FINAL REPORT

CITY OF WARREN WASTEWATER TREATMENT PLANT

WARREN, MICHIGAN

PERFORMANCE TESTING:
SEWAGE SLUDGE INCINERATOR (EU-INCINERATOR)

RWDI #2304506
August 21, 2023

SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI USA LLC (RWDI) was retained by The City of Warren Wastewater Treatment Plant (Warren WWTP) to complete a testing program at the sewage sludge incinerator (EU-INCINERATOR) located in Warren, Michigan. The purpose of the testing program was to determine compliance of EU-INCINERATOR with Michigan EGLE Permit Number MI-ROP-B1792-2021 and 40 CFR 60 Subpart MMMM requirements. Testing consisted of the following:

- Carbon Monoxide (CO);
- Oxides of Nitrogen (NO_x);
- Sulfur Dioxide (SO_2);
- Filterable Particulate Matter (PM);
- Hydrogen Chloride (HCl);
- Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF);
- Lead (Pb);
- Cadmium (Cd);
- Mercury (Hg); and
- Visible Emissions.

Executive i: Results Summary - CEMS

Parameter	Units	Test 1	Test 2	Test 3	Average	ROP Limit
NOx	ppm @ 7% O_2	136.17	111.35	131.99	126.5	220
CO	ppm @ 7% O_2	1,324.0	1,716.3	1,549.4	1529.9	3,800
SO_2	ppm @ 7% O_2	4.98	10.41	0.54	5.31	26

Executive ii: Results Summary – Method 5, 26A, 23 and 29

Parameter	Units	Test 1	Test 2	Test 3	Average	ROP Limit
PM	mg/dscm @ 7% O_2	31.76	8.44	10.07	16.76	80
	lb per 1,000 lb of exhaust air, corrected to 50% excess air	0.022	0.006	0.007	0.011	0.2
HCl	ppm @ 7% O_2	0.28	0.25	0.39	0.30	1.2
D&F (TEQ)	ng/m^3 @ 7% O_2	0.053	0.042	0.036	0.044	0.32
Pb	mg/dscm @ 7% O_2	0.013	0.018	0.009	0.013	0.30
Cd	mg/dscm @ 7% O_2	0.0028	0.0032	0.0021	0.0027	0.095
Hg	mg/dscm @ 7% O_2	0.040	0.050	0.039	0.043	0.28

Executive iii: Results Summary – Method 22 – Visible Emissions

Parameter	Units	Test 1	Test 2	Test 3	Average	ROP Limit
Visible Emissions	Percentage	0%	0%	0%	0%	5%

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1 INTRODUCTION

RWDI USA LLC (RWDI) was retained by The City of Warren Wastewater Treatment Plant (Warren WWTP) to complete a testing program at the sewage sludge incinerator (EUINCINERATOR) located in Warren, Michigan. The purpose of the testing program was to determine compliance of EUINCINERATOR with Michigan EGLE Permit Number MI-ROP-B1792-2021 and 40 CFR 60 Subpart MMMM requirements. Testing consisted of the following:

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- Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF);
- Lead (Pb);
- Cadmium (Cd);
- Mercury (Hg); and
- Visible Emissions.

1.1 Location and Dates of Testing

The test program was completed on June 27th and 28th, 2023 at the Warren WWTP.

1.2 Purpose of Testing

The testing program was completed as compliance testing under Permit MI-ROP-B1792-2021 and to demonstrate compliance with the emission limitations contained in the applicable New Source Performance Standard (NSPS) at 40 CFR Part 60 Subpart MMMM.

1.3 Description of Source

The process is a Nichols Herreshoff hearth sludge incinerator with ten hearths. Processed sewage sludge solids are dried and combusted with natural gas as a supplemental fuel during the incineration process. Emissions from the incinerator are controlled by a VenturiPak wet scrubber consisting of three stages including: 1) Quench stage, 2) Subcooling Stage (Impingement Type Wet Scrubber), and 3) Venturi Stage followed by a mist eliminator.

1.4 Personnel Involved in Testing

Table 1.4: Testing Personnel

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2 PROCESS INFORMATION

Operational data collected during the testing is provided in **Appendix A**.

3 SOURCE DESCRIPTION

3.1 Description of Process and Emission Control Equipment

Refer to Section 1.3 for a description of the process.

3.2 Process Flow Sheet or Diagram

Stack parameters are found in **Figure 1a and 1b**.

3.3 Type and Quantity of Raw and Finished Materials

The process combusts dewatered biosolids which are fed to the incinerator at a maximum rate of 6.6 wet tons per hour, which is equivalent to an 85% feed rate of 5.6 wet tons per hour.

3.4 Normal Rated Capacity of Process

The rated capacity of the facility is 6.6 wet tons of biosolids per hour. Average production is typically between 4.5 to 5.5 wet tons per hour.

3.5 Process Instrumentation Monitored During the Test

An O_2 continuous emissions monitoring system is permanently installed to monitor O_2 concentrations in the gas stream and O_2 is monitored during the testing. The incinerator process is regulated through monitoring of combustion temperature and exhaust gas pressure drop. Water flow through the scrubber and pH of the scrubber water is also monitored.

4 SAMPLING AND ANALYSIS PROCEDURES

The emission test program will utilize the following test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A)

- Method 1 – Sample and Velocity Traverses for Stationary Sources
- Method 2 – Determination of Stack Gas Velocity and Volumetric Flowrate
- Method 3A – Determination of Molecular Weight of Dry Stack Gases
- Method 4 – Determination of Moisture Content in Stack Gases
- Method 5 – Determination of Particulate Matter Emissions from Stationary Sources
- Method 6C – Determination of Sulfur Dioxide Emissions from Stationary Sources
- Method 7E – Determination of Nitrogen Oxides Emissions from Stationary Sources
- Method 10 – Determination of Carbon Monoxide Emissions from Stationary Sources
- Method 23 – Determination of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans from Stationary Sources
- Method 26A – Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources
- Method 29 – Determination of Metals Emissions from Stationary Sources
- Method 205 – Verification of Gas Dilution Systems for Field Instrument Calibrations
- Method 22 – Visible Determination of Fugitive Emissions

4.1 Stack Velocity, Temperature, and Volumetric Flow Rate (EPA Method 1-4)

Stack gas velocity traverses were conducted in accordance with the procedures outlined in Method 1 and Method 2. S-type pitot tubes with thermocouple assemblies, calibrated in accordance with Method 2, Section 4.1.1, was used to measure exhaust gas velocity pressures (using a manometer) and temperatures during testing. The S-type pitot tube dimensions outlined in Sections 2-6 through 2-8 was within specified limits, therefore, a baseline pitot tube coefficient of 0.84 (dimensionless) will be assigned. A diagram of the sample points is provided in Figure 1. Cyclonic flow checks were performed. The existence of cyclonic flow was determined by measuring the flow angle at each sample point. The flow angle was the angle between the direction of flow and the axis of the stack. If the average of the absolute values of the flow angles is greater than 20 degrees, cyclonic flow exists. The Molecular Weight of the gas stream was evaluated according to procedures outlined in Title 40, Part 60, Appendix A, Method 3A. The O_2 /CO_2 content of the gas stream was measured using an analyzer. Exhaust gas was extracted as part of the sampling train. Exhaust gas moisture content was determined gravimetrically.

