FINAL REPORT

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CITY OF GRAND RAPIDS

GRAND RAPIDS, MICHIGAN

COMPLIANCE TESTING REPORT: EUCHP1 AND EUCHP3 EMISSIONS REPORT

RWDI #2305586
September 15, 2023

SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI USA LLC (RWDI) has been retained by the City of Grand Rapids Environmental Support Department (Grand Rapids ESD) to complete the emission sampling program at the Grand Rapids Water Resource Recovery Facility (WRRF) located at 1300 Market Avenue SW, Grand Rapids, Michigan 49503. WRRF operates two (2) RICE engines, EUCHP1 and EUCHP3. Testing consisted of emissions for nitrogen oxides (NO_x), carbon monoxide (CO), non-methane organic compounds (NMOC), and formaldehyde (CH_2O) from each engine. The testing was required by Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit-to-install (PTI) 37-19B.

Compliance testing took place on July 18, 2023.

Executive Table i: Results Summary – Engine 1

Source	Analyte	Units	Average	Limit
EUCHP3	NO_x	$ppmv_d$ @ 15% O_2	41	82
		g/hp-hr	0.50	0.55
	CO	$ppmv_d$ @ 15% O_2	4.7	270
		g/hp-hr	0.03	0.44
	NMOC	$ppmv_d$ @ 15% O_2	4.5	80
		g/hp-hr	0.03	0.105
	CH_2O	lb/hr	0.076	0.056

After one (1) 60-minute test on EUCHP3, it was found that the engine was exceeding its permittable limit for formaldehyde. At this point, the testing program was stopped until a diagnosis could be completed to determine the cause. Testing did not commence on EUCHP1.

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1 INTRODUCTION

RWDI USA LLC (RWDI) has been retained by the City of Grand Rapids Environmental Support Department (Grand Rapids ESD) to complete the emission sampling program at the Grand Rapids Water Resource Recovery Facility (WRRF) located at 1300 Market Avenue SW, Grand Rapids, Michigan 49503. WRRF operates two (2) RICE engines, EUCHP1 and EUCHP3. Testing consisted of emissions for nitrogen oxides (NO_x), carbon monoxide (CO), non-methane organic compounds (NMOC), and formaldehyde (CH_2O) from each engine. The testing was required by Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit-to-install (PTI) 37-19B.

1.1 Location and Date of Testing

The testing program was completed on July 18, 2023 at the Grand Rapids WRRF facility located at 1300 Market Avenue SW, Grand Rapids, Michigan 49503.

1.2 Purpose of the Testing

The purpose of testing was to show compliance with Michigan Department of Environment, Great Lakes, and Energy PTI 37-19b.

1.3 Description of the Source

Grand Rapids WRRF operates two (2) RICE engines with a nominal rating of 1.411 MW, used for electricity generation and heat for a heat loop for the digester tanks and incidental building heat.

1.4 Personnel Involved in Testing

Table 1.4.1: List of Testing Personnel

Russel Lewis Supervisor RFLewis@grcity.us	**Blue Water Renewable, LLC** 1300 Market Ave SW Grand Rapids, Michigan	(616) 456-3639
Eric Grinstern Air Quality Division GrinsternE@michigan.gov	**State of Michigan** Department of Environment, Great Lakes, and Energy	(616)558-0616
Mason Sakshaug Technical Supervisor Mason.Sakshaug@rwdi.com	**RWDI USA LLC** 2239 Star Court Rochester Hills, MI 48309	(989) 323-0355
Ben Durham Senior Field Technician Ben.Durham@rwdi.com		(734) 474-1731

2 SUMMARY OF RESULTS

2.1 Operating Data

Operational data collected during the testing included the following (found in **Appendix A**):

- Engine Power Output (kW)
- Engine Operating Horsepower (bHp)
- Fuel flow

2.2 Applicable Permit Number

The purpose of testing was to show compliance with Michigan Department of Environment, Great Lakes, and Energy PTI 37-19b.

3 SOURCE DESCRIPTION

3.1 Description of Process and Emission Control Equipment

Refer to Section 1.3 for a description of the process. Both engines are equipped with an oxidation catalyst for the control of CO, VOC, and CH_2O.

3.2 Process Flow Sheet or Diagram

A process schematic can be provided upon request.

3.3 Type and Quantity of Raw and Finished Materials

The Engines use natural gas to produce power.

