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**Compliance Test Report for PM, SO₂, NO_x, CO,
HCl, PCDD/PCDF, Cd, Pb, and Hg from
Multiple Hearth Incinerators 12, 13, and 14 at
Great Lakes Water Authority in Detroit,
Michigan**

Prepared by:

Air Dynamics Testing
Project Number: 1078.24
Test Date: July 23–25, 2024

Prepared for:

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Table of Contents

EXECUTIVE SUMMARY	iv
1.0 INTRODUCTION	1
2.0 FACILITY DESCRIPTION AND SOURCE INFORMATION	3
2.1 Facility and Process Description	3
3.0 SUMMARY OF EVENTS AND RESULTS.....	4
3.1 Site Test Plan	4
3.2 Deviation from Test Plan	4
3.3 Results – EUINC12	4
3.4 Results – EUINC13	5
3.5 Results – EUINC14	6
4.0 METHODOLOGY	7
4.1 Sample Point Determination – EPA Method 1	7
4.2 Velocity and Volumetric Flow Rate – EPA Method 2	7
4.3 Oxygen and Carbon Dioxide Determination – EPA Method 3A	8
4.4 Moisture Content – EPA Method 4	8
4.5 Determination of PM – EPA Method 5	8
4.6 Sulfur Dioxide Determination – EPA Method 6C	9
4.7 Nitrogen Oxides Determination – EPA Method 7E	9
4.8 Carbon Monoxide Determination – EPA Method 10	9
4.9 Dioxin and Furan – EPA Method 23	9
4.10 Hydrogen Chloride – EPA Method 26A	10
4.11 Metals – EPA Method 29	10
5.0 AIR DYNAMICS QUALITY ASSURANCE AND QUALITY CONTROL	11
5.1 Sampling Protocol	11
5.2 Equipment Maintenance and Calibration	11
5.2.1 Equipment Maintenance	12
5.2.2 Equipment Calibration	13
6.0 AIR DYNAMICS DATA REDUCTION VALIDATION AND REPORTING	14
7.0 LIMITATIONS AND SIGNATURES	15

List of Tables and Figures

Table ES-1. Emissions Results Summary	v
Table 1-1. Emissions Sampling Summary	1
Table 1-2. Project Personnel	2
Table 3-1. Results – EUINC12	4
Table 3-2. Results – EUINC13	5
Table 3-3. Dioxins/Furans Results – EUINC13.....	5
Table 3-4. Results – EUINC14	6
Table 3-5. Dioxins/Furans Results – EUINC14.....	6
Table 4-1. Sampling Procedures	7
Table 4-2. Sampling Points.....	7
Figure 4-1. Method 5 Front Half Filterable PM Set-Up.....	8
Figure 4-2. Method 23 Sampling Train Schematic.....	9
Figure 4-3. Method 29 Sampling Train	10
Table 5-1. Test Equipment - Routine Maintenance Schedule.....	12
Table 5-2. Field Equipment Calibration Summary	13

List of Appendices

Appendix A:	Sample Calculations
Appendix B:	Field Data Spreadsheets
Appendix C:	Reference Method CEMS
Appendix D:	Laboratory Data
Appendix E:	Calibration Data
Appendix F:	Submitted Protocol
Appendix G:	Production Data

EXECUTIVE SUMMARY

Air Dynamics Testing, LLC. (Air Dynamics) was contracted by Great Lakes Water Authority (GLWA) to sample air emissions at the Water Resource Recovery Facility (WRRF) in Detroit, Michigan, on July 23–25, 2024. Multiple Hearth Incinerators 12, 13, and 14, identified as EUINC12, EUINC13, and EUINC14, were tested to evaluate emissions of particulate matter (PM), sulfur dioxide (SO₂), nitrogen oxides (NO_x), carbon monoxide (CO), hydrogen chloride (HCl), polychlorinated dibenzo-p-dioxins (PCDD)/polychlorinated dibenzofurans (PCDF), and multiple metals (cadmium [Cd], lead [Pb], and mercury [Hg]). The testing program was performed consistent with US EPA Methods 1, 2, 3A, 4, 5, 6C, 7E, 10, 23, 26A, and 29. The test results are summarized below in Table ES-1.