4.2 Carbon Monoxide, Oxides of Nitrogen, Sulfur Dioxide, Oxygen, and Carbon Dioxide (EPA Methods 3A, 6C, 7E, and 10)

NOx, SO_2, CO, O_2, and CO_2 concentrations was determined utilizing RWDI's continuous emissions monitoring (CEM) system. 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.

Zero and upscale calibration checks was conducted both before and after each test run to quantify measurement system calibration drift and sampling system bias. Upscale is either the mid- or high-range gas, whichever most closely approximates the flue gas level. During these checks, the calibration gases was introduced into the sampling system at the probe outlet so that the calibration gases was analyzed in the same manner as the flue gas samples.

A gas sample was continuously extracted from the stack and delivered to a series of gas analyzers, which measure the pollutant or diluent concentrations in the gas. The analyzers were calibrated on-site using EPA Protocol No. 1 certified calibration mixtures. The probe tip was equipped with a sintered stainless-steel filter for particulate removal. The end of the probe will be connected to a heated Teflon sample line, which delivers the sample gases from the stack to the CEM system. The heated sample line will be designed to maintain the gas temperature above 250°F to prevent condensation of stack gas moisture within the line.

Before entering the analyzers, the gas sample passed directly into a refrigerated condenser, which cools the gas to approximately 35°F to remove the stack gas moisture. After passing through the condenser, the dry gas was enter a Teflon-head diaphragm pump and a flow control panel, which will deliver the gas in series to the NO_x, SO_2, CO, O_2, CO_2 analyzers. Each of these analyzers were measure the respective gas concentrations on a dry volumetric basis.

4.3 Particulate Matter and Hydrochloric Acid (EPA Method 5/26A)

Method 5, "Determination of Particulate Emissions from Stationary Sources" and Method 26A, "Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources" was used to measure particulate matter and hydrochloric acid concentrations and emission rates. Figure 2 provides the sampling train. The stack sampling system was consist of (1) a glass nozzle, (2) a steel probe with glass liner, (3) tared quartz filter, (4) a set of four Greenburg-Smith (GS) impingers with the first and third modified and the second was a standard GS impinger, The first two contained 100 ml 0.1N H_2SO_4, the third empty, and a fourth impinger filled with silica gel, (5) a length of sample line, and (6) a calibrated pump and dry gas meter. A sampling train leak test was conducted before and after each test run. After completion of the final leak test for each test run, the filter was recovered, and the probe, nozzle and the front half of the filter holder assembly was brushed, and triple rinsed with acetone. The acetone rinses was collected in a pre-cleaned sample container. The impinger catch solution was transferred to pre-cleaned sample containers. The impingers and back half of the filter housing was triple rinsed with deionized water (DI H20), and the rinses added to the back half train sample jar. The containers were labeled with the test number, test location, test date, and the level of liquid will be marked on the outside of each container.

4.4 Dioxins and Furans (EPA Method 23)

Method 23, " Determination of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans from Stationary Sources " was used to evaluate CDD/CDF concentrations. Figure 4 provides the sampling train. The Method 23 sampling train was consist of (1) a borosilicate glass or quartz nozzle, (2) a steel probe with glass liner, (3) a heated quartz filter, (4) a glass recirculating ice water condenser system, (5) a XAD-2 sorbent trap, (6) an empty potbellied impinger, (7) a set of four GS impingers, (8) a length of sample line, and (9) calibrated pump and dry gas meter. Prior to each test, the first and second impingers was filled with 100 ml of HPLC water, the third impinger was empty, and the fourth impinger was contain silica gel. Upon completion of the final leak test for each test tun, the filter was recovered, the nozzle and the front half of the filter housing will be brushed, and triple rinsed with acetone and toluene. The rinses were collected in a pre-cleaned sample container. The back half of the filter housing and condenser was rinsed with acetone and toluene. The containers was labeled with the test number, test location, test date, and the level of liquid was marked on the outside of each container.

4.5 Lead, Cadmium, and Mercury (EPA Method 29)

The sample train consisted of a teflon coated steel nozzle, a heated glass probe, a heated quartz filter, two chilled impingers each with 100 mL of 5% HNO_3/10% H_2O_2, an empty impinger, two chilled impingers each with 100 mL of 4% $KMnO_4$/10% H_2SO_4, an impinger with 200 grams of silica gel, and a dry gas metering console. The temperature of the filter was monitored and controlled to 248 + 250F.

At the end of each test run, the nozzle, probe, and filter front half were then rinsed with 100 mL of 0.1 N nitric acid into the first sample jar. The filter was then recovered into the original labeled petri dish.

The contents of the 5% HNO_3/10% H_2O_2 impinger were poured back into the original reagent jar. Any condensate in the empty impinger was poured into a sample jar. The 4% $KMnO_4$/10% H_2SO_4 impingers were then recovered into another sample jar.

The moisture catch was then determined gravimetrically. The filter back half and 5% HNO_3/10% H_2O_2 impingers were rinsed with 100 mL of 0.1 N nitric acid into a sample jar.

The empty impinger was rinsed with 100 mL of 0.1 nitric acid into a sample jar. The 4% $KMnO_4$/10% H_2SO_4 impingers were then rinsed with 100 mL 4% $KMnO_4$/10% H_2SO_4 and 100 mL of DI water into the jar containing the 4% $KMnO_4$/10% H_2SO_4 reagent. The 4% $KMnO_4$/10% H_2SO_4 impingers and connecting glassware were rinsed with 25 mL of 8 N HCl if any brown residue remained. This HCl rinse was added to a jar containing 200 mL of DI water.

4.6 Gas Dilution System (EPA Method 205)

Calibration gases were mixed using an Environics 4040 Gas Dilution System. The mass flow controllers are factory calibrated using a primary flow standard traceable to the United States National Institute of Standards and Technology (NIST). Each flow controller utilizes an 11-point calibration table with linear interpolation, to increase accuracy and reduce flow controller nonlinearity. The calibration is done yearly, and the records will be included in the Source Testing Report. A multi-point EPA Method 205 check will be executed in the field prior to testing to ensure accurate gas-mixtures. The gas dilution system consisting of calibrated orifices or mass flow controllers and dilutes a high-level calibration gas to within ±2% of predicted values. The gas divider is capable of diluting gases at set increments and will be evaluated for accuracy in the field in accordance with US EPA Method 205 "*Verification of Gas Dilution Systems for Field Instrument Calibrations*". The gas divider dilutions were measured to evaluate that the responses are within ±2% of predicted values. In addition, a certified mid-level calibration gas within ±10% of one of the tested dilution gases were introduced into an analyzer to ensure the response of the gas calibration is within ±2% of gas divider dilution concentration.