3.4 Normal Rated Capacity of Process

Both engines have a nominal rating of 1.411 MW (12.07 MMBTU/hr).

3.5 Process Instrumentation Monitored During the Testing

Engine parameters included the following:

- Engine Power Output (kW)
- Engine Operating Horsepower (bHp)
- Fuel flow

4 POLLUTANTS TO BE MEASURED

Testing consisted of emissions for nitrogen oxides (NO_x), carbon monoxide (CO), non-methane organic compounds (NMOC), and formaldehyde (CH_2O).

5 SAMPLING AND ANALYSIS PROCEDURES

The following section provides brief descriptions of the proposed sampling methods and discusses any proposed modifications to the reference test methods.

5.1 Stack Velocity, Temperature, and Volumetric Flow Rate Determination

The exhaust velocities and flow rates were determined following the USEPA Method 2, "Determination of Stack Gas Velocity and Flow Rate (Type S Pitot Tube)" from the outlet only. Velocity measurements were taken with a pre-calibrated S-Type pitot tube and incline manometer. Volumetric flow rates were determined following the equal area method as outlined in US EPA Method 2. Temperature measurements were made simultaneously with the velocity measurements and were conducted using a chromel-alumel type "k" thermocouple in conjunction with a digital temperature indicator.

The dry molecular weight of the stack gas was determined following calculations outlined in US EPA Method 3A "Determination of Molecular Weight of Dry Stack Gas" for O_2. USEPA Method 320 was used for CO_2 content.

Stack moisture content was determined in accordance with USEPA Method 320.

5.2 NO_x, CO, VOC and CH_20 by USEPA Method 320

Emissions testing was performed at the outlet of each engine. Pollutant concentrations was determined utilizing RWDI's continuous emissions monitoring system (CEM) which consists of the FTIR and oxygen analyzer (measuring on wet basis).

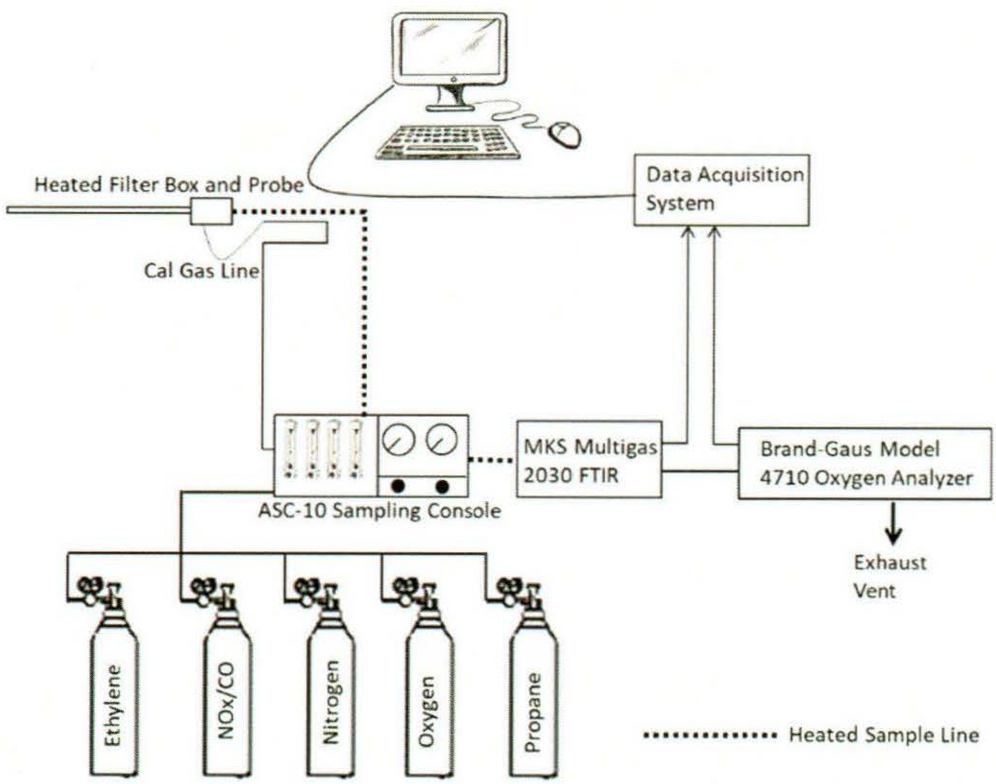
Stack gas concentrations for NO_x, CO, H_2O, CH_2O, CO_2 and O_2 was measured using EPA Reference Methods 320 and 3A.

