:38:14
6/7 16:45:26
6/7 16:52:38

Appendix A.3
EUCHP3 Data Sheets

TEST DATA

Number of Test Runs	3			
Traverse Points	16			
	Run 1	**Run 2**	**Run 3**	**Average**
Stack Cross-Sectional Diameter 1 (**circular**) (in)	15.0	15.0	15.0	15.0
Stack Cross-Sectional Diameter 2 (**circular**) (in)	15.0	15.0	15.0	15.0
Pitot Tube Coefficient (Cp)	0.84	0.84	0.84	0.84
Barometric Pressure at Ground Level (Pbar) (in Hg)	29.80	29.80	29.83	29.81
Elevation Difference Between Ground Level and Meter Box Locations (ft)	0	0	0	0
Elevation Difference Between Ground Level and Sampling Locations (ft)	37	37	37	37
Percent by Volume Moisture as Measured in Stack Gas (%H2O)	11.24	11.24	11.22	11.23
Air Percent by Volume Oxygen in Stack Gas (%-dry)	10.34	10.33	10.33	10.33
Air Percent by Volume Carbon Dioxide in Stack Gas (%-dry)	5.96	5.97	5.96	5.96
Air Percent by Volume Nitrogen in Stack Gas (%-dry)	**83.70**	**83.70**	**83.71**	83.70
Average Pitot Rotation Angle	2.3			
Brake Horsepower (bhp)	1746.2	1743.5	1743.5	1744.4
Test Run Start Time (hrmin)	6/7/2022 8:37	6/7/2022 9:51	6/7/2022 11:05	
Test Run Stop Time (hrmin)	6/7/2022 9:37	6/7/2022 10:51	6/7/2022 12:05	

DETAILED RESULTS

Stack Gas Conditions	**Run 1**	**Run 2**	**Run 3**	**Average**
Stack Cross-Sectional Area (A) (ft2)	1.23	1.23	1.23	1.23
Barometric Pressure at Sampling Location (in Hg)	29.76	29.76	29.79	29.77
Dry Molecular Weight of Stack Gas (Md) (lb/lb-mole)	29.37	29.37	29.37	29.37
Wet Molecular Weight of Stack Gas (Ms) (lb/lb-mole)	28.09	28.09	28.09	28.09
Average Absolute Stack Gas Pressure (Ps) (in Hg)	29.62	29.62	29.69	29.65
Average Stack Gas Static Pressure (ps) (in H2O)	-1.90	-1.90	-1.40	-1.73
Average Stack Gas Temperature (ts) (°F)	740.9	754.0	767.5	754.1
Average Stack Gas Temperature (Ts) (°R)	1,200.9	1,214.0	1,227.5	1,214.1
Average Stack Gas Velocity (Vs) (ft/sec)	119.72	123.32	124.88	122.64
Average Stack Gas Velocity (Vs) (ft/min)	7,183	7,399	7,493	7,358
Wet Volumetric Stack Gas Flow at Actual Conditions (Qaw) (acfm)	8,815	9,080	9,195	9,030
Wet Volumetric Stack Gas Flow at Standard Conditions (scfm)	3,835	3,908	3,922	3,888
Dry Volumetric Stack Gas Flow at Standard Conditions (Qstd) (dscfm)	3,404	3,468	3,482	3,452
Percent by Volume Moisture as measured in Stack Gas (%H2O)	11.24	11.24	11.22	11.23

	Run 1	**Run 2**	**Run 3**	**Average**
Dry Mole Fraction of Flue Gas (Mfd)	0.888	0.888	0.888	0.888
Average Velocity Pressure (Delta P) (in H2O)	1.94	2.04	2.06	2.01
Average Square Root of Delta P	1.39	1.42	1.43	1.41

MEASURED DATA FROM TEST RUNS

Point Count	Run #	Pitot Delta P (in H2O)	Square Root of Delta P	Stack Pressure (in H2O)	Stack Temp (°F)
1	1	1.90	1.378	-1.9	761
2	1	1.90	1.378		761
3	1	2.10	1.449		761
4	1	2.40	1.549		761
5	1	2.00	1.414		748
6	1	1.40	1.183		730
7	1	1.50	1.225		684
8	1	1.40	1.183		684
9	1	2.00	1.414		764
10	1	2.00	1.414		765
11	1	2.00	1.414		766
12	1	1.90	1.378		766
13	1	2.50	1.581		761
14	1	2.00	1.414		741
15	1	2.10	1.449		702
16	1	1.90	1.378		700
17	2	2.00	1.414	-1.9	771
18	2	2.00	1.414		772
19	2	2.20	1.483		772
20	2	2.50	1.581		772
21	2	2.10	1.449		772
22	2	1.40	1.183		737
23	2	1.30	1.140		700
24	2	1.20	1.095		690
25	2	2.10	1.449		766
26	2	2.20	1.483		769
27	2	2.30	1.517		771
28	2	2.40	1.549		772
29	2	2.60	1.612		770
30	2	2.30	1.517		760
31	2	2.20	1.483		740
32	2	1.90	1.378		730
33	3	1.90	1.378	-1.4	773
34	3	2.00	1.414		773
35	3	2.20	1.483		774
36	3	2.40	1.549		774
37	3	2.20	1.483		771
38	3	1.80	1.342		766
39	3	1.80	1.342		750
40	3	1.60	1.265		750
41	3	2.20	1.483		772
42	3	2.10	1.449		773
43	3	2.10	1.449		773
44	3	2.00	1.414		774
45	3	2.50	1.581		774
46	3	2.40	1.549		773
47	3	2.10	1.449		760
48	3	1.70	1.304		750

TEST DATA - EPA Method 3A (O_2)

Number of Concentration Runs: 3

Analyzer Calibration

	Run 1	Run 2	Run 3	Average
Actual Concentration of the Mid-Level Calibration Gas (%)	10.190	10.190	10.190	10.190
Actual Concentration of the High-Level Calibration Gas (%)	20.00	20.00	20.00	20.00
Analyzer Span During Test Run (%)	20.00	20.00	20.00	20.00
Calibration Gas QA	**GOOD**	**GOOD**	**GOOD**	
Analyzer Calibration Response for Zero Gas (%)	0.02	0.02	0.02	0.02
Analyzer Calibration Response for Mid-Level Gas (%)	10.23	10.23	10.23	10.23
Analyzer Calibration Response for High Level Gas (%)	20.07	20.07	20.07	20.07
Initial System Calibration Response for Zero Gas (%)	0.03	0.02	0.02	0.02
Initial System Calibration Response for Upscale Gas (%)	10.18	10.19	10.22	10.20
Final System Calibration Response for Zero Gas (%)	0.02	0.02	0.02	0.02
Final System Calibration Response for Upscale Gas (%)	10.19	10.22	10.22	10.21

Analyzer Calibration QA

	Run 1	Run 2	Run 3	Average
Initial System Calibration Bias for Zero Gas (% of Span)	0.08	0.00	0.01	0.03
Initial System Calibration Bias for Upscale Gas (% of Span)	-0.28	-0.21	-0.07	-0.19
Final System Calibration Bias for Zero Gas (% of Span)	0.00	0.01	0.03	0.01
Final System Calibration Bias for Upscale Gas (% of Span)	-0.21	-0.07	-0.05	-0.11
System Drift for Zero Gas (% of Span)	-0.08	0.01	0.02	-0.02
System Drift for Upscale Gas (% of Span)	0.07	0.14	0.02	0.08
Analyzer Calibration Error for Zero Gas (% of Span)	0.08	0.08	0.08	0.08
Analyzer Calibration Error for Mid-Level Gas (% of Span)	0.22	0.22	0.22	0.22
Analyzer Calibration Error for High-Level Gas (% of Span)	0.33	0.33	0.33	0.33