4.7 Visual Fugitive Emissions (EPA Method 22)

Method 22, " Visual Determination of Fugitive Emissions from Material Sources and Smoke Emissions from Flares" was used to measure opacity of the EU-INCINERATOR ash handing operation lagoons. Triplicate test runs of 60 minutes was conducted to note presence of fugitive emissions at the ash lagoon. EPA Method 22 was used to determine the frequency of fugitive emissions from stationary sources.

4.8 Description of Recovery and Analytical Procedures

All sample recovery and analytical procedures following the prescribed methods of USEPA Method 1 to 4, 5/26A and 23.

4.9 Sampling Port Description

All sampling ports meet USEPA Method 1 locations and can be found in the **Figure Section.**

5 TEST RESULTS AND DISCUSSION

5.1 Detailed Results

Table 5.1.1: Results Summary – CEMS

Parameter	Units	Test 1	Test 2	Test 3	Average	ROP Limit
NOx	ppm @ 7% O_2	136.17	111.35	131.99	126.5	220
CO	ppm @ 7% O_2	1,324.0	1,716.3	1,549.4	1529.9	3,800
SO_2	ppm @ 7% O_2	4.98	10.41	0.54	5.31	26

Table 5.1.2: Results Summary – Method 5, 26A, 23 and 29

Parameter	Units	Test 1	Test 2	Test 3	Average	ROP Limit
PM	mg/dscm @ 7% O_2	31.76	8.44	10.07	16.76	80
	lb per 1,000 lb of exhaust air, corrected to 50% excess air	0.022	0.006	0.007	0.011	0.2
HCl	ppm @ 7% O_2	0.28	0.25	0.39	0.30	1.2
D&F (TEQ)	ng/m^3 @ 7% O_2	0.053	0.042	0.036	0.044	0.32
Pb	mg/dscm @ 7% O_2	0.013	0.018	0.009	0.013	0.30
Cd	mg/dscm @ 7% O_2	0.0028	0.0032	0.0021	0.0027	0.095
Hg	mg/dscm @ 7% O_2	0.040	0.050	0.039	0.043	0.28

Table 5.1.3: Results Summary – Visible Emissions Method 22

Parameter	Units	Test 1	Test 2	Test 3	Average	ROP Limit
Visible Emissions	Percentage	0%	0%	0%	0%	5%

5.1.1 Discussion of Results

The detailed results can be found in the following Appendices:

- **Appendix B –** Summary of Continuous Emissions Monitoring
- **Appendix C –** Summary of Particulate Matter & Hydrogen Chloride Results (Method 5 and 26A)
- **Appendix D –** Summary of Dioxin & Furan Results (Method 23)
- **Appendix E –** Summary of Metals (Method 29)
- **Appendix F –** Summary of Visible Emissions (Method 22)

5.2 Variations in Testing Procedures

The testing program was completed in adherence to the methods. No variations were made.

5.3 Process Upset Conditions During Testing

There were no process disruptions during testing. The incinerator bypass stack was not opened or used during any testing.

5.4 Maintenance Performed in Last Three Months

A portion of the scrubber Annual Inspection was conducted in May 2023 and minor maintenance/cleaning activities were performed on the scrubber at that time. In addition, in June 2023, the ID fan bearings were replaced and internal work was done on the incinerator to clear drop chutes on Hearth 5 and replace broken teeth on Hearths 5 and 6.

5.5 Re-Test

This was not a retest.

5.6 Audit Samples

No audit samples were collected.

5.7 Process Data

Process data is included in **Appendix A**. Process operating data collected during the testing includes:

- Sewage sludge feed rate
- Sewage sludge feed moisture content
- Operating temperatures of each hearth for Hearths 1 – 8
- Pressure drop across the wet scrubber
- Scrubber liquid flow rate
- pH of the scrubber liquid

Please note that new operational parameter limits have been established based on the operating data collected during this testing event.

5.8 Field Data Sheets

Field data can be found in **Appendix G.**

5.9 Calibration Data

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

5.10 Laboratory Data

Laboratory data can be found in **Appendix I.**

5.11 Example Calculations

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

TABLES

Table 1: Summary of Sampling Parameters and Methodology (EU-INCINERATOR)

Source Location	No. of Tests per Stack	Sampling Parameter	Sampling Method
EU-INCINERATOR	3	Velocity, Temperature and Flow Rate	U.S. EPA [1] Methods 1-4
	3	Dioxins & Furans	U.S. EPA [1] Method 23
	3	Filterable PM / HCl	U.S. EPA [1] Method 5/26A
	3	Metals	U.S. EPA [1] Method 29
	6	Oxygen & Carbon Dioxide	U.S. EPA [1] Method 3A
	3	Carbon Monoxide, Oxides of Nitrogen, & Sulfur Dioxide	U.S. EPA [1] Method 10, 7E and 6C

Notes:

[1] U.S. EPA - United States Environmental Protection Agency

Table 2: Sampling Summary and Sample Log (Filterable PM, HCl, D&F, and Metals) (EU-INCINERATOR)

Source and Test #	Sampling Date	Start Time	End Time	Filter ID / Trap ID
EU-INCINERATOR - Dioxins & Furans				
Blank	27-Jun-23	-	-	83QFF
Proof Blank	26-Jun-23	13:18	15:18	83QFF / Trap #3
Test #1	27-Jun-23	9:40	11:48	83QFF / Trap #5
Test #2	27-Jun-23	13:05	15:11	83QFF / Trap #2
Test #3	27-Jun-23	15:47	17:52	83QFF / Trap #1
EU-INCINERATOR - Filterable PM / HCL				
Blank	28-Jun-23	-	-	QZ78
Test #1	28-Jun-23	8:50	10:18	QZ69
Test #2	28-Jun-23	11:13	12:41	QZ55
Test #3	28-Jun-23	13:17	14:45	QZ59
EU-INCINERATOR - Metals				
Blank	27-Jun-23	-	-	QZ78
Test #1	27-Jun-23	9:40	11:48	QZ78
Test #2	27-Jun-23	13:05	15:11	QZ73
Test #3	27-Jun-23	15:47	17:52	QZ70

Table 3A: Sampling Summary - Flow Characteristics - Filterable PM / HCL
EU-INCINERATOR