Oxygen measurements were taken continuously following USEPA Method 3A on the outlet (using a wet oxygen analyzer or equivalent). Stratification checks using O_2 as the surrogate for all pollutants, was completed on the exhaust of each engine at three points (16.7%, 50% and 83.3% of inner diameter) on a line passing through the centroidal area, as per the alternative approach in EPA Method 7E Section 8.1.2.

Regular performance checks on the CEMS were carried out by zero and span calibration checks on the oxygen analyzer and necessary QA procedures on the FTIR using USEPA Protocol calibration gases. These checks will verify the ongoing precision of the FTIR with time by introducing pollutant-free (zero) air followed by known calibration gas (span) into the FTIR. The response of the monitor to pollutant-free air and the corresponding sensitivity to the span gases was reviewed frequently as an ongoing indication of analyzer performance.

Monitoring was conducted by drawing a sample stream of flue gases through a stainless-steel probe attached to a heated filter and a heated sample line that is attached to the MAX Analytical ASC-10ST sampling console. Lengths of unheated sample line was kept to a minimum and insulated. The ASC-10ST sampling console delivers a continuous sample to the MKS MultiGas 2030 FTIR and oxygen analyzer for analysis. The heated filter and line were maintained at approximately 191°C (375°F) and the MKS MultiGas 2030 FTIR and ASC-10ST gas components were kept at 191°C (375°F). The end of the probe was connected to a heated Teflon sample line, which will deliver the sample gases from the stack to the FTIR system. The heated sample line was designed to maintain the gas temperature at approximately 375°F to prevent condensation of stack gas moisture within the line and condition air to the same temperature as the FTIR. A schematic of the sampling system setup is depicted in **Figure 5.2a.**

Figure 5.2a: MKS 2030 Multigas FTIR/ASC-10ST/Model 4710 Oxygen Analyzer Sampling System Schematic



The ASC-10ST was used to deliver calibration gases (Calibration Transfer Standard (CTS), QA Spike and Nitrogen) to the FTIR in direct (to analyzer) and system (to probe) modes.

A laptop computer was utilized for operating the MKS MultiGas 2030 FTIR and MAX Analytical ASC-10ST sampling console and logging the multi-gas FTIR data. Data was logged as one-minute averages for the actual test period (FTIR PRN files and Spectra). All concentration data was determined using the MKS 2030 MultiGas FTIR software. A typical MKS 2030 FTIR and ASC-10 ST configuration is depicted in **Figure 5.2b.**

For oxygen measurement only, prior to testing, a 3-point analyzer calibration error check was conducted using USEPA protocol gases. The calibration error check was performed by introducing zero, mid and high-level calibration gases directly into the analyzer. The calibration error check was performed to confirm that the analyzer response is within ±2% of the certified calibration gas introduced. Prior to each test run, a system-bias test was performed where known concentrations of calibration gases were introduced at the probe tip to measure if the analyzers response was within ±5% of the introduced calibration gas concentrations. At the conclusion of each test run a system-bias check was performed to evaluate the percent drift from pre and post-test system bias checks. The system bias checks were used to confirm that the analyzer did not drift greater than ±3% throughout a test run. The analyzer will measure the respective gas concentrations on a wet volumetric basis which was converted to a dry volumetric number.

The probe tip was equipped with a heated filter for particulate removal. The end of the probe was connected to a heated Teflon sample line, which will deliver the sample gases from the stack to the FTIR/4710 Oxygen analyzer system. The heated sample line was designed to maintain the gas temperature at approximately 375°F to prevent condensation of stack gas moisture within the line.

Figure 5.2b: Typical MKS 2030 Multigas FTIR and ASC-10ST Configuration

6 NUMBER AND LENGTH OF SAMPLING RUNS

Testing consisted of one (1) 1-hour test on EUCHP3. Testing on EUCHP1 was not completed.

7 STACK INFORMATION

EUCHP1 and EUCHP3 had identical stack measurements.