Table ES-1. Emissions Results Summary

Test Location	Test Parameter	Unit	Result	Permit Limit
EUINC12	PM	mg/dscm @ 7% O ₂	71.31	80
	SO ₂	ppmvd @ 7% O ₂	0.10	26
	CO	ppmvd @ 7% O ₂	63.46	3,800
	HCl	ppmvd @ 7% O ₂	0.2579	1.2
	Cd	mg/dscm @ 7% O ₂	0.0074	0.095
	Pb	mg/dscm @ 7% O ₂	0.058	0.30
	Hg	mg/dscm @ 7% O ₂	0.032	0.28
EUINC13	PM	mg/dscm @ 7% O ₂	56.18	80
	SO ₂	ppmvd @ 7% O ₂	0.21	26
	CO	ppmvd @ 7% O ₂	468.81	3,800
	HCl	ppmvd @ 7% O ₂	18.33	1.2
	Dioxins/Furans (PCDD/PCDF)	ng/dscm @ 7% O ₂	0.06	TEQ Basis: 0.32 OR TMB Basis – 5.0
	Cd	mg/dscm @ 7% O ₂	0.0036	0.095
	Pb	mg/dscm @ 7% O ₂	0.067	0.30
	Hg	mg/dscm @ 7% O ₂	0.061	0.28
EUINC14	PM	mg/dscm @ 7% O ₂	8.58	80
	SO ₂	ppmvd @ 7% O ₂	0.42	26
	NO _x	ppmvd @ 7% O ₂	141.33	220
	CO	ppmvd @ 7% O ₂	415.92	3,800
	HCl	ppmvd @ 7% O ₂	0.72	1.2
	Dioxins/Furans (PCDD/PCDF)	ng/dscm @ 7% O ₂	0.07	TEQ Basis: 0.32 OR TMB Basis – 5.0
	Cd	mg/dscm @ 7% O ₂	0.005	0.095
	Pb	mg/dscm @ 7% O ₂	0.041	0.30
	Hg	mg/dscm @ 7% O ₂	0.052	0.28

1.0 INTRODUCTION

Air Dynamics Testing, LLC. (Air Dynamics) has prepared this source test report on behalf of GLWA. Air Dynamics conducted source emissions testing on July 23–25, 2024, at the facility in Detroit, Michigan, in fulfillment of the submitted test plan for Multiple Hearth Incinerators 12, 13, and 14 to demonstrate compliance with GLWA's Permit No. MI-ROP-B2103-2014d issued by the State of Michigan Department of Environment, Great Lakes, and Energy (EGLE).

Table 1-1 below presents the emission unit and parameters that were tested. The test was conducted in accordance with approved Environmental Protection Agency (EPA) Registered Test Methods and the accepted EGLE Compliance Test Protocol Form included in the Appendices of this document.