Stack Gas Parameter		Test No. 1	Test No. 2	Test No. 3	Average
	Testing Date	28-Jun-23	28-Jun-23	28-Jun-23	
Stack Temperature	°F	103	109	98	104
Moisture	%	6.3%	7.5%	4.5%	6.1%
Velocity	ft/s	10.80	11.00	10.80	10.87
Referenced Flow Rate	CFM	6,901	6,867	7,060	6,943
Sampling Isokinetic Rate	%	101.1	101.5	98.6	100.4

Notes:

[1] Referenced flow rate expressed as dry at 101.3 kPa, 68 °F, and Actual Oxygen

Table 3C: Sampling Summary - Flow Characteristics - Metals

EU-INCINERATOR

Stack Gas Parameter		Test No. 1	Test No. 2	Test No. 3	Average
	Testing Date	27-Jun-23	27-Jun-23	27-Jun-23	
Stack Temperature	°F	95	95	93	94
Moisture	%	4.6%	3.5%	4.5%	4.2%
Velocity	ft/s	11.30	10.80	10.80	10.97
Referenced Flow Rate	CFM	7,156	6,898	6,877	6,977
Sampling Isokinetic Rate	%	100.9	97.4	98.4	98.9

Notes:

[1] Referenced flow rate expressed as dry at 101.3 kPa, 68 °F, and Actual Oxygen

Table 4: Sampling Summary - CEMS - June 27, 2023

RWDI Project #2304506

Incinerator - June 28, 2023				O_2	CO_2
Test ID	Date	Start	End	%	%
1	2023-06-27	9:39	11:48	8.66	8.80
2	2023-06-27	13:05	15:11	8.47	9.11
3	2023-06-27	15:37	17:53	8.16	9.25
		Average		8.43	9.06

Needs to be filled in
Linked to CEMs Bias calcs
Calcuations

Table 5: Sampling Summary - CEMs - June 28, 2023

RWDI Project #2304506

Incinerator - June 28, 2023				O_2	CO_2	NOx	NOx	CO	CO	SO2	SO2
Test ID	Date	Start	End	%	%	ppm	ppm @ 7% O2	ppm	ppm @ 7% O2	ppm	ppm @ 7% O2
1	2023-06-28	8:50	10:17	8.82	8.84	118.4	136.17	1151.0	1324.0	4.33	4.98
2	2023-06-28	11:13	12:40	7.72	9.71	105.6	111.35	1627.0	1716.3	9.87	10.41
3	2023-06-28	13:17	14:44	9.30	8.57	110.1	131.99	1292.8	1549.4	0.45	0.54
		Average		8.61	9.04	111.4	126.5	1357.0	1529.9	4.88	5.31
		Limit					**220**		**3800**		**26**
		Percent of Limit					**57.5%**		**40.3%**		**20.4%**

(green)	Needs to be filled in
(blue)	Linked to CEMs Bias calcs
(orange)	Calcuations

Table 6: Summary of Particulate and Hydrogen Chloride Results

Company	Warren WWTP			
Source	Incinerator			
Parameter(s) / Method(s)	Particulate / Hydrogen Chloride / US EPA Method 5 / 26A			
Date	28-Jun-23	28-Jun-23	28-Jun-23	
Test Number	Test 1	Test 2	Test 3	Average
Test Start Time	8:50	11:13	13:17	--
Test End Time	10:18	12:41	14:45	--
Stack Information				
Flow Rate (ft^3/min) (Actual)	8,003	8,152	7,968	8,041
Flow (ft3/min) (Standard Wet)	7,363	7,426	7,396	7,395
Flow (ft3/min) (Standard Dry)	6,901	6,867	7,060	6,943
Flow (m^3/min) (Standard Dry)	195	194	200	197
Percent Moisture (%)	6.3	7.5	4.5	6.1
Pressure Ps ("Hg)	29.37	29.37	29.37	29.37
Average Stack Temperature Ts (°F)	103.3	108.9	98.3	103.5
Molecular Weight of Stack Gas dry (Md) (g/mole)	29.77	29.86	29.74	29.79
Molecular Weight of Stack Gas wet (Ms) (g/mole)	29.03	28.97	29.21	29.07
Stack Gas Specific Gravity (Gs) (kg/L)	1.0	1.0	1.0	1.0
Water Vapor Volume Fraction (%)	0.1	0.1	0.0	0.1
Average Stack Velocity Vs (ft/sec)	10.8	11.0	10.8	10.9
Area of Stack (ft^2)	12.3	12.3	12.3	12.3
Percent Carbon Dioxide (%)	8.84	9.71	8.57	9.04
Percent Oxygen (%)	8.82	7.72	9.30	8.61
Percent Carbon Monoxide (%)	0.0	0.0	0.0	0.0
Meter Info				
Isokinetic Variation I (%)	101.1	101.5	98.6	100.4
Meter Pressure Pm ("Hg)	29.4	29.4	29.4	29.4
Meter Temperature Tm (°F)	71.8	75.3	78.3	75.1
Measured Sample Volume Vm (ft^3)	47.72	47.97	48.16	47.95
Sample Volume (Vm St ft^3)	45.93	45.87	45.79	45.86
Sample Volume (Vm St m^3)	1.30	1.30	1.30	1.30
Total Weight of Sampled Gas (lbs) wet	3.68	3.71	3.62	3.67
Total Weight of Sampled Gas (lbs) dry	3.53	3.54	3.52	3.53
Gas Density Ps wet (in hg)	0.08	0.07	0.08	0.08
Gas Density Ps dry (in hg)	0.08	0.08	0.08	0.08
Condensate Volume (ft^3)	3.07	3.73	2.18	3.00
Nozzle Size (in)	0.00099	0.00099	0.00099	0.00099
Impinger Gain (g)	49.1	67.5	36.3	51.0
Silica Gel Gain (g)	16.1	11.7	9.9	12.6
Total Gas Sampled (vm st ft^3 + condensate volume)	49.00	49.60	47.97	48.86

Particulate Results					ROP Limit	% of ROP Limit
Nozzle/Probe/Filter Weight (mg)	35.9	10.4	10.9	19.1		
Total Particulate (mg)	35.9	10.4	10.9	19.1		
Total Particulate Emission Rate (lb/hr)	0.72	0.21	0.22	0.38		
lb/1000 lb (wet) @ 50% excess air	0.022	0.006	0.007	0.011	**0.2**	**5.72%**
Total Particulate Concentration (mg/dscm) (dry) @ 7% O2	31.76	8.44	10.07	16.76	**80**	**21.0%**
Total Particulate Concentration (gr/dscf)	0.014	0.0037	0.0044	0.0073		