Table 7.1: Summary of the Stack Characteristics

Source	Diameter	Approximate Duct Diameters from Flow Disturbance	Number of Ports	Points per Traverse	Total Points per Test
EUCHP1 EUCHP3	15"	2.13 downstream and 2.67 upstream	2	8	16 Flow

8 FLUE GAS CONDITIONS

Table 8.1: Flue Gas Conditions

Parameter	Flue Gas Conditions		
	Stack Temperature	Flow Rate	Percent Moisture
EUCHP1	NA	NA	NA
EUCHP3	753°F	4,008 dscfm	11.35%

9 TEST RESULTS AND DISCUSSION

9.1 Detailed Results

Detailed results for all analytes are provided in **Appendices B and C**.

Table 9.1.1: Results Summary – EUCHP3

Source	Analyte	Units	Average	Limit
EUCHP3	NO_x	ppmv$_d$ @ 15% O_2	41	82
		g/hp-hr	0.50	0.55
	CO	ppmv$_d$ @ 15% O_2	4.7	270
		g/hp-hr	0.03	0.44
	NMOC	ppmv$_d$ @ 15% O_2	4.5	80
		g/hp-hr	0.05	0.105
	CH_2O	lb/hr	0.076	0.056

9.2 Discussion of Results

The detailed results of individual tests can be found in **Appendices B and C**.

After one (1) 60-minute test on EUCHP3, it was found that the engine was exceeding its permittable limit for formaldehyde. At this point, the testing program was stopped until a diagnosis could be completed to determine the cause. Testing did not commence on EUCHP1.

9.3 Variations in Testing Procedures

Only one (1) test was completed on unit EUCHP3. Testing was not completed on EUCHP1.

9.4 Process Upset Conditions During Testing

There were no upsets in the process during testing.

9.5 Maintenance Performed in Last Three Months

All maintenance in the last three months has been routine.

9.6 Re-Test

This was not a retest.

9.7 Audit Samples

This test did not require any audit samples.

9.8 Process Data

Process data can be found in **Appendix A**.

9.9 Field Notes

Field notes can be found in **Appendix D**.

9.10 Calibration Data

Calibration can be found in **Appendix E**.

9.11 Source Testing Plan and EGLE Correspondence

Copy of the correspondence received from the Source Testing Plan from EGLE and the Source Testing Plan submitted can be found in **Appendix F**.

9.12 Example Calculations

Example calculations can be found in **Appendix G**.

9.13 Laboratory Data

There was no laboratory data affiliated with this testing.

TABLES

Table 1: Summary of Emissions - EUCHP3

Grand Rapids ESD

Facility: Grand Rapids ESD
City: Grand Rapids, MI
Source: EUCHP3
Date: 7/18/2023

	Symbol	Units	Test 1	Corrected to 15% O_2	Limits
Nitrogen Oxides Concentration	NO_x	ppmvd	74.05	41.28	82.0
Carbon Monoxide Concentration	CO	ppmvd	8.41	4.71	270
Formaldehyde Concentration	CH2O	ppmvd	4.08	-	
Oxygen Concentration	O_2	$\%_{wet}$	9.32	-	-
Oxygen Concentration	O_2	$\%_{dry}$	10.51	-	-
VOC (as propane) Concentration	C3H8	ppmvd	7.89	4.48	60
Formaldehyde Emission Rate	CH2O	pph	0.076	-	0.056
Nitrogen Oxides Concentration	NO_x	g/HP-hr	0.50	-	0.55
Carbon Monoxide Concentration	CO	g/HP-hr	0.03	-	0.44
Non-Methane Organic Compounds Concentration	NMOC	g/HP-hr	0.05	-	0.105