Table 1-1. Emissions Sampling Summary

Test Location	Parameter	Test Method	# of Test Runs	Sample Duration (min)	Analytical Approach
EUINC12	Exhaust Flow	US EPA Method 1, 2	3	80	Pitot Tube
	Exhaust Temp	US EPA Method 1, 2	3	80	Thermocouple
	O ₂ /CO ₂	US EPA Method 3A	3	80	NDIR/Paramagnetic
	Moisture	US EPA Method 4	3	80	Gravimetric
	PM	US EPA Method 5*	3	80	Gravimetric
	SO ₂	US EPA Method 6C	3	80	UV Absorption
	CO	US EPA Method 10	3	80	NDIR/GFC
	HCl	US EPA Method 26A*	3	80	Ion Chromatography
	Pb, Cd, Hg	US EPA Method 29	3	80	Atomic Absorption
EUINC13	Exhaust Flow	US EPA Method 1, 2	3	80	Pitot Tube
	Exhaust Temp	US EPA Method 1, 2	3	80	Thermocouple
	O ₂ /CO ₂	US EPA Method 3A	3	80	NDIR/Paramagnetic
	Moisture	US EPA Method 4	3	80	Gravimetric
	PM	US EPA Method 5*	3	80	Gravimetric
	SO ₂	US EPA Method 6C	3	80	UV Absorption
	CO	US EPA Method 10	3	80	NDIR/GFC
	Dioxins/Furans	US EPA Method 23	3	80	GC-MS
	HCl	US EPA Method 26A*	3	80	Ion Chromatography
	Pb, Cd, Hg	US EPA Method 29	3	80	Atomic Absorption
EUINC14	Exhaust Flow	US EPA Method 1, 2	3	80	Pitot Tube
	Exhaust Temp	US EPA Method 1, 2	3	80	Thermocouple
	O ₂ /CO ₂	US EPA Method 3A	3	80	NDIR/Paramagnetic
	Moisture	US EPA Method 4	3	80	Gravimetric
	PM	US EPA Method 5*	3	80	Gravimetric
	SO ₂	US EPA Method 6C	3	80	UV Absorption
	NO _x	US EPA Method 7E	3	80	Chemiluminescence
	CO	US EPA Method 10	3	80	NDIR/GFC
	Dioxins/Furans	US EPA Method 23	3	80	GC-MS
	HCl	US EPA Method 26A*	3	80	Ion Chromatography
	Pb, Cd, Hg	US EPA Method 29	3	80	Atomic Absorption

*Note: Method 5 and 26A trains were combined.

A list of personnel involved with testing is provided below in Table 1-2.

Table 1-2. Project Personnel

Firm	Contact	Title	Phone No.
Air Dynamics	Dave Williams	Project Manager/Field Team Leader	(855) 839-8378
Air Dynamics	Abel Bates	Field Technician	(855) 839-8378
Air Dynamics	David Conder	Field Technician	(855) 839-8378
Air Dynamics	Ernest Brummet	Field Technician	(855) 839-8378
Air Dynamics	Mike Murphy	Field Technician	(855) 839-8378
GLWA	Melvin Dacres	Management Professional	(313) 297-0363
EGLE	Jeremy Howe	Environmental Manager	(231) 878-6687

2.0 FACILITY DESCRIPTION AND SOURCE INFORMATION

2.1 Facility and Process Description

GLWA operates a flexible group. The flexible group covers all sewage sludge incinerators subject to the 40 CFR Part 60, Subpart Mmmm emissions guidelines through Rule 972. Three (3) MHIs are included in this group that require testing: EUINC12, EUINC13, and EUINC14.

Sludge is dewatered with belt filter presses and conveyed to the multiple hearth furnaces with belt conveyors. The sludge conveyors are equipped with weigh scales for continuous monitoring of the amount of sludge being incinerated. The dewatered sludge is introduced at the top hearth and rabbled down through successive hearths in a spiral path. The moisture in the sludge is evaporated in the upper hearths as hot combustion gases traveling concurrently from the middle hearths where combustion takes place. The maximum feed rate is 3.12 dry tons per hour at 25% solids and 75% volatiles condition. It is a continuous feed process. Under normal operating conditions each incinerator runs between 2.0 and 2.5 dry tons per hour with temperature of the solids between 50 and 80°F. The furnace is equipped with auxiliary natural gas burners at hearths 2, 4, 6, 8, 10, and 12. The firing rate of the burners is modulated by a central control system to sustain the desired hearth temperatures.

Each air pollution control system is comprised of a Double Zero Hearth afterburner section of Hearths 1 and 2, a quench section, and EnviroCare® Venturi-Pak (venturi throat sections and mist eliminator) scrubber system. The total pressure-drop across the wet scrubber ranges between 25 and 40 inches of water column (in. wc). The total scrubber water flow should be greater than 1,416 gallons per minute (gpm). Exhaust gases pass through this MHI via an induced draft (ID) fan and exit the scrubber at 100–150°F.

3.0 SUMMARY OF EVENTS AND RESULTS

3.1 Site Test Plan

Air Dynamics arrived on July 22, 2024, to set up equipment. On July 23, 2024, three (3) test runs were conducted on EUINC12. On July 24 and 25, 2024, three (3) test runs were conducted on EUINC14. On July 25, 2024, three (3) test runs were conducted on EUINC13.