CONCENTRATION CALCULATIONS - DRY SYSTEM

Calculate the Average Effluent Oxygen O_2 Concentration

	Run 1	Run 2	Run 3	Average
Average O_2 Concentration Indicated by Gas Analyzer, dry basis (%-dry)	10.33	10.34	10.37	10.35
Average of Initial and Final System Calibration Bias Check Responses for the Zero Gas (%)	0.024	0.016	0.019	0.020
Average of Initial and Final System Calibration Bias Check Responses for the Upscale Calibration Gas (%)	10.185	10.206	10.222	10.205
Average Effluent O_2 Concentration, dry basis (%-dry)	10.336	10.327	10.335	10.332

TEST DATA - EPA Method 25A

Number of Concentration Runs: 3

Analyzer Calibration

	Run 1	Run 2	Run 3	Average
Actual Concentration of the Low-Level Calibration Gas (ppmv)	300.00	300.00	300.00	300.00
Actual Concentration of the Mid-Level Calibration Gas (ppmv)	500.00	500.00	500.00	500.00
Actual Concentration of the High-Level Calibration Gas (ppmv)	850.00	850.00	850.00	850.00
Analyzer Span During Test Run (ppmv)	1000.00	1000.00	1000.00	1000.00
Calibration Gas QA	**GOOD**	**GOOD**	**GOOD**	
Average Effluent TGO Concentration at MDL (ppmvw)	20.00	20.00	20.00	20.00
Initial Analyzer Calibration Response for Zero Gas (ppmv)	0.22	0.22	0.22	0.22
Initial Analyzer Calibration Response for Low-Level Gas (ppmv)	299.87	299.87	299.87	299.87
Initial Analyzer Calibration Response for Mid-Level Gas (ppmv)	498.49	498.49	498.49	498.49
Initial Analyzer Calibration Response for High Level Gas (ppmv)	851.37	851.37	851.37	851.37
Initial Analyzer Calibration Response for Zero Gas (ppm)	0.60	0.51	0.34	0.48
Inital Analyzer Calibration Response for Mid-Level Gas (ppm)	500.40	500.07	498.05	499.51
Final Analyzer Calibration Response for Zero Gas (ppm)	0.51	0.34	0.36	0.40
Final Analyzer Calibration Response for Mid-Level Gas (ppm)	500.07	498.05	499.63	499.25

Analyzer Calibration QA

	Run 1	Run 2	Run 3	Average
Zero Drift (% of Span)	-0.01	-0.02	0.00	-0.01
Calibration Drift for Mid-Level Cal. Gas (% of Span)	-0.03	-0.20	0.16	-0.03
Calibration Error for Low-Level Gas (% of Cal. Gas Tag Value)	0.04	0.04	0.04	0.04
Calibration Error for Mid-Level Gas (% of Cal. Gas Tag Value)	0.30	0.30	0.30	0.30

DETAILED RESULTS

Emission Results

	Run 1	Run 2	Run 3	Average
Average THC Mass Emission Rate as Propane, (lb/hr)	10.78	10.89	10.94	10.87
Average THC Mass Emission Rate as Propane, (g/bhp-hr, dry)	2.80	2.83	2.85	2.83
NMEOC Mass Emission Rate as Propane, (lb/hr)	-1.64	-1.76	-1.74	-1.71
NMEOC Mass Emission Rate as Propane, (g/bhp-hr, dry)	-0.42	-0.46	-0.45	-0.45

CONCENTRATION CALCULATIONS

Average Effluent Total Hydrocarbons (THC) Concentration	Run 1	Run 2	Run 3	Average
Cmeas = Average Organic Concentration as Measured by Gas Analyzer (ppmvw as propane)	409.83	405.28	405.22	406.78
Average of Initial and Final System Calibration Bias Check Responses for the Zero Gas (ppmv)	0.55	0.42	0.35	0.44
Average of Initial and Final System Calibration Bias Check Responses for the Upscale Calibration Gas (ppmv)	500.23	499.06	498.84	499.38
Corrected Total Hydrocarbons Dry Concentration Measured as Propane (ppmvw as propane)	409.54	405.96	406.09	407.20
Corrected Total Hydrocarbons Dry Concentration Measured as Propane (ppmvd as propane)	461.40	457.37	457.42	458.73

Methane Corrections	Run 1	Run 2	Run 3	Average
ENTER METHANE CONCENTRATION FROM FTIR (ppmvd as methane)	1169.68	1169.42	1167.29	1168.80
Methane:Propane Response Factor	2.40	2.40	2.40	2.40
Corrected Methane Concentration (ppmvd as propane)	487.37	487.26	486.37	487.00

Ethane Corrections	Run 1	Run 2	Run 3	Average
ENTER ETHANE CONCENTRATION FROM FTIR (ppmvd as ethane)	66.03	65.99	65.88	65.97
Ethane:Propane Response Factor	1.50	1.50	1.50	1.50
Corrected Ethane Concentration (ppmvd as propane)	44.02	43.99	43.92	43.98
Methane/Ethane Corrected TGO Concentration (ppmvd as propane)	**-69.99**	**-73.88**	**-72.88**	-72.25

Oxygen Corrected Total Hydrocarbons Concentration	Run 1	Run 2	Run 3	Average
Correction for Oxygen (Enter % Oxygen)	15.0	15.0	15.0	15.0
Average Effluent THC Concentration Corrected to 15% Oxygen (ppmvd as propane)	257.7	255.2	255.4	256.1
Average Effluent NMEOC Concentration Corrected to 15% Oxygen (ppmvd as propane)	-39.1	-41.2	-40.7	-40.3

Maximum Effluent Total Hydrocarbons (THC) Concentration	Run 1	Run 2	Run 3	Average
Cmeas = Maximum Organic Concentration as Measured by Gas Analyzer, wet basis (ppmv as Propane)	434.05	425.36	421.52	426.98

TEST DATA - EPA Method 320

Testing Data

Number of Concentration Runs: 3

EMISSIONS	Run 1	Run 2	Run 3	Average
Carbon Monoxide Emissions (lb/hr)	0.055	0.057	0.058	0.057
Nitrogen Oxides Emissions (lb/hr)	1.752	1.808	1.817	1.792
Formaldehyde Emissions (lb/hr)	0.021	0.021	0.023	0.022
Carbon Monoxide Emissions (g/bhp-hr, dry)	0.014	0.015	0.015	0.015
Nitrogen Oxides Emissions (g/bhp-hr, dry)	0.455	0.470	0.473	0.466
Formaldehyde Emissions (g/bhp-hr, dry)	0.0054	0.0056	0.0059	0.0056

CONCENTRATIONS	Run 1	Run 2	Run 3	Average
Moisture Content (%)	11.24	11.24	11.22	11.2
Carbon Dioxide Concentration (%-Wet)	5.29	5.30	5.29	5.3
Carbon Monoxide Concentration (ppmvw)	3.30	3.33	3.37	3.3
Nitrogen Oxides Concentration (ppmvw)	63.77	64.57	64.68	64.3
Methane Concentration (ppmvw)	1038.21	1037.98	1036.32	1037.5
Ethane Concentration (ppmvw)	58.61	58.57	58.49	58.6
Formaldehyde Concentration (ppmvw)	1.15	1.17	1.23	1.18
Carbon Monoxide Concentration (ppmvd)	3.72	3.75	3.80	3.76
Nitrogen Oxides Concentration (ppmvd)	71.8	72.7	72.9	72.5
Methane (ppmvd)	1169.7	1169.4	1167.3	1168.8
Ethane (ppmvd)	66.0	66.0	65.9	66.0
Formaldehyde (ppmvd)	1.30	1.32	1.39	1.33