Table 2: EUCHP3 Flow Measurements

Grand Rapids ESD

Facility: Grand Rapids ESD
City: Grand Rapids, MI
Source: EUCHP3

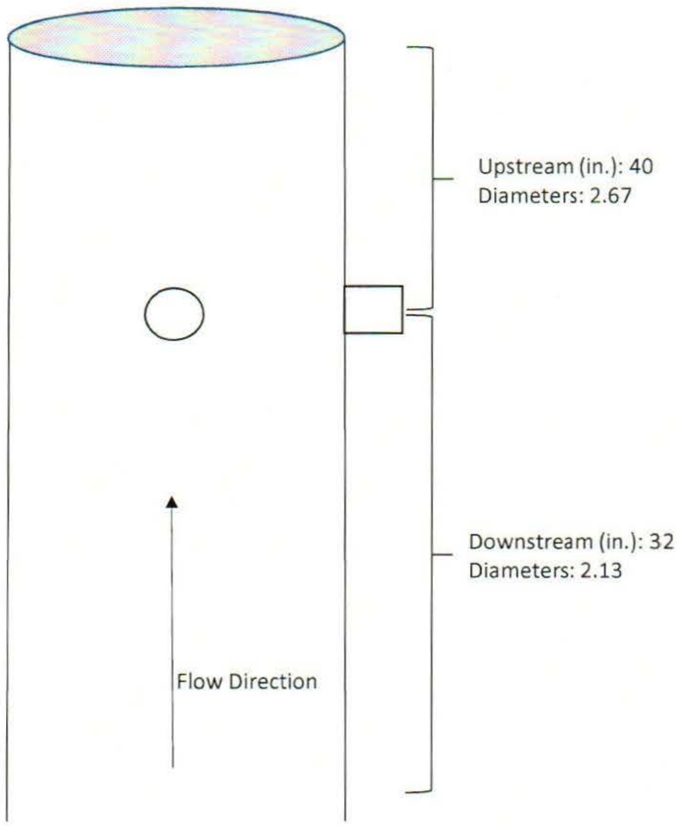
Parameter	Units	Test 1
Stack Gas Temperature	°F	753.1
Stack Gas Moisture	%	11.35
Velocity	ft/sec	144.9
Actual Flowrate	acfm	10,665
Dry Reference Flowrate	dscfm	4,008
Dry Reference Flowrate	m^3/s	1.89

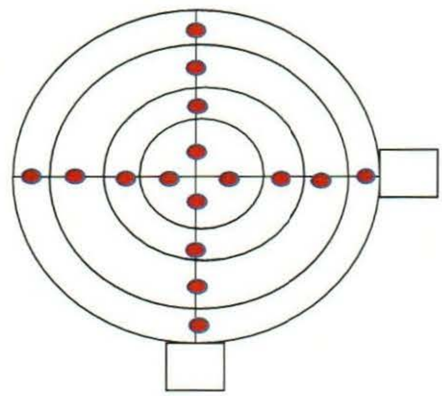
FIGURES

Figure No. 1

Diameter: 15

Sampling Points (in.)	
1	0.50
2	1.58
3	2.91
4	4.85
5	10.16
6	12.09
7	13.43
8	14.50