3.2 Deviation from Test Plan

There were no deviations from the test plan to report.

3.3 Results – EUINC12

Air Dynamics conducted emissions sampling for PM, SO₂, CO, HCl, Cd, Pb, and Hg utilizing the aforementioned US EPA registered methods on July 23, 2024. Table 3-1 displays detailed results of the test program.

Table 3-1. Results – EUINC12

Stack Gas Characteristic	Unit	Run 1 7/23/2024 (10:02–11:30)	Run 2 7/23/2024 (12:28–15:49)	Run 3 7/23/2024 (16:37–18:08)	Average
PM	mg/dscm @ 7% O ₂	77.36	85.71	50.85	71.31
SO ₂	ppmvd @ 7% O ₂	0.11	0.03	0.16	0.10
CO	ppmvd @ 7% O ₂	72.05	51.58	66.75	63.46
HCl	ppmvd @ 7% O ₂	0.3015	0.3333	0.1388	0.2579
Cd	mg/dscm @ 7% O ₂	0.0081	0.0075	0.0066	0.0074
Pb	mg/dscm @ 7% O ₂	0.074	0.046	0.050	0.058
Hg	mg/dscm @ 7% O ₂	0.039	0.037	0.020	0.032

3.4 Results – EUINC13

Air Dynamics conducted emissions sampling for PM, SO₂, CO, HCl, PCDD/PCDF, Cd, Pb, and Hg utilizing the aforementioned US EPA registered methods on July 25, 2024. Tables 3-2 and 3-3 display detailed results of the test program.

Table 3-2. Results – EUINC13

Stack Gas Characteristic	Unit	Run 1 7/25/2024 (09:15–10:43)	Run 2 7/25/2024 (11:16–12:44)	Run 3 7/25/2024 (13:14–14:43)	Average
PM	mg/dscm @ 7% O ₂	22.19	87.10	59.27	56.18
SO ₂	ppmvd @ 7% O ₂	0.16	0.21	0.26	0.21
CO	ppmvd @ 7% O ₂	181.20	612.40	612.83	468.81
HCl	ppmvd @ 7% O ₂	0.67	52.04	2.27	18.33
Dioxins/Furans (PCDD/PCDF)	ng/dscm @ 7% O ₂	0.05	0.06	0.08	0.06
Cd	mg/dscm @ 7% O ₂	0.0109	0.0000	0.0000	0.0036
Pb	mg/dscm @ 7% O ₂	0.074	0.059	0.069	0.067
Hg	mg/dscm @ 7% O ₂	0.055	0.076	0.052	0.061

Table 3-3. Dioxins/Furans Results – EUINC13

Stack Gas Characteristic	Unit	Run 1 7/25/2024 (15:18–16:44)	Run 2 7/25/2024 (17:10–18:36)	Run 3 7/25/2024 (18:49–19:16)	Average
Dioxins/Furans (PCDD/PCDF)	ng/dscm @ 7% O ₂	0.05	0.06	0.08	0.06

3.5 Results – EUINC14

Air Dynamics conducted emissions sampling for PM, SO₂, NO_x, CO, HCl, PCDD/PCDF, Cd, Pb, and Hg utilizing the aforementioned US EPA registered methods on July 24–25, 2024. Tables 3-4 and 3-5 display detailed results of the test program.

Table 3-4. Results – EUINC14

Stack Gas Characteristic	Unit	Run 1 7/24/2024 (09:04–10:32)	Run 2 7/24/2024 (11:37–13:06)	Run 3 7/24/2024 (13:48–15:19)	Average
PM	mg/dscm @ 7% O ₂	7.90	7.41	10.43	8.58
SO ₂	ppmvd @ 7% O ₂	0.47	0.58	0.20	0.42
NO _x	ppmvd @ 7% O ₂	141.36	131.43	151.20	141.33
CO	ppmvd @ 7% O ₂	536.40	280.32	431.03	415.92
HCl	ppmvd @ 7% O ₂	0.73	1.21	0.22	0.72
Dioxins/Furans (PCDD/PCDF)	ng/dscm @ 7% O ₂	0.06	0.06	0.08	0.07
Cd	mg/dscm @ 7% O ₂	0.005	0.003	0.007	0.005
Pb	mg/dscm @ 7% O ₂	0.045	0.032	0.047	0.041
Hg	mg/dscm @ 7% O ₂	0.049	0.061	0.044	0.052