HCl Results					ROP Limit	% of ROP Limit
Sample Weight (µg)	470	470	630	523		
Blank Correction (µg)	0	0	0	0		
Total Weight (µg)	470	470	630	523		
HCl Concentration (mg/dscm) (dry)	0.36	0.36	0.49	0.40		
HCl Emission Rate (lb/hr)	0.009	0.009	0.013	0.011		
HCl Concentration (ppm)	0.24	0.24	0.32	0.27		
HCl Concenration (ppm) @7% O2	0.28	0.25	0.39	0.30	**1.2**	**25.4%**

Table 7: Sampling Results - Dioxins and Furans - TOTAL TOXIC EQUIVALENCY
Source: EU-INCINERATOR

Test:	Blank	Test #1			Test 1 Concentration @68 °F and 7% O_2	Test #2			Test 2 Concentration @68 °F and 7% O_2	Test #3			Test 3 Concentration @68 °F and 7% O_2	Average Concentration	Average Concentration @68 °F and 7% O_2		
Sample Volume (ft^3) [1]:		69.2				66.5				64.9							
Sample Volume (m^3) [1]:		1.96				1.88				1.84							
Stack Flow Rate (dscfm) [1]:		6821				6564				6537							
Stack Flow Rate (m^3/s) [1]:		3.22				3.10				3.09							
	(pg)	(pg)	(pg/m^3)	(pg/s)	(ng/m^3)	(pg)	(pg/m^3)	(pg/s)	(ng/m^3)	(pg)	(pg/m^3)	(pg/s)	(ng/m^3)	(pg/m^3)	(ng/m^3)	ROP Limit	% of ROP Limit
Total TEQ	--	91.5	47	150	0.053	71.6	38.0	120	0.042	60.0	33	102	0.036	39	0.044	**0.32**	**13.7%**

Notes:

[1] Sample volume and volumetric flow rate based on dry referenced conditions (101.3 kPa and 68 °F)

'<' indicates that laboratory results were below the Reportable Detection Limit (RDL) This detection limit was used to calculate the concentration and emission rate.

*CDD = chlorodibenzo-*p*-dioxin

**CDF = chlorodibenzo-*p*-furan

Test 1	8.66	O2	8.8	CO2
Test 2	8.47	O2	9.11	CO2
Test 3	8.16	O2	9.25	CO2

Table 8: Summary of Metal Results

Company	Warren WTP			
Source	Incinerator			
Parameter / Method	Metals / USEPA Method 29			
Date	27-Jun-23	27-Jun-23	27-Jun-23	
Test Number	**Test 1**	**Test 2**	**Test 3**	**Average**
Test Start Time	9:40	13:05	15:47	--
Test End Time	11:48	15:11	17:52	--
Stack Information				
Flow Rate (ft3/min) (Actual)	8,362	7,962	7,991	8,105
Flow (ft3/min) (Standard Wet)	7,498	7,148	7,205	7,284
Flow (ft3/min) (Standard Dry)	7,156	6,898	6,877	6,977
Flow (m3/min) (Standard Dry)	203	195	195	198

Percent Moisture (%)	4.6	3.5	4.5	4.2
Pressure Ps ("Hg)	28.23	28.23	28.23	28.23
Average Stack Temperature Ts (oF)	95.5	94.9	92.5	94.3
Molecular Weight of Stack Gas dry (Md) (g/mole)	29.75	29.80	29.81	29.79
Molecular Weight of Stack Gas wet (Ms) (g/mole)	29.22	29.38	29.27	29.29
Stack Gas Specific Gravity (Gs) (kg/L)	1.0	1.0	1.0	1.0
Water Vapor Volume Fraction (%)	0.0	0.0	0.0	0.0
Average Stack Velocity Vs (ft/sec)	11.3	10.8	10.8	11.0
Area of Stack (ft2)	12.3	12.3	12.3	12.3
Percent Carbon Dioxide (%)	8.8	9.1	9.3	9.1
Percent Oxygen (%)	8.7	8.5	8.2	8.4
Percent Carbon Monoxide (%)	0.0	0.0	0.0	0.0

Meter Info				
Isokinetic Variation I (%)	100.9	97.4	98.4	98.9
Meter Pressure Pm ("Hg)	28.3	28.3	28.3	28.3
Meter Temperature Tm (oF)	74.6	73.8	74.4	74.3
Measured Sample Volume Vm (ft3)	73.73	68.50	69.09	70.44
Sample Volume (Vm St ft3)	67.88	63.13	63.62	64.88
Sample Volume (Vm St m3)	1.92	1.79	1.80	1.84
Total Weight of Sampled Gas (lbs) wet	5.37	4.97	5.04	5.13
Total Weight of Sampled Gas (lbs) dry	5.22	4.86	4.90	4.99
Gas Density Ps wet (in hg)	0.08	0.08	0.08	0.08
Gas Density Ps dry (in hg)	0.08	0.08	0.08	0.08
Condensate Volume (ft3)	3.24	2.28	3.03	2.85
Nozzle Size (in)	0.00099	0.00099	0.00099	0.00
Impinger Gain (g)	53.8	33.2	46.4	44.5
Silica Gel Gain (g)	15.0	15.2	17.9	16.0
Total Gas Sampled (vm st ft3 + condensate volume)	71.12	65.42	66.65	67.73

Lead Results						
Lead Weight (ug)	22.22	28.20	15.13	21.85		
Lead mg/dscm (dry)	0.012	0.016	0.008	0.012	**ROP Limit**	**% of ROP Limit**
Lead mg/dscm (dry) @ 7% O_2	0.013	0.018	0.009	0.013	**0.3**	**4.4%**
Lead (gr/dscf)	5.05E-06	6.89E-06	3.67E-06	5.21E-06		
Lead (lb/hr)	0.00031	0.00041	0.00022	0.00031		

Cadmium Results						
Cadmium Weight (ug)	4.78	5.11	3.54	4.48		
Cadmium mg/dscm (dry)	0.0025	0.0029	0.0020	0.012	**ROP Limit**	**% of ROP Limit**
Cadmium mg/dscm (dry) @ 7% O_2	0.0028	0.0032	0.0021	0.0027	**0.095**	**2.9%**
Cadmium (gr/dscf)	1.09E-06	1.25E-06	8.59E-07	1.06E-06		
Cadmium (lb/hr)	6.88E-05	7.58E-05	5.23E-05	6.56E-05		