MOLECULAR WEIGHTS	Run 1	Run 2	Run 3	Average
Carbon Monoxide (g/g-mole)	28.01	28.01	28.01	28.01
Nitrogen Oxides (g/g-mole)	46.01	46.01	46.01	46.01
Methane (g/g-mole)	16.04	16.04	16.04	16.04
Ethane (g/g-mole)	30.07	30.07	30.07	30.07
Formaldehyde (g/g-mole)	30.031	30.031	30.031	30.031

OXYGEN CORRECTED CONCENTRATIONS	Run 1	Run 2	Run 3	Average
Correction for Oxygen (Enter % Oxygen)	15.00	15.00	15.00	15.00
Average Effluent CO Concentration Corrected to 15% Oxygen (ppmvd)	2.08	2.09	2.12	2.10
Average Effluent NO_X Concentration Corrected to 15% Oxygen (ppmvd)	40.12	40.63	40.69	40.48
Average Effluent CH_2O Concentration Corrected to 15% Oxygen (ppmvd)	0.72	0.74	0.77	0.74

US EPA Method 1 Traverse Point Determination

Relative Port Location	1.0	2.0
From Far Wall to Outside of Port (in.)	24.25	24.25
Nipple Length or Wall Thickness (in.)	9.25	9.25
Port Protrusion Length (opt) (in.)	0.00	0.00
Depth of Stack or Duct (in.)	15.00	15.00
Stack or Duct Type	Circular	
Port Hole Inner Diameter (in.)		
Stack or Duct Width (If Rectangular) (in.)		
Stack Outer Circumference (in.)		
Number of Ports Traversed	2	
Elevation of Meter Box from Sea Level (ft)	607	
Elevation of Ports from Sea Level (ft)	637	
Stack Build-up (in.)	0.0	
Stack Cross-Sectional Diameter 1 (in)	15.0	
Stack Cross-Sectional Diameter 2 (in)	15.0	

Note:

Add nipple protrusion length to Point 1 only.
Actual nipple length = (length - protrusion)

Relocate to a distance equal to the inside diameter of the nozzle being used or to the above minimum distances, whichever is larger.

This Stack having a diameter of less than or equal to 24-inches shall have not traverse points located within 0.5-inches of the stack wall.

'Pt. Adj.' denotes that the traverse point has been adjusted to 0.5-inch from the stack wall.

"Vertical" or "Horizontal" Flow	Vertical
Direction of Flow	Up
"Velocity" or "Isokinetic" Traverse	Velocity

Port Distance Upstream from Flow Disturbance (in.)	12.0
Diameters Upstream from Flow Disturbance (³ 0.5 De)	0.8
Minimum Traverse Points Needed for a Velocity Traverse *	16
Minimum Traverse Points Needed for a Isokinetic Traverse *	24

Port Distance Downstream from Flow Disturbance (in.)	30.0
Diameters Downstream from Flow Disturbance (³ 2.0 De)	2.0
Minimum Traverse Points Needed for a Velocity Traverse *	16
Minimum Traverse Points Needed for a Isokinetic Traverse *	24

Minimum Traverse Points per Method 1	16
Number of Traverse Points for this Circular Stack or Duct	16
Point Overide	
Duct Area - in^2	176.71
Duct Area - ft^2	1.2272

New Method 1 verified on 6/7/2022 by: TW

	Port	Point	% of Duct Depth	Dist. From Inside Wall (Decimal)	Dist. From Outside Wall (Decimal)
Pt. Adj	1	1	3.2	0.5	9.8
	1	2	10.5	1.6	10.8
	1	3	19.4	2.9	12.2
	1	4	32.3	4.8	14.1
	1	5	67.7	10.2	19.4
	1	6	80.6	12.1	21.3
	1	7	89.5	13.4	22.7
Pt. Adj	1	8	96.8	14.5	23.8
Pt. Adj	2	1	3.2	0.5	9.8
	2	2	10.5	1.6	10.8
	2	3	19.4	2.9	12.2
	2	4	32.3	4.8	14.1
	2	5	67.7	10.2	19.4
	2	6	80.6	12.1	21.3
	2	7	89.5	13.4	22.7
Pt. Adj	2	8	96.8	14.5	23.8

MAQS

USEPA METHOD 2 GAS VELOCITY TRAVERSE
AND VOLUMETRIC FLOWRATE DATA SHEET

Client: Grand Rapids WPR
Sampling Location: Unit #3 Exhaust
Run Number: 1
Date: 6/7/22 Time: 8:47 - 9:08
Port and Stack: 24.25 in.
Port: 9.25 in.
Nipple Protrusion: 0 in.
Stack Diameter: 19 in.
Bar. Pressure: 29.8 in Hg
Static Pressure: -1.9 in H_2O
Moisture %: 11.24
% CO2: 5.3 % CO: 0
% O2: 10.3 % N2: 84.4

Stack Diagram

Weather conditions:

Operators: TW DK Manometer ID: MB12
Pitot Tube number: 6'C Umbilical ID: #7 Site Elevation: 607 ft. Upstream: 12 in.
Pitot Tube factor, Cp: 0.84 Pitot Line ID: 1A Port Height: 30 ft. Downstream: 30 in.
Leak Check- Positive: Pre: ☑ @ 6" Post: ☑ @ 7" Negative: Pre: ☑ @ 6.5 Post: ☑ @ 7.0

% of Stack Diameter	Point Distance (in.)	Traverse Point Number	Velocity Head (ΔP) in H2O	Stack Temp °F	Null Angle (zero ΔP angle)	Flow Angle Ø (90° from null angle)
2.47		1	1.9	761		-2
		2	1.9	761		+3
		3	2.1	761		0
		4	2.4	761		+3
		5	2.0	748		0
		6	1.4	730		+7
		7	1.5	684		0
		8	1.4	684		+10
9:00		1	2.0	764		0
		2	2.0	765		+2
		3	2.0	766		+2
		4	1.9	766		+2
		5	2.5	761		+4
		6	2.0	741		0
		7	2.1	702		0
9:08		8	1.9	700		+2

MAQS

USEPA METHOD 2 GAS VELOCITY TRAVERSE
AND VOLUMETRIC FLOWRATE DATA SHEET

Client: Grand Rapids Water Resource Recovery

Sampling Location: Unit # 3

Run Number: 2

Date: 6/7/22 Time: 9:53 - 10:13

Port and Stack: 24.25 in.

Port: 10 in.

Nipple Protrusion: 9.25 in.

Stack Diameter: 15.00 in.

Bar. Pressure: 29.8 in Hg

Static Pressure: ~~-2~~ -1.9 in H_2O

Moisture %: 11.2k

% CO2: 5.3 % CO: 0

% O2: 10.3 % N2: 84.4

Stack Diagram

Weather conditions:

Operators: TW, DK Manometer ID: MB12

Pitot Tube number: 6'C Umbilical ID: #7

Pitot Tube factor, Cp: 0.84 Pitot Line ID: 1A

Site Elevation: 607 ft. Port Height: 30 ft.