Table 3-5. Dioxins/Furans Results – EUINC14

Stack Gas Characteristic	Unit	Run 1 7/25/2024 (09:15–10:43)	Run 2 7/25/2024 (11:16–12:44)	Run 3 7/25/2024 (13:14–14:43)	Average
Dioxins/Furans (PCDD/PCDF)	ng/dscm @ 7% O ₂	0.06	0.06	0.08	0.07

4.0 METHODOLOGY

The sampling procedures used by Air Dynamics were performed according to Title 40 CFR Part 60 Appendix A and are as follows:

Table 4-1. Sampling Procedures

Methods	Descriptions
US EPA Method 1	Determination of Velocity Traverses for Stationary Sources
US EPA Method 2	Determination of Stack Gas Velocity and Volumetric Flow Rate
US EPA Method 3A	Oxygen and Carbon Dioxide Determination
US EPA Method 4	Determination of Moisture Content in Stack Gas
US EPA Method 5	Determination of Particulate Matter Emissions
US EPA Method 6C	Determination of Sulfur Dioxide Emissions from Stationary Sources
US EPA Method 7E	Determination of Nitrogen Oxides Emissions
US EPA Method 10	Determination of Carbon Monoxide Emissions from Stationary Sources
US EPA Method 23	Determination of Dioxin and Furan
US EPA Method 26A	Determination of Hydrogen Halide and Halogen
US EPA Method 29	Determination of Metals Emissions

4.1 Sample Point Determination – EPA Method 1

Sampling point locations were determined according to EPA Reference Method 1.

Table 4-2. Sampling Points

Location	Dimension	Ports	Points Per Port	Total Points
EUINC12	53" ID	2	12	24
EUINC13	53" ID	2	12	24
EUINC14	53" ID	2	12	24

** Exact measurement points and distances to disturbances are listed in the Appendices.

4.2 Velocity and Volumetric Flow Rate – EPA Method 2

EPA Method 2 was used to determine the gas velocity and flow rate at the stack. Each set of velocity determinations included the measurement of gas velocity pressure and gas temperature at each of the Method 1 determined traverse points. The velocity pressures were measured with a Type S pitot tube. Gas temperature measurements were made with a Type K thermocouple and digital pyrometer.

4.3 Oxygen and Carbon Dioxide Determination – EPA Method 3A

In this method, the tester continuously sampled the effluent gas and conveyed the sample to an analyzer that measured the concentration of O_2 and CO_2 . Quality assurance of the analyzer was first determined by direct injection of known EPA protocol 1 gas concentrations. A system check of the probe, connection lines, and conditioner was also determined prior to and after each sample period to determine drift bias.

4.4 Moisture Content – EPA Method 4

The flue gas moisture content at the testing locations was determined in accordance with EPA Method 4. The gas moisture was determined by quantitatively measuring condensed moisture in the chilled impingers and silica absorption. The amount of moisture condensed was determined gravimetrically. A dry gas meter was used to measure the volume of gas sampled.

4.5 Determination of PM – EPA Method 5

Filterable particulate matter (PM) was measured using EPA Methods 1–5, including the determination of the proper number of sampling points and their locations in the stack (RM1), stack velocity and volumetric flow rate (RM2), stack gas molecular weight (RM3A), and stack gas moisture content (RM4). For this testing program, the EPA Method 5 sampling train was combined with the EPA Method 26 sampling train. Sampling was conducted isokinetically for a period of 80 minutes per run, collecting a minimum of 60 dry standard cubic feet. A diagram of the Method 5 train is shown below in Figure 4-1.