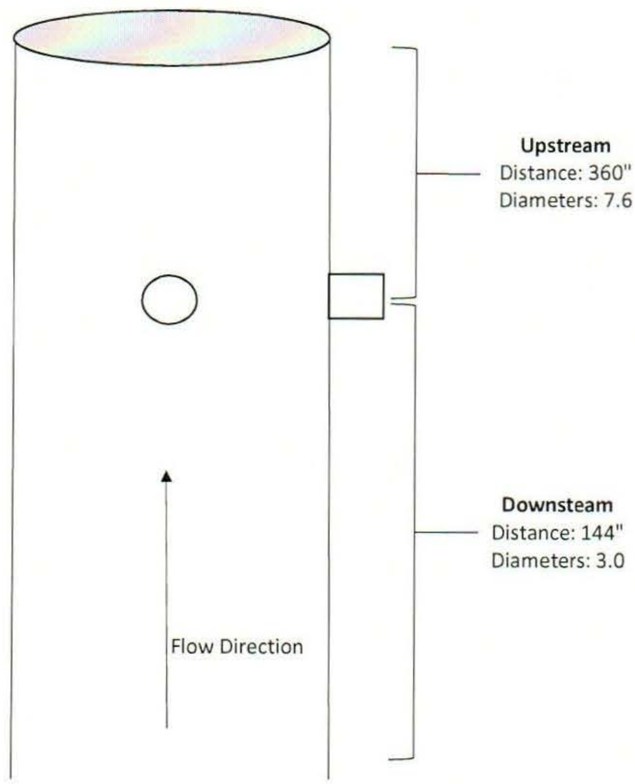
Mercury Results						
Mercury Weight (ug)	68.0	79.2	63.7	70.3		
Mercury (mg/dscm) (dry)	0.035	0.044	0.035	0.038	**ROP Limit**	**% of ROP Limit**
Mercury (mg/dscm) (dry) @ 7% O_2	0.040	0.050	0.039	0.043	**0.28**	**15.3%**
Mercury (gr/dscf)	1.55E-05	1.94E-05	1.55E-05	1.68E-05		
Mercury (lb/hr)	9.79E-04	1.17E-03	9.41E-04	1.03E-03		

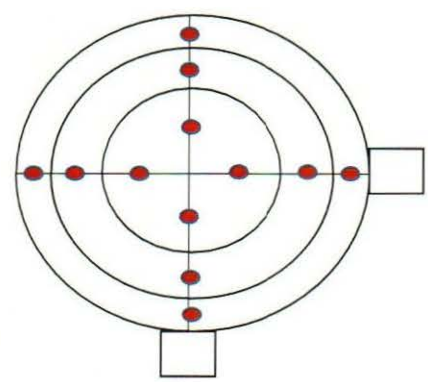
FIGURES

Figure No. 1A: EU-INCINERATOR Traverse Point Schematic (CEMs)

Diameter (in.): 47.5

Sampling Points (in.)	
1	2.09
2	6.94
3	14.06
4	33.44
5	40.57
6	45.41





Not to Scale

EU-INCINERATOR
City of Warren
Warren Wastewater Treatment Plant
Warren, Michigan

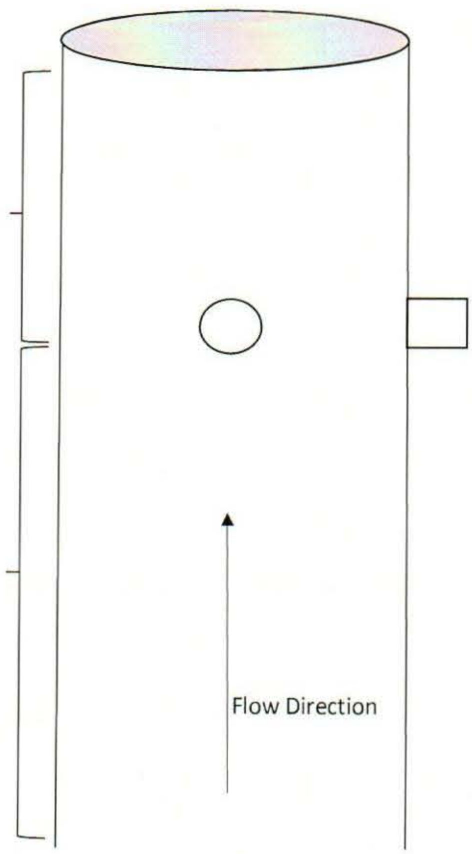
Date:
June 27th & 28th, 2023

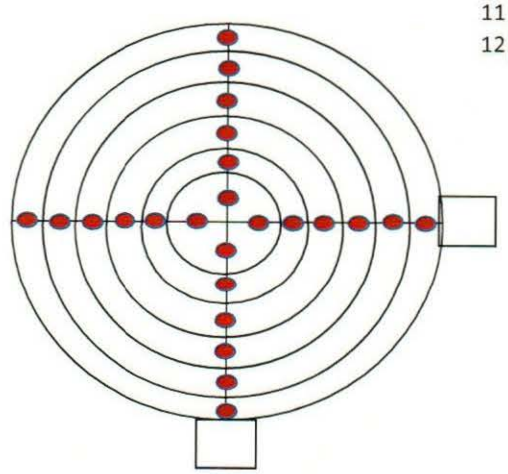
RWDI USA LLC
2239 Star Court
Rochester Hills, MI 48309

Figure No. 1B: EU-INCINERATOR Traverse Point Schematic (Method 5/26A/23/29)

Diameter: 47.5

Sampling Points (in.)	
1	1.00
2	3.18
3	5.61
4	8.41
5	11.88
6	16.91
7	30.59
8	35.63
9	39.09
10	41.90
11	44.32
12	46.50