Upstream: 12 in. 10

Downstream: ~~30~~ ~~in~~ 5 in

Leak Check- Positive: Pre: ☑ @ 7 Post: ☑ @ 6 Negative: Pre: ☑ @ 8 Post: ☑ @ 7

% of Stack Diameter	Point Distance (in.)	Traverse Point Number	Velocity Head (ΔP) in H2O	Stack Temp °F	Null Angle (zero ΔP angle)	Flow Angle Ø (90° from null angle)
		1	2.0	771		
		2	2.0	772		
		3	2.2	772		
		4	2.5	772		
		5	2.1	772		
		6	1.4	737		
		7	1.3	700		
		8	1.2	690		
		1	2.1	766		
		2	2.2	769		
		3	2.3	771		
		4	2.4	772		
		5	2.6	770		
		6	2.3	760		
		7	2.2	740		
		8	1.9	730		

MAQS

USEPA METHOD 2 GAS VELOCITY TRAVERSE
AND VOLUMETRIC FLOWRATE DATA SHEET

Client GRWRR

Sampling Location Unit #3

Run Number: 3 11:07 - 11:20

Date 6/7/22 Time ~~10:07~~ - 10:20

Port and Stack 24.25 in. TW

Port 9.25 in.

Nipple Protrusion 0 in.

Stack Diameter 15 in.

Bar. Pressure 29.83 in Hg

Static Pressure -1.4 in H_2O

Moisture % 11.22

% CO2 5.3 % CO 0

% O2 10.3 % N2 84.4

Stack Diagram

Weather conditions:

Operators TW, DLC Manometer ID: MB 12

Pitot Tube number L'C Umbilical ID: #7

Pitot Tube factor, Cp 0.84 Pitot Line ID: 1A

Site Elevation 607 ft. Upstream 12 in.

Port Height 30' ft. Downstream 30 in.

Leak Check- Positive: Pre: ☑@ 7 Post: ☑@ 6 Negative: Pre: ☑@ 8 Post: ☑@ 7

% of Stack Diameter	Point Distance (in.)	Traverse Point Number	Velocity Head (ΔP) in H2O	Stack Temp °F	Null Angle (zero ΔP angle)	Flow Angle Ø (90° from null angle)
		1	1.9	773		
		2	2.0	773		
		3	2.2	774		
		4	2.4	774		
		5	2.2	771		
		6	1.8	766		
		7	1.8	750		
		8	1.6	750		
		1	2.2	772		
		2	2.1	773		
		3	2.1	773		
		4	2.0	774		
		5	2.5	774		
		6	2.4	773		
		7	2.1	760		
		8	1.7	750		

Montrose AQS CEM Calibration Field Data Sheet

Client GRAND RAPIDS
Date 6/7/22
Analyzer #'s 2, 41

Operator TW
Sampling Location Unit #3

Range					
Cyinder Values					
Time	Pollutant VOC	Pollutant O2	Pollutant	Pollutant	Pollutant
7:37		20.06			
7:39:30		10.23			
7:42		0.01			
7:55:30	90.75				
7:58:30	0.4	10.17			
8:03	0.35	0.03			
8:19	851				
8:21	497				
8:22:30	299.4				
8:25	0.52				
8:30	500.6				
8:32:30	0.68	0.08			
8:37	417	10.32			
9:40:30	0.46	0.01			
9:43	500.1	20.9			
9:45:30	0.83	10.2			
9:51	407	10.35			
10:54	0.5	0.02			
10:57	498	20.9			
10:59:30	0.6	10.22			
11:05	413	10.35			
12:09	0.51	0.03			

Environics # yes / no

Notes: Run/Cal Info & File Name

- O2 Cal Error ✓
- "
- O2 Cal Error
- BIAS ✓
- BIAS ✓
- 850 propane
- 500 propane
- 300 propane
- ZERO
- 500 propane
- ZERO
- START Run #1 (Unit #3)
- START Run #2 (Unit #3)
- START Run #3 (Unit #3)

Cylinder Serial Numbers

20.7% O_2 = CC469833 ~~50~~, 89.5% = ALM012402
10.19% O_2 = CC153070 500.6 propane = CC160162
498 propane = CC20[illegible]

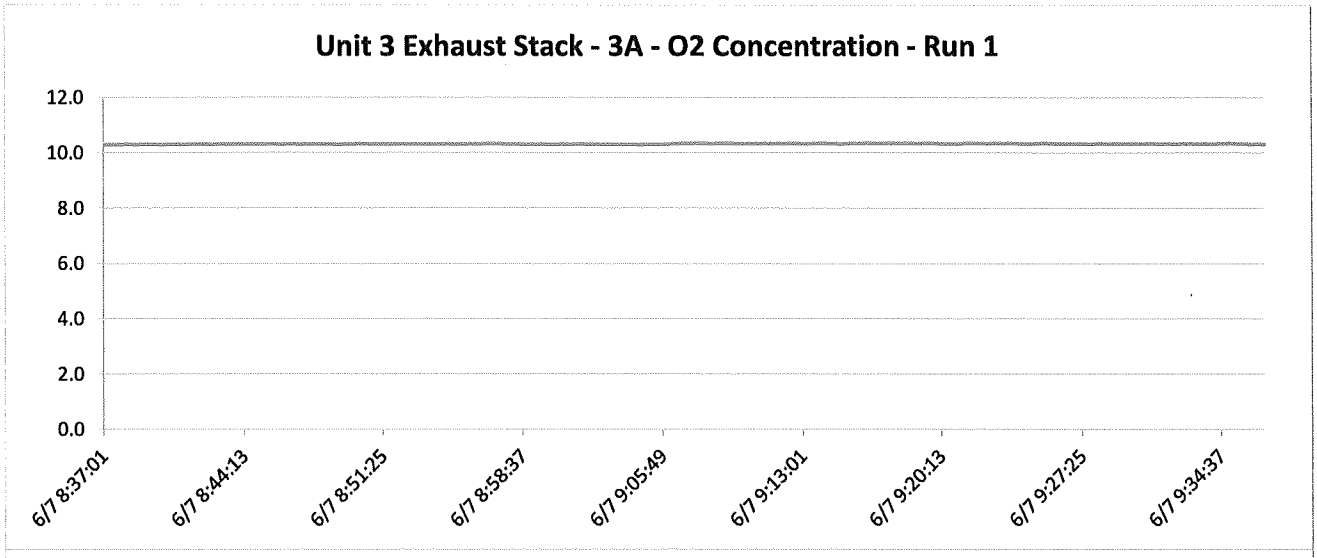
Montrose AQS CEM Calibration Field Data Sheet