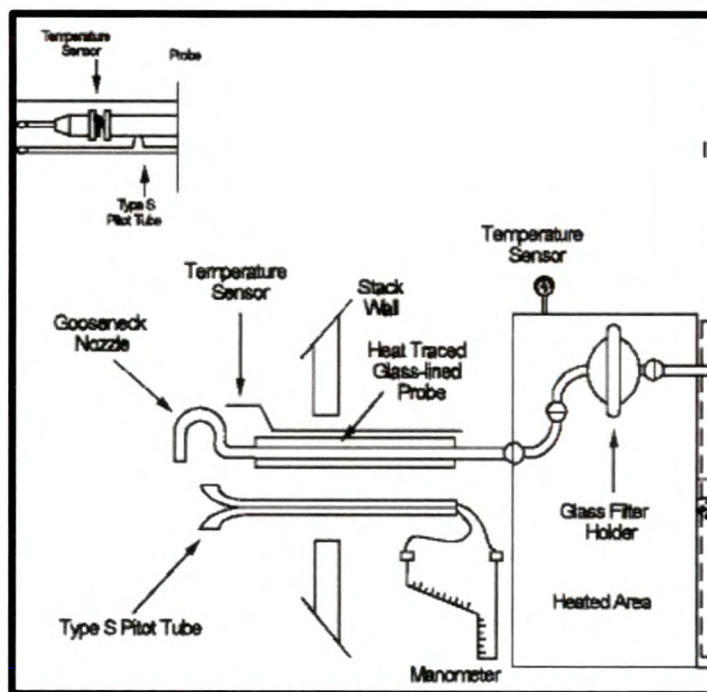


Figure 4-1. Method 5 Front Half Filterable PM Set-Up

Stack gas was withdrawn from the stack and conditioned (moisture was removed) before being analyzed by ultraviolet (UV) detection. The SO₂ molecules were absorbed by specific wave lengths. Molecular absorption was directly proportional to the concentration of SO₂. Quality assurance of the analyzer was first determined by direct injection of known EPA protocol 1 gas concentrations. A system check of the probe, connection lines, and conditioner was also determined prior to and after each sample period to determine drift bias.

Stack gas was withdrawn from the stack and conditioned (moisture was removed) before being analyzed by chemiluminescent detection. The NO molecules reacted with ozone to form NO₂. This reaction produced photons measured by the detector and was directly proportional to the concentration of NO. Quality assurance of the analyzer was first determined by direct injection of known EPA protocol 1 gas concentrations. A system check of the probe, connection lines, and conditioner was also determined prior to and after each sample period to determine drift bias.

Stack gas was withdrawn from the stack and conditioned (moisture was removed) before being analyzed by infrared detection. Specific wavelengths of infrared light were absorbed by CO molecules. Molecular absorption was directly proportional to the concentration of CO. Quality assurance of the analyzer was first determined by direct injection of known EPA protocol 1 gas concentrations. A system check of the probe, connection lines, and conditioner was also performed prior to and after each sample period to determine drift bias.

A sample was withdrawn from the gas stream isokinetically and collected in the sample probe, on a glass fiber filter, and on a packed column of adsorbent material. The sample was not separated into a particle vapor fraction. The PCDD's and PCDF's were extracted from the sample, separated by high resolution gas chromatography, and measured by high resolution mass spectrometry. A diagram of the Method 23 train is shown below in Figure 4-2.