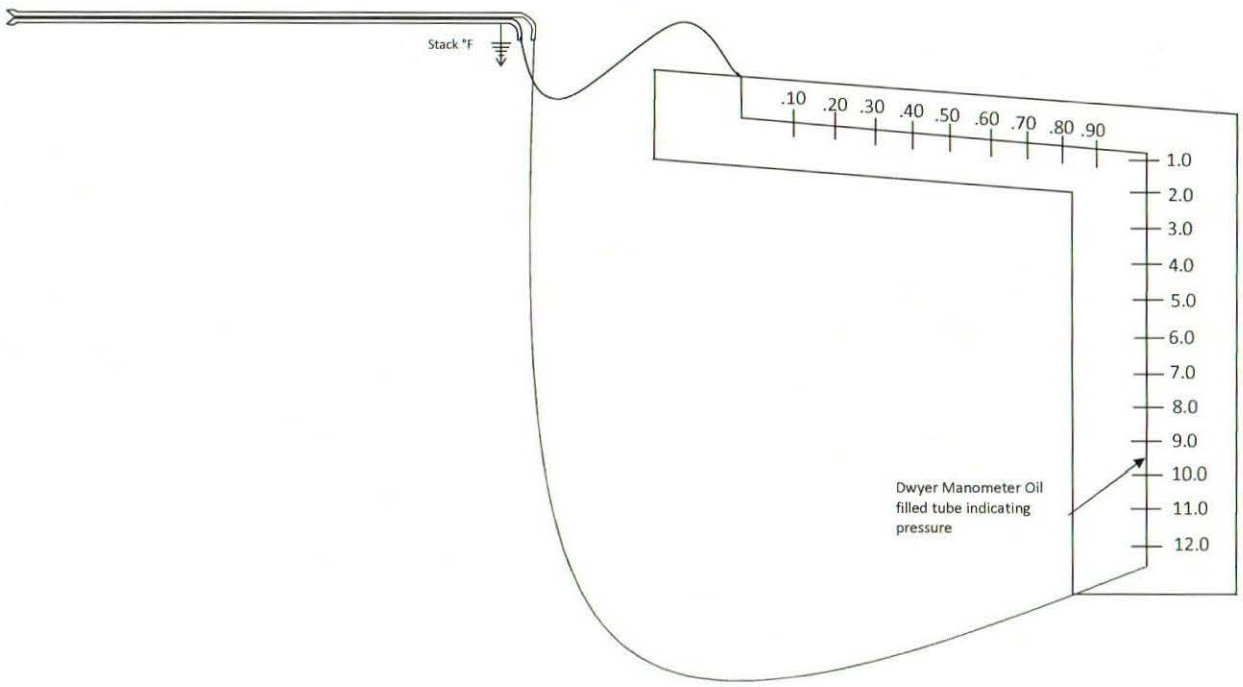
Not to scale

EUCHP1 & EUCHP3
City of Grand Rapids
WRRF
Grand Rapids, Michigan

Date:
18-Jul-23

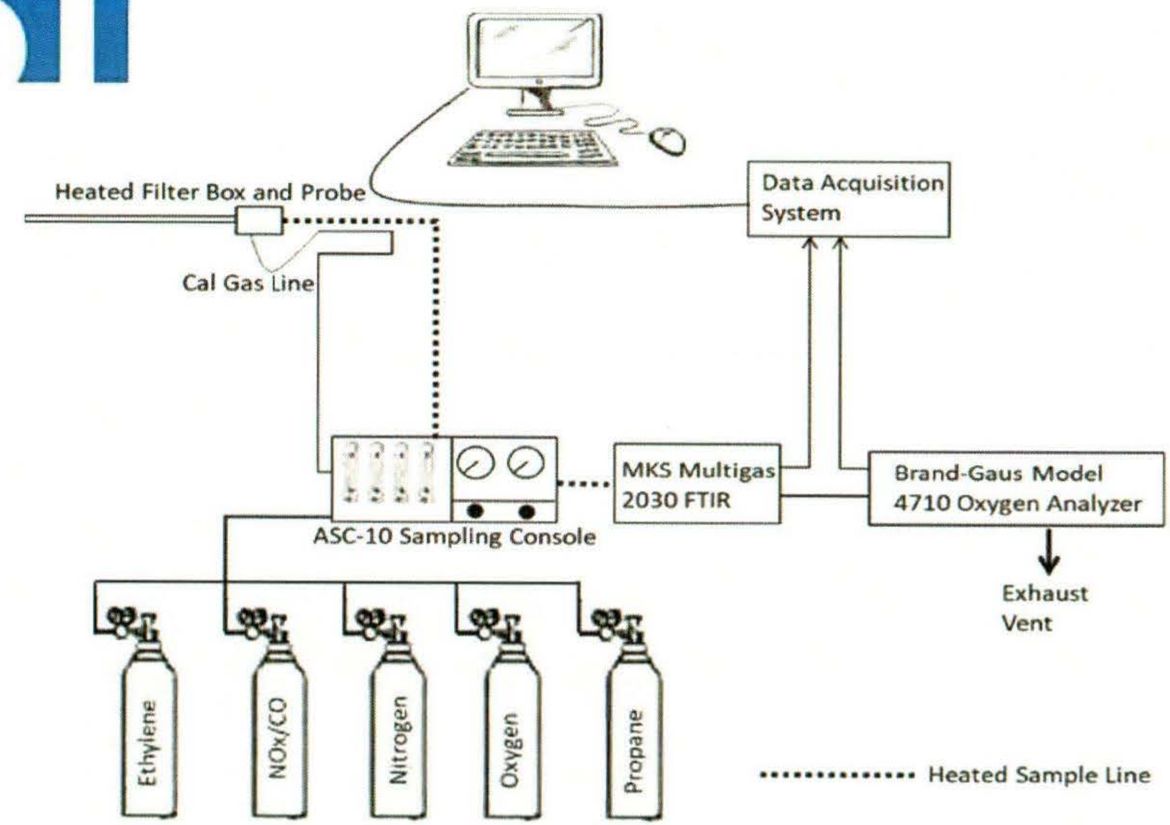
RWDI USA LLC
2239 Star Court
Rochester Hills, MI 48309

Figure No. #2: USEPA 2 Schematic



USEPA Method 2 **Grand Rapids ESD** EUCHP3 Grand Rapids, Michigan Project #2305586	**Date: July 18, 2023**

Figure No. #3: USEPA 3A/320 Schematic



USEPA Method 3A/320

Grand Rapids ESD

EUCHP3

Grand Rapids, Michigan

Project# 2305586

Date: July 18, 2023