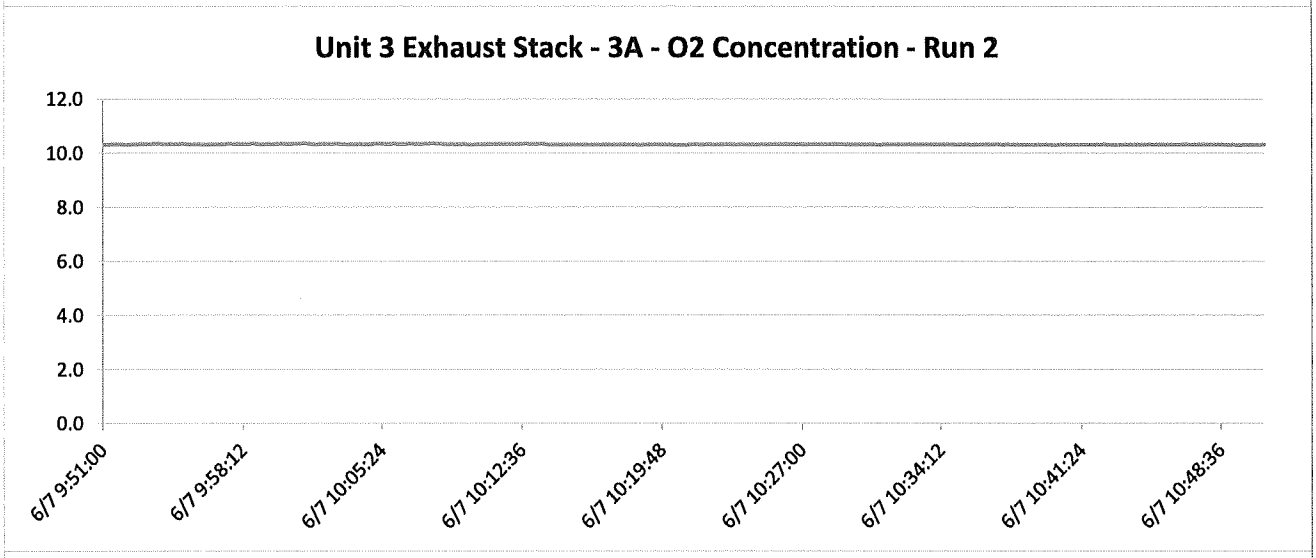
Client GRWRR
Date 6/7/22
Analyzer #'s 2, 41

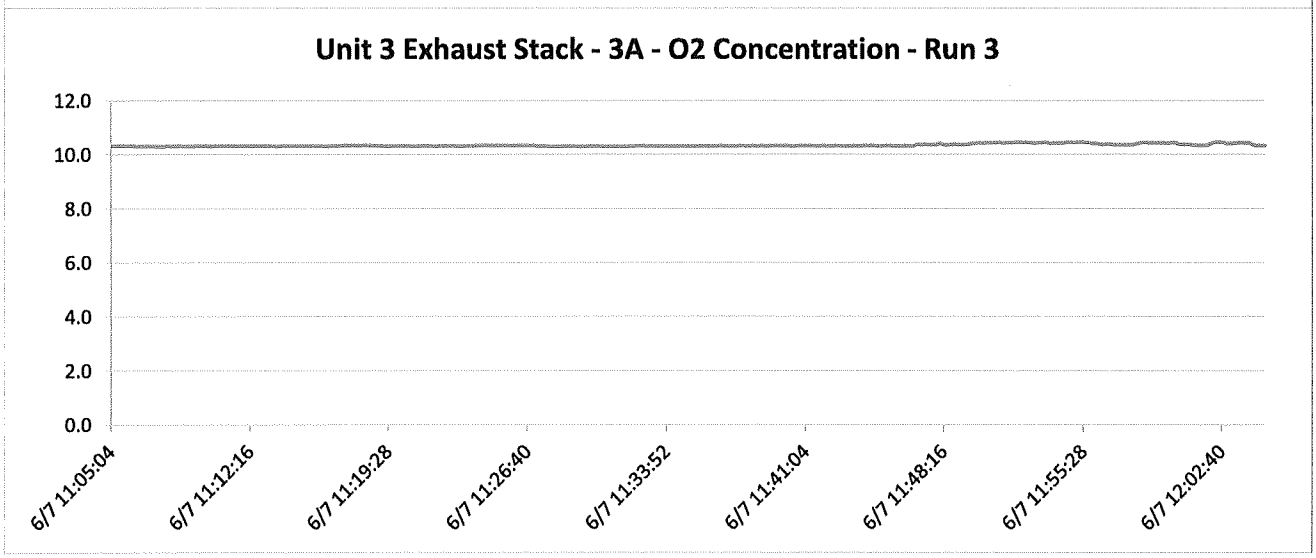
Operator NO D/C
Sampling Location Unit #1

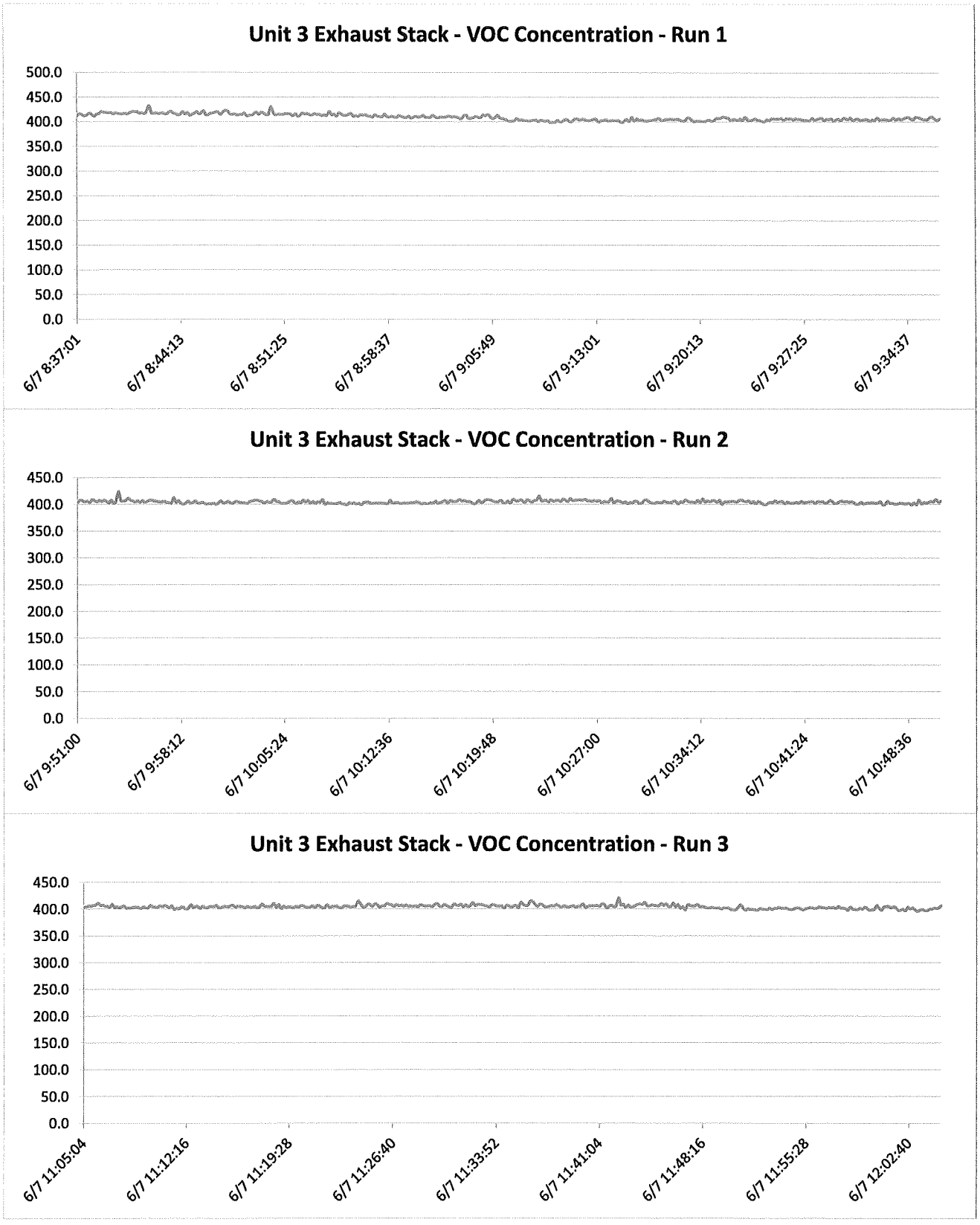
Range						
Cyinder Values						Environics # yes / no
Time	Pollutant	Pollutant	Pollutant	Pollutant	Pollutant	Notes: Run/Cal Info & File Name
12:11:30	499	20.9				
12:14	0.5	10.2				
13:26	378	10.2				START Run #4 (Run #1 Unit 1)
14:28	0.41	0.03				
14:30:30	495	20.9				
14:33	0.46	10.24				
14:38	380	10.26				START Run #5 (Run #2 Unit #1)
15:11:30	0.5	0.03				
15:45	499	20.9				
15:48	0.28	10.24				
15:55	376	10.3				START Run #6 (Run 3 Unit #1)
16:59	0.2	0.03				
17:01	498	20.9				
17:04	0.2	10.2				