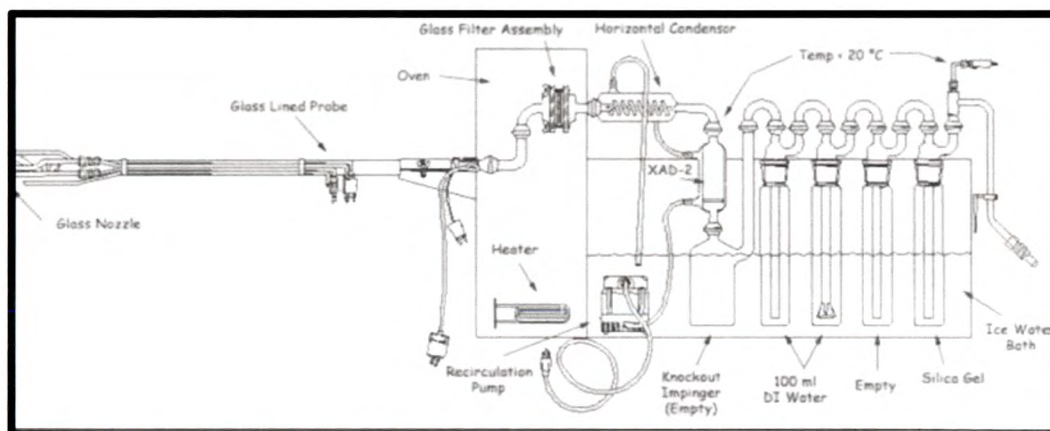


Figure 4-2. Method 23 Sampling Train Schematic

4.10 Hydrogen Chloride – EPA Method 26A

Gaseous and particulate pollutants were withdrawn isokinetically from the source and collected in an optional cyclone, on a filter, and in absorbing solutions. The cyclone collected any liquid droplets and was not necessary if the source emissions did not contain them. The filter collected particulate matter including halides but was not routinely recovered or analyzed. Acidic and alkaline absorbing solutions collected the gaseous hydrogen halides and halogens. Following sampling of emissions containing liquid droplets, any halides/halogens dissolved in the liquid in the cyclone and on the filter were vaporized to gas and collected in the impingers by pulling conditioned ambient air through the sampling train. The hydrogen halides were solubilized in the acidic solutions and formed chloride, bromide, and fluoride ions.

The halogens had a very low solubility in the acidic solution and passed through to the alkaline solution where they were hydrolyzed to form a proton, the halide ion, and the hypohalous acid. Sodium thiosulfate was added to the alkaline solution to assure reaction with the hypohalous acid to form a second halide ion such that two (2) halide ions were formed for each molecule of halogen gas. The halide ions in the separate solutions were measured by ion chromatography.

4.11 Metals – EPA Method 29

A stack sample was withdrawn isokinetically from the source, particulate emissions were collected in the probe and on a heated filter, and gaseous emissions were then collected in an aqueous acidic solution of hydrogen peroxide (analyzed for all metals including Hg) and an aqueous acidic solution of potassium permanganate (analyzed only for Hg). The recovered samples were digested, and fractions were analyzed for Hg by cold vapor atomic absorption spectroscopy and for Cd and Pb by atomic absorption spectroscopy. A diagram of the Method 29 train is shown below in Figure 4-3.