Not to scale

EU-INCINERATOR
City of Warren
Warren Wastewater Treatment Plant
Warren, Michigan

Date:
June 27th & 28th, 2023

RWDI USA LLC
2239 Star Court
Rochester Hills, MI 48309

Figure 2
USEPA Method 26A/5
City of Warren Wastewater Treatment Plant

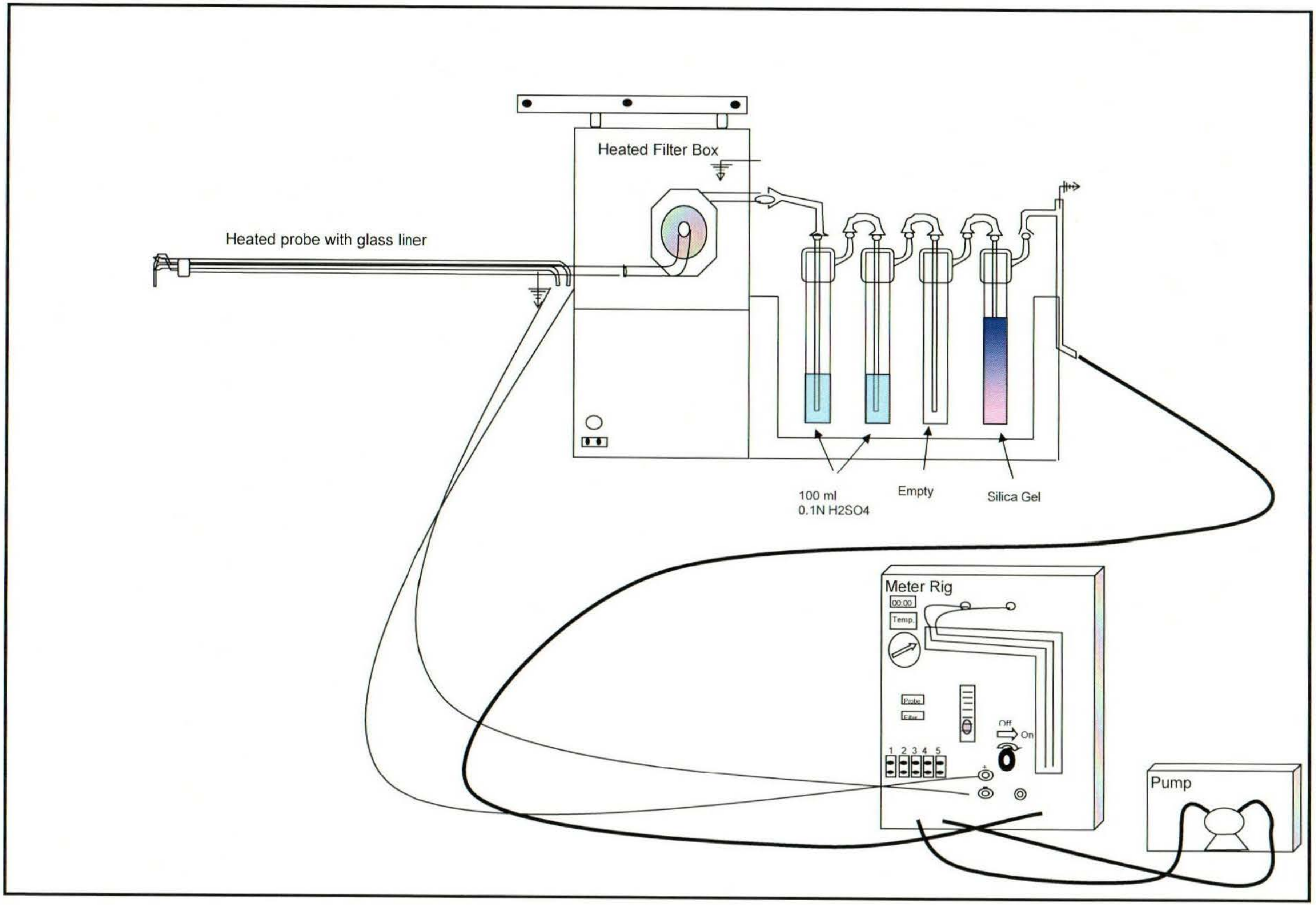
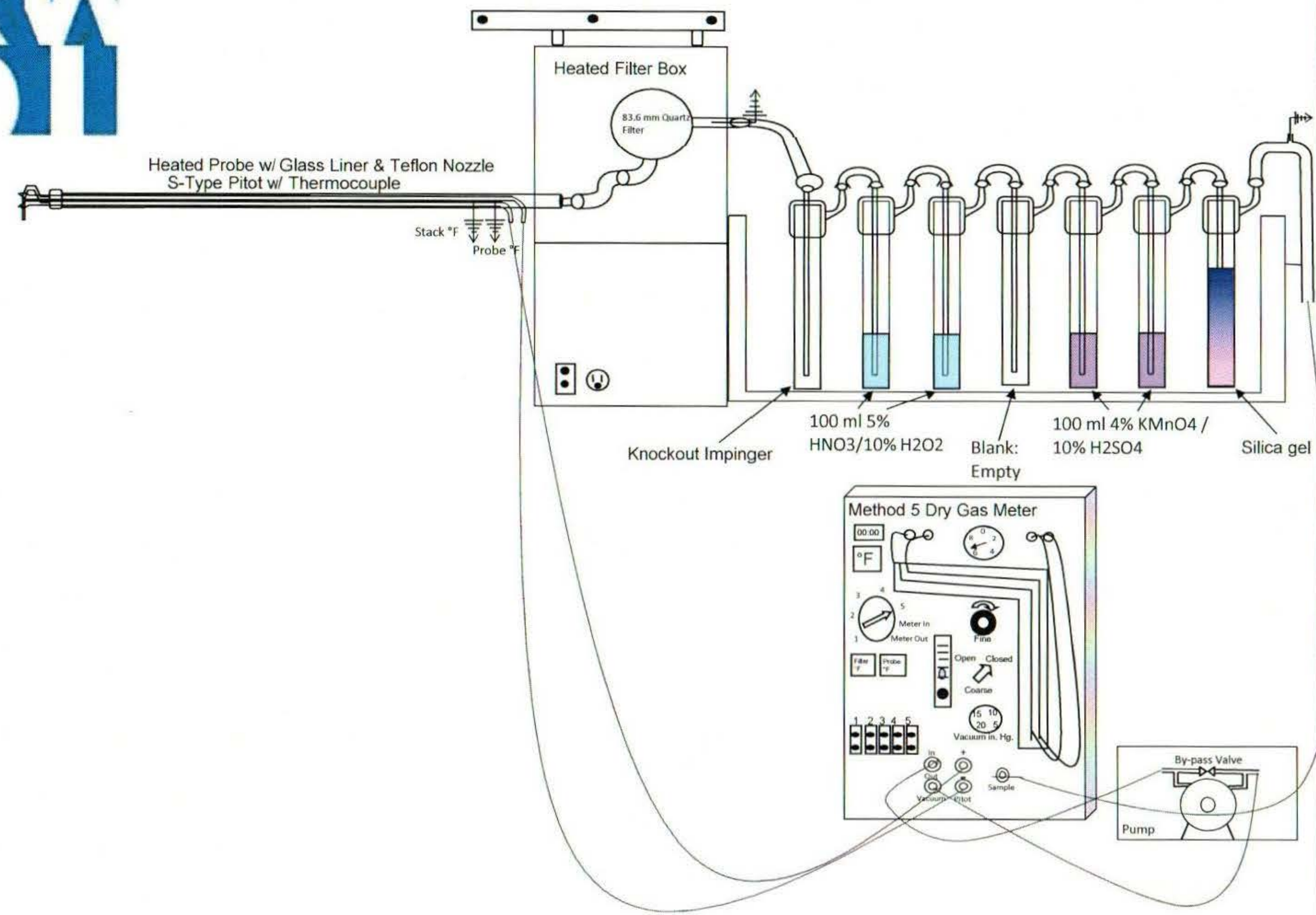