Cylinder Serial Numbers


Unit 3 Exhaust Stack - 3A - O2 Concentration - Run 1
12.0
10.0
8.0
6.0
4.0
2.0
0.0
6/7 8:37:01
6/7 8:44:13
6/7 8:51:25
6/7 8:58:37
6/7 9:05:49
6/7 9:13:01
6/7 9:20:13
6/7 9:27:25
6/7 9:34:37


Unit 3 Exhaust Stack - 3A - O2 Concentration - Run 2
12.0
10.0
8.0
6.0
4.0
2.0
0.0
6/7 9:51:00
6/7 9:58:12
6/7 10:05:24
6/7 10:12:36
6/7 10:19:48
6/7 10:27:00
6/7 10:34:12
6/7 10:41:24
6/7 10:48:36


Unit 3 Exhaust Stack - 3A - O2 Concentration - Run 3
12.0
10.0
8.0
6.0
4.0
2.0
0.0
6/7 11:05:04
6/7 11:12:16
6/7 11:19:28
6/7 11:26:40
6/7 11:33:52
6/7 11:41:04
6/7 11:48:16
6/7 11:55:28
6/7 12:02:40


Unit 3 Exhaust Stack - VOC Concentration - Run 1
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
6/7 8:37:01
6/7 8:44:13
6/7 8:51:25
6/7 8:58:37
6/7 9:05:49
6/7 9:13:01
6/7 9:20:13
6/7 9:27:25
6/7 9:34:37
Unit 3 Exhaust Stack - VOC Concentration - Run 2
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
6/7 9:51:00
6/7 9:58:12
6/7 10:05:24
6/7 10:12:36
6/7 10:19:48
6/7 10:27:00
6/7 10:34:12
6/7 10:41:24
6/7 10:48:36
Unit 3 Exhaust Stack - VOC Concentration - Run 3
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
6/7 11:05:04
6/7 11:12:16
6/7 11:19:28
6/7 11:26:40
6/7 11:33:52
6/7 11:41:04
6/7 11:48:16
6/7 11:55:28
6/7 12:02:40

Appendix A.4
RM CEMS Test Data

Run Number: 1 **Unit #1 (EUCHP1)**
Start Time: 6/7/2022 13:25
Stop Time: 6/7/2022 14:25

Minute Number	Raw 3A - O2 Concentration (uncorrected) (%) (dry)	Raw VOC Concentration (uncorrected) (ppmv) (dry)
1	10.22	377.37
2	10.23	378.63
3	10.24	376.69
4	10.23	375.81
5	10.24	376.48
6	10.24	375.49
7	10.23	376.80
8	10.23	376.08
9	10.23	376.82
10	10.23	375.10
11	10.24	376.22
12	10.25	375.80
13	10.25	376.29
14	10.25	377.31
15	10.24	377.16
16	10.24	377.35
17	10.23	376.78
18	10.23	376.94
19	10.22	375.85
20	10.22	375.26
21	10.23	375.56
22	10.23	376.69
23	10.23	376.43
24	10.23	375.82
25	10.25	375.42
26	10.25	376.21
27	10.26	374.55
28	10.27	375.24
29	10.27	373.50
30	10.27	374.75
31	10.27	374.68
32	10.28	373.82
33	10.28	374.14
34	10.28	375.06
35	10.27	374.83
36	10.26	373.38
37	10.26	372.53
38	10.26	374.62
39	10.25	373.48
40	10.25	373.84
41	10.25	374.40
42	10.25	373.18
43	10.26	371.65
44	10.28	372.67
45	10.27	372.93
46	10.27	373.02
47	10.26	371.93
48	10.26	372.00
49	10.27	373.44
50	10.28	373.32
51	10.27	374.53
52	10.26	373.01
53	10.26	372.27
54	10.25	372.12
55	10.25	372.91
56	10.25	373.62
57	10.24	371.69
58	10.25	373.04
59	10.25	372.06
60	10.25	371.74
AVERAGE:	**10.25**	**374.67**

RUN 1 - SIXTY (60) 1-MINUTE AVERAGES RESULTS

Run Number: 2 **Unit #1 (EUCHP1)**
Start Time: 6/7/2022 14:38
Stop Time: 6/7/2022 15:38

Minute Number	Raw 3A - O2 Concentration (uncorrected) (%) (dry)	Raw VOC Concentration (uncorrected) (ppmv) (dry)
1	10.26	378.20
2	10.24	377.18
3	10.24	378.87
4	10.25	377.37
5	10.25	378.39
6	10.27	378.88
7	10.27	379.35
8	10.27	378.94
9	10.26	378.21
10	10.25	377.28
11	10.26	378.15
12	10.26	377.69
13	10.27	379.10
14	10.26	377.34
15	10.26	377.96
16	10.26	375.10
17	10.26	377.50
18	10.26	377.06
19	10.27	375.49
20	10.27	376.58
21	10.27	376.60
22	10.27	377.05
23	10.28	377.02
24	10.28	376.36
25	10.29	375.82
26	10.30	376.44
27	10.30	377.59
28	10.29	377.46
29	10.29	377.12
30	10.28	375.97
31	10.28	376.08
32	10.28	375.10
33	10.29	375.97
34	10.29	379.94
35	10.28	379.11
36	10.28	381.81
37	10.28	380.59
38	10.28	380.81
39	10.28	380.79
40	10.29	380.98
41	10.29	378.51
42	10.30	378.36
43	10.31	378.86
44	10.30	378.97
45	10.29	378.95
46	10.54	373.96
47	10.34	375.26
48	10.31	374.22
49	10.32	374.42
50	10.31	373.88
51	10.31	374.66
52	10.30	373.76
53	10.30	374.64
54	10.32	372.74
55	10.32	372.18
56	10.31	369.00
57	10.32	370.17
58	10.33	370.51
59	10.32	369.20
60	10.32	369.31
AVERAGE:	**10.29**	**376.58**

RUN 2 - SIXTY (60) 1-MINUTE AVERAGES RESULTS

Run Number: 3 **Unit #1 (EUCHP1)**
Start Time: 6/7/2022 15:55
Stop Time: 6/7/2022 16:55