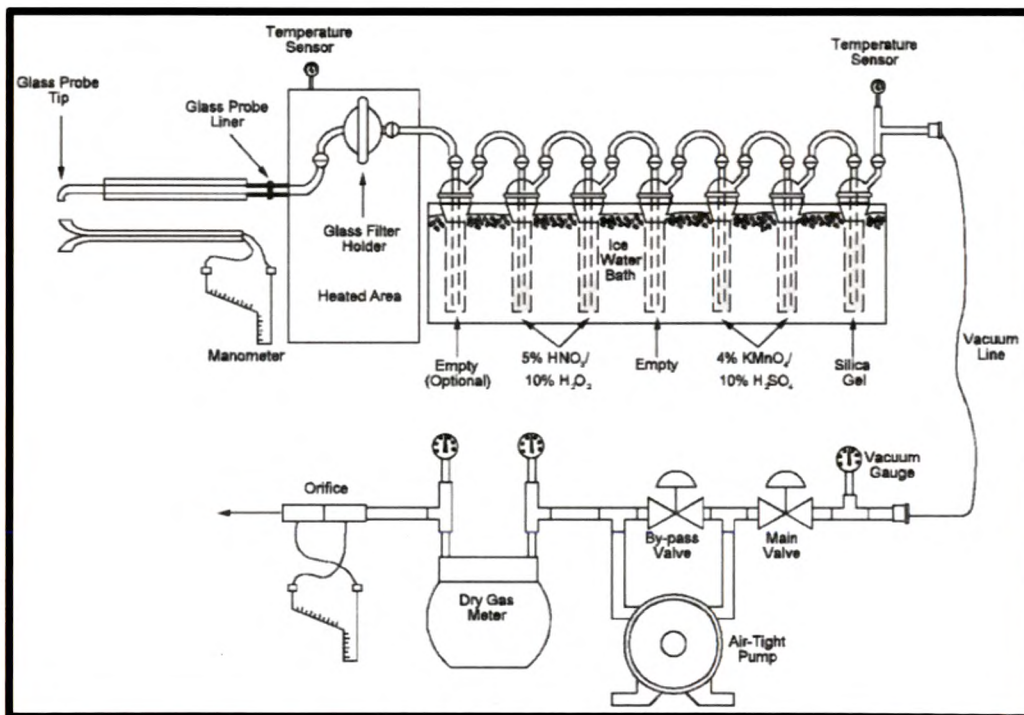


Figure 4-3. Method 29 Sampling Train

5.0 AIR DYNAMICS QUALITY ASSURANCE AND QUALITY CONTROL

5.1 Sampling Protocol

Air Dynamics Testing, LLC. (Air Dynamics) is organized to facilitate sample management, analytical performance management, and data management. Personnel are assigned specific tasks to ensure implementation of the quality assurance/quality control (QA/QC) program. The Senior Project Manager in charge of air emission measurement projects reports directly to the Director of Air Analysis Services and is the QA officer responsible for program effectiveness and compliance.

The analysts perform the data reduction, analyses, and initial data review. Each analyst must check and initial their work, making certain that it is complete, determining that any instrumentation utilized has been properly calibrated, and ensuring that the analysis has been performed within the QA/QC limits.

The Senior Project Manager evaluates and verifies the data submitted by the analysts, verifies that the data and documentation are complete, confirms that all analysis has been performed within QA criteria specific to each method, checks calculations, assembles and signs the data package, and reviews the final report.

5.2 Equipment Maintenance and Calibration

The Field Supervisor and Field Technicians are in charge of routine maintenance and calibration of all source-testing equipment. Relevant calibration information is included in the Appendices of this report.

5.2.1 Equipment Maintenance

All major pieces of equipment have maintenance logs where all maintenance activities are recorded and documented. Table 5-1 shows routine maintenance that is performed on Air Dynamics source testing equipment.

Table 5-1. Test Equipment - Routine Maintenance Schedule

Equipment	Acceptance Limits	Frequency of Service	Methods of Service
Pumps	• Absence of leaks • Ability to draw vacuum within equipment specifications	Every 500 hours of operation or 6 months, whichever is less	• Visual inspection • Lubrication
Flow Meters	• Free mechanical movement • Absence of malfunction • Calibration within tolerance	Every 500 hours of operation or 6 months, whichever is less	• Visual inspection • Clean • Calibrate
Electronic Instrumentation	• Absence of malfunction • Proper response to calibration gases and signals	As recommended by manufacturer or when required due to unacceptable limits	• Clean • Replace parts as necessary • Other recommended manufacturer service
Mobile Laboratory Sampling System	• Absence of leaks • Sample lines clean and free of debris • Proper input flow rates to analyzers	At least once per month or sooner depending on nature of use	• Change filters • Change gas dryer • Leak check • Check for contamination
Sample Lines	• Absence of soot and particulate buildup • Adequate sample flow	At least once per month or sooner depending on nature of use	• Flush with solvents and water • Heat and purge line with nitrogen

5.2.2 Equipment Calibration

Current calibration information on equipment used during testing is included in the Appendices of this report.

The S-Type pitot tubes are calibrated initially upon purchase and then annually. Visual measurements are taken prior to each use to ensure accidental damage has not occurred. Measurements are performed using a micrometer and protractor.

Each temperature sensor is marked and identified. This is done by marking each thermocouple end connector with a number. The sensor is calibrated as a unit with the control box potentiometer and associated lead wire as an identified unit. Calibrations are performed initially and annually at three (3) set-points over the range of expected temperatures for that particular thermocouple. A reference output-voltage/thermocouple calibrator is used as a temperature reference source for the multi-point calibrations.

The field barometer is adjusted initially and semiannually to within 0.1" Hg of the actual atmospheric pressure at the Air Dynamics laboratory facility in Plainfield, Indiana. All dry gas field meters are calibrated before initial use. Once the meter is placed in operation, its calibration is checked after each test series or bimonthly, whichever is less. Dry gas meters are calibrated against