Figure No. 3: Schematic of USEPA Method 29



USEPA Method 29

City of Warren

Warren Wastewater Treatment Plant

Warren, Michigan

Project 2304506

Date: June 27th to 28th, 2023

Figure 4
USEPA Method 23
City of Warren Wastewater Treatment Plant

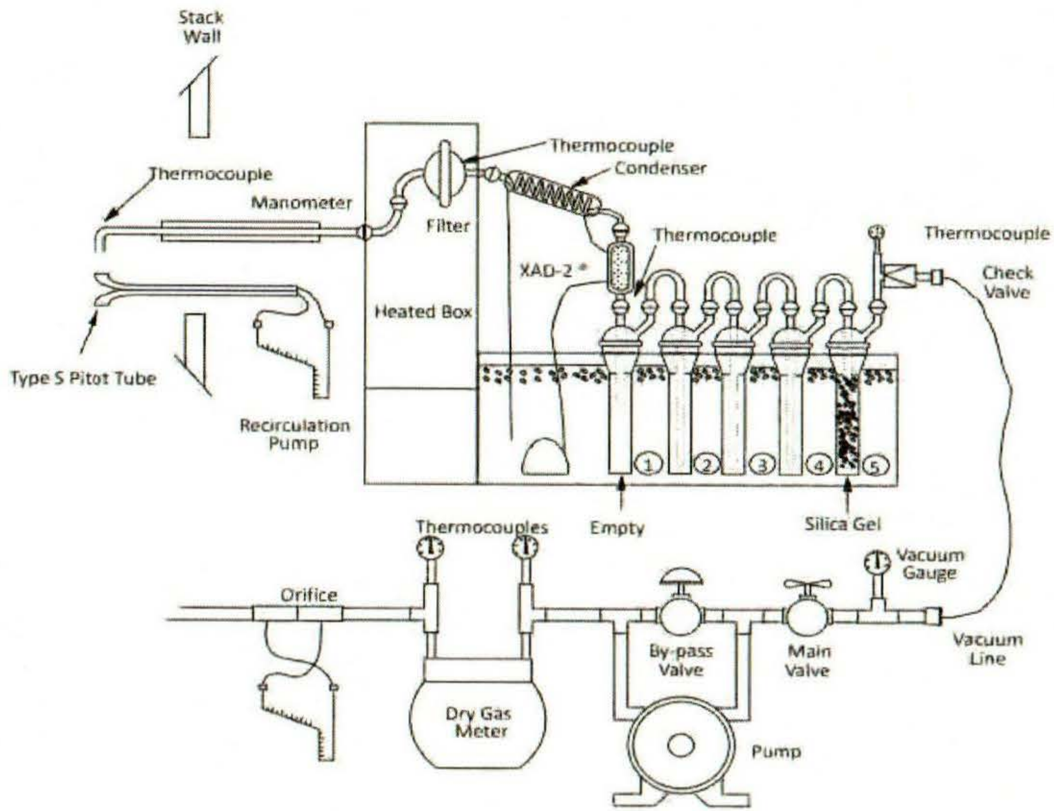
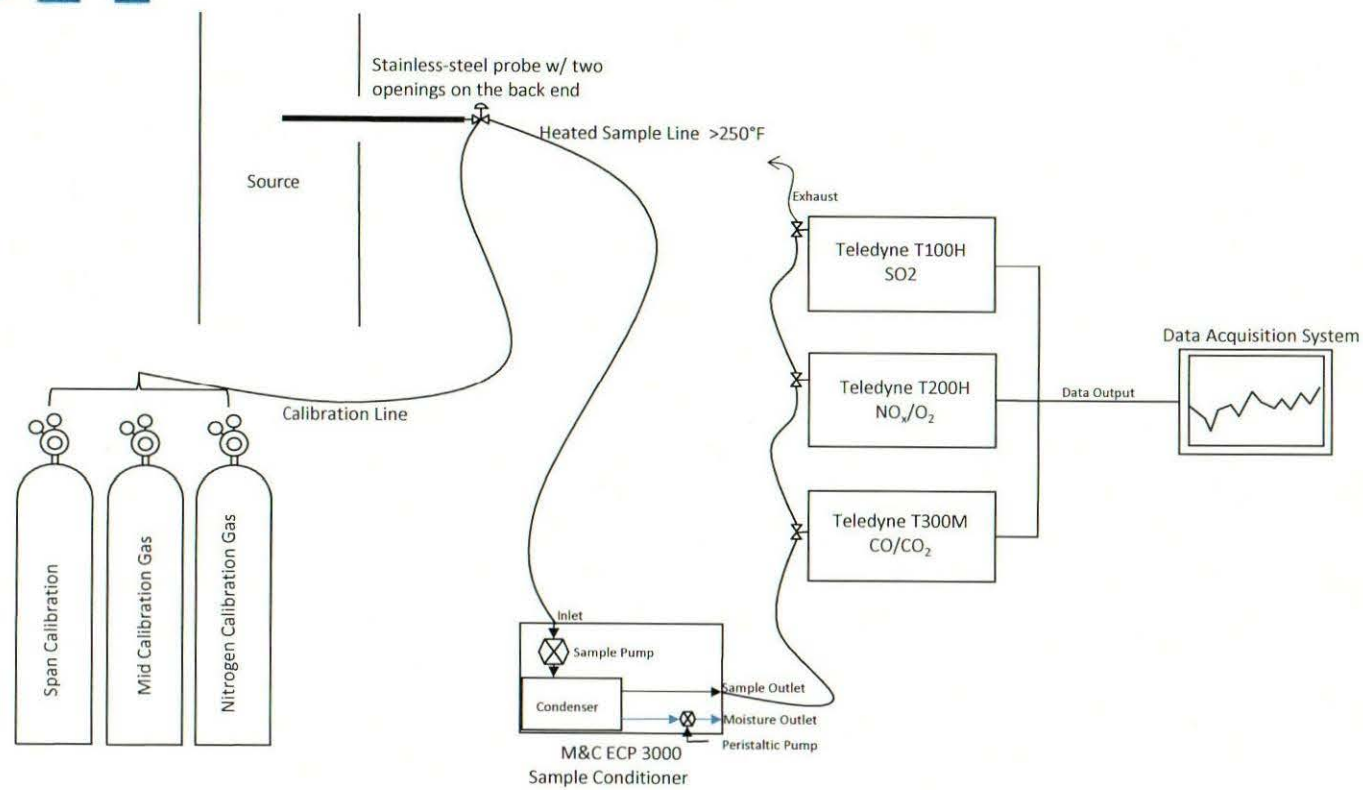


Figure 23-1. Method 23 Sampling Train

Figure No. 5: USEPA Method 3A,6C,7E,10 Schematic



USEPA Method 3A,6C,7E,10

City of Warren

Warren Wastewater Treatment Plant

Incinerator

Warren, Michigan

Project# 2304506

Date: June 27 to 28, 2023