Minute Number	Raw 3A - O2 Concentration (uncorrected) (%) (dry)	Raw VOC Concentration (uncorrected) (ppmv) (dry)
1	10.33	378.65
2	10.33	376.82
3	10.32	377.51
4	10.32	377.72
5	10.32	378.46
6	10.33	380.28
7	10.32	377.47
8	10.32	380.28
9	10.33	379.15
10	10.34	379.10
11	10.33	381.04
12	10.33	380.57
13	10.33	379.66
14	10.33	378.81
15	10.34	379.47
16	10.33	378.99
17	10.33	379.41
18	10.34	378.44
19	10.32	378.67
20	10.34	378.93
21	10.34	378.75
22	10.33	378.55
23	10.31	377.96
24	10.31	377.60
25	10.31	378.63
26	10.30	378.30
27	10.31	380.11
28	10.31	378.22
29	10.31	378.93
30	10.31	378.56
31	10.30	378.85
32	10.29	378.31
33	10.30	378.94
34	10.29	378.26
35	10.29	377.93
36	10.29	379.29
37	10.30	378.91
38	10.30	379.79
39	10.30	379.32
40	10.30	378.98
41	10.30	377.92
42	10.31	378.11
43	10.31	378.90
44	10.30	379.05
45	10.30	378.47
46	10.30	378.91
47	10.29	378.69
48	10.29	379.53
49	10.30	377.88
50	10.30	377.64
51	10.31	378.42
52	10.30	379.68
53	10.31	378.96
54	10.31	378.97
55	10.30	380.45
56	10.30	379.57
57	10.30	380.49
58	10.30	380.35
59	10.30	382.09
60	10.29	383.34
AVERAGE:	**10.31**	**379.02**

RUN 3 - SIXTY (60) 1-MINUTE AVERAGES RESULTS

Run Number: 1 **Unit #3 (EUCHP3)**
Start Time: 6/7/2022 8:37
Stop Time: 6/7/2022 9:37

Minute Number	Raw 3A - O2 Concentration (uncorrected) (%) (dry)	Raw VOC Concentration (uncorrected) (ppmv) (dry)
1	10.32	415.39
2	10.32	417.45
3	10.32	418.74
4	10.32	418.13
5	10.32	419.86
6	10.32	420.79
7	10.32	418.44
8	10.32	416.66
9	10.32	419.08
10	10.32	417.71
11	10.32	418.85
12	10.32	415.33
13	10.32	416.73
14	10.33	418.84
15	10.33	416.18
16	10.32	414.94
17	10.33	415.65
18	10.32	415.42
19	10.33	414.89
20	10.33	413.83
21	10.33	412.58
22	10.32	411.84
23	10.32	410.53
24	10.32	410.56
25	10.32	411.03
26	10.31	410.23
27	10.31	409.77
28	10.31	409.99
29	10.32	411.53
30	10.34	408.01
31	10.35	403.54
32	10.34	403.04
33	10.34	401.72
34	10.34	401.48
35	10.34	403.90
36	10.34	404.46
37	10.34	402.82
38	10.34	401.74
39	10.34	404.58
40	10.35	402.98
41	10.35	404.83
42	10.35	405.29
43	10.34	404.02
44	10.33	402.10
45	10.34	406.38
46	10.35	405.56
47	10.35	405.37
48	10.34	403.76
49	10.35	406.50
50	10.34	406.24
51	10.33	404.59
52	10.33	406.26
53	10.33	405.69
54	10.33	406.26
55	10.33	405.44
56	10.33	404.92
57	10.33	405.12
58	10.33	407.51
59	10.34	407.30
60	10.33	407.43
AVERAGE:	**10.33**	**409.83**

RUN 1 - SIXTY (60) 1-MINUTE AVERAGES RESULTS

Run Number: 2 **Unit #3 (EUCHP3)**
Start Time: 6/7/2022 9:51
Stop Time: 6/7/2022 10:51

Minute Number	Raw 3A - O2 Concentration (uncorrected) (%) (dry)	Raw VOC Concentration (uncorrected) (ppmv) (dry)
1	10.35	406.68
2	10.35	408.10
3	10.38	409.30
4	10.36	408.65
5	10.35	405.98
6	10.34	406.70
7	10.36	405.90
8	10.37	404.09
9	10.35	404.03
10	10.36	401.86
11	10.37	404.44
12	10.36	404.25
13	10.36	407.17
14	10.35	405.97
15	10.37	404.44
16	10.36	405.04
17	10.36	404.94
18	10.36	403.29
19	10.35	402.12
20	10.34	402.26
21	10.36	403.60
22	10.36	403.62
23	10.36	403.15
24	10.33	403.60
25	10.33	403.29
26	10.33	405.23
27	10.33	407.00
28	10.33	404.79
29	10.34	407.26
30	10.33	405.48
31	10.33	407.32
32	10.34	406.95
33	10.34	408.95
34	10.34	407.78
35	10.34	408.55
36	10.34	407.94
37	10.34	405.83
38	10.34	406.45
39	10.33	404.63
40	10.33	405.25
41	10.33	404.28
42	10.33	404.58
43	10.33	405.70
44	10.33	406.76
45	10.33	405.52
46	10.33	405.93
47	10.34	406.68
48	10.33	402.93
49	10.33	405.80
50	10.33	403.90
51	10.33	405.16
52	10.33	405.06
53	10.33	405.26
54	10.34	405.77
55	10.34	402.75
56	10.33	403.32
57	10.33	402.70
58	10.33	402.01
59	10.33	403.86
60	10.33	406.81
AVERAGE:	**10.34**	**405.28**

RUN 2 - SIXTY (60) 1-MINUTE AVERAGES RESULTS

Run Number: 3 **Unit #3 (EUCHP3)**
Start Time: 6/7/2022 11:05
Stop Time: 6/7/2022 12:05

Minute Number	Raw 3A - O2 Concentration (uncorrected) (%) (dry)	Raw VOC Concentration (uncorrected) (ppmv) (dry)
1	10.36	407.03
2	10.35	408.04
3	10.34	406.22
4	10.34	403.61
5	10.34	404.48
6	10.34	405.95
7	10.34	403.43
8	10.34	404.43
9	10.34	404.60
10	10.34	405.55
11	10.34	406.46
12	10.34	404.98
13	10.36	406.18
14	10.36	406.49
15	10.34	404.95
16	10.34	405.43
17	10.34	405.26
18	10.34	405.77
19	10.34	405.26
20	10.36	408.76
21	10.36	407.59
22	10.36	408.57
23	10.33	406.96
24	10.33	406.64
25	10.33	407.55
26	10.33	406.77
27	10.32	407.27
28	10.34	409.09
29	10.33	406.85
30	10.33	405.50
31	10.33	407.64
32	10.34	410.61
33	10.34	406.38
34	10.34	406.07
35	10.34	406.54
36	10.34	406.27
37	10.34	406.88
38	10.34	409.04
39	10.34	407.39
40	10.34	408.62
41	10.34	408.03
42	10.35	406.41
43	10.38	406.09
44	10.39	403.98
45	10.40	402.14
46	10.45	402.13
47	10.46	400.25
48	10.47	400.68
49	10.46	402.12
50	10.47	401.64
51	10.47	401.75
52	10.41	403.02
53	10.38	403.49
54	10.44	401.23
55	10.45	401.10
56	10.42	402.12
57	10.37	403.72
58	10.46	400.66
59	10.45	398.49
60	10.38	402.85
AVERAGE:	**10.37**	**405.22**

RUN 3 - SIXTY (60) 1-MINUTE AVERAGES RESULTS

Appendix A.5
Example Calculations

EPA Methods 3A, 25A, and 320 Nomenclature and Sample Calculations

Run No. - 1

Constants

CO_2F_{wt}= 44.0	in wg= 0.073529	NO_2F_{wt}= 46.01	$HClF_{wt}$= 36.46
O_2F_{wt}= 32.0	gr= 0.000142857	COF_{wt}= 28.01	SO_2F_{wt}= 64.06
CON_2F_{wt}= 28.0	mmBtu= 1000000 Btu	$H_2SO_4F_{wt}$= 98.08	Cl_2F_{wt}= 70.91
H_2OF_{wt}= 18.015	CF_{wt}= 12.011	T_{std}= 527.67	P_{std}= 29.92
ArF_{wt}= 40.0	PF_{wt}= 44.0962		

Stack Variables

Cp =	0.84		pitot tube coefficient (dimensionless)
P_{bar} =	29.84	in. Hg	barometric pressure
E_{box} =	0	ft	elevation difference between ground level and meter box
E_{sam} =	37	ft	elevation difference between ground level and sampling ports
$\%CO_2$ =	6.04	%	percent CO_2 by volume (dry basis) (dimensionless)
$\%O_2$ =	10.21	%	percent O_2 by volume (dry basis) (dimensionless)
A =	1.2272	ft^2	stack cross-sectional area
P_g =	-1.70	in. H_2O	flue gas static pressure
T_{savg} =	1192.31	R	average absolute flue gas temperature (460R+tsavg °F)
$SQ\Delta P_{avg}$ =	1.39	in. wg	average square root ΔP

Calculated Stack Variables

Barometric pressure at sampling location

NOTE: Barometric pressure recorded at ground level

$$P_{sam} = P_{bar} - [(E_{sam} / 100 \text{ ft}) * 0.1 \text{ in. Hg}]$$

$$P_{sam} = 29.84 - ((37.0 / 100) * 0.1)$$

$$P_{sam} = 29.80 \text{ in. Hg}$$

Percent moisture by volume as measured in flue gas utilizing an FTIR

$$\%H_2O = 11.29$$

Absolute flue gas pressure

$$P_s = P_{sam} + (Pg / 13.6)$$

$$P_s = 29.80 + (-1.70 / 13.6)$$

$$P_s = 29.68 \text{ in. Hg}$$

Dry mole fraction of flue gas (dimensionless)

$$M_{fd} = 1 - (\%H_2O / 100)$$

$$M_{fd} = 1 - (11.29 / 100)$$

$$M_{fd} = 0.887$$

Dry molecular weight of flue gas (lb/lb-mole)

$$M_d = [(\%CO_2 / 100) * 44.0] + [(\%O_2 / 100) * 32.0] + [((100 - \%CO_2 - \%O_2) / 100) * 28.0]$$

$$M_d = ((6.04 / 100) * 44.0) + ((10.21 / 100) * 32.0) + (((100 - 6.04 - 10.21) / 100) * 28.0)$$

$M_d =$ 29.38 lb/lb-mole

$M_d =$ 29.38

Wet molecular weight of flue gas (lb/lb-mole)

$$M_s = M_d * M_{fd} + (H_2OF_{wt} * (\%H_2O / 100))$$

$$M_s = 29.375 * 0.887 + 18.02 * (11.29 / 100)$$

$M_s =$ 28.09 lb/lb-mole

Average flue gas velocity (ft/sec)

$$v_s = 85.49 * Cp * (SQ\Delta P_{avg}) * (T_{savg} / (P_s * M_s))^{0.5}$$

$$v_s = 85.49 * 0.84 * (1.3912) * (1{,}192.31 / (29.678 * 28.093)) \text{ ^ } 0.5$$

$v_s =$ 119.48 ft/sec

Wet volumetric flue gas flow rate at actual conditions (acfm)

$$Q_{aw} = v_s * A * 60 \text{ sec/min}$$

$$Q_{aw} = 119.476 * 1.227 * 60$$

$Q_{aw} =$ 8,797 ft^3/min

Wet volumetric flue gas flow rate at standard conditions (scfm)

$$Q_{sdw} = v_s * A * (T_{std} / T_{savg}) * (P_s / P_{std}) * 60 \text{ sec/min}$$

$$Q_{sdw} = 119.476 * 1.227 * (527.7 / 1{,}192.313) * (29.678 / 29.92) * 60$$

$Q_{sdw} =$ 3,862 ft^3/min

Dry volumetric flue gas flow rate at standard conditions (dscfm)

$$Q_{sd} = M_{fd} * v_s * A * (T_{std} / T_{savg}) * (P_s / P_{std}) * 60 \text{ sec/min}$$

$$Q_{sd} = 0.887 * 119.4758 * 1.2272 * (527.7 / 1{,}192.313) * (29.678 / 29.92) * 60$$

$Q_{sd} =$ 3,426 ft^3/min

Percent Excess Air

$$\%EA = [\%O_2 - (0.5) * \%CO] / [0.264 * (100 - \%CO_2 - \%O_2) - (\%O_2 - 0.5 * \%CO)]$$

$$\%EA = ((10.21 - (0.5) * 0.00) / (0.264 * (100 - 6.04 - 10.21) - (10.21 - 0.5 * 0.00))) * 100$$

%EA = 85.77 %

Fuel Data

Brake Horsepower (BHP)

BHP = 1744.8

Method 25A Calculations

THC concentration (ppmvd as propane)

THCppmvd = 424.56 ppmvd as propane

Methane concentration (ppmvd as methane)

CH4ppmvd = 1096.25 ppmvd as methane

Methane:Propane Response Factor

M2P RF = 2.40

Methane concentration (ppmvd as propane)

CH4ppmvdP = CH4ppmvd / M2P RF

CH4ppmvdP = 456.77 ppmvd as propane

Ethane concentration (ppmvd as ethane)

C2H6ppmvd = 60.48 ppmvd as ethane

Ethane:Propane Response Factor

E2P RF = 1.50

Ethane concentration (ppmvd as propane)

C2H6ppmvdP = C2H6ppmvd / E2P RF

C2H6ppmvdP = 40.32 ppmvd as propane

NMEOC concentration (ppmvd as propane)

NMEOCppmvd = THCppmvd - CH4ppmvdP - C2H6ppmvdP

NMEOCppmvd = -72.53 ppmvd as propane

THC mass emission rate (lb/hr as propane)

MERTHC = (60 min/hr * THC ppmvd * PFwt * Qsd) / (385.3 ft3 * 106)

MERTHC = 10.0 lb/hr (as propane)

THC mass emission rate (g/bhp-hr as propane)

MERTHCgbhphr = MERTHC * 453.592 / BHP

MERTHCgbhphr = 2.60 lb/hr (as propane)

NMEOC mass emission rate (lb/hr as propane)

MERNMEOC = (60 min/hr * NMEOC ppmvd * PFwt * Qsd) / (385.3 ft3 * 106)

MERNMEOC = -1.7 lb/hr (as propane)

NMEOC mass emission rate (g/bhp-hr as propane)

MERNMEOCgbhphr = MERNMEOC * 453.592 / BHP

MERNMEOCgbhphr = -0.44 g-bhp-hr

Method 320 Calculations

CO concentratoin (ppmvd)

COppmvd = 7.45 ppmvd

CO mass emission rate (lb/hr)

MERCO = (60 min/hr * COppmvw * COFwt * lb * Qsd) / (385.3 ft3 * 106)

MERCO = 0.111 lb/hr

CO mass emission rate (g/bhp-hr)

MERCO = MERCO * 453.6 / BHP

MERCO = 0.029 g-bhp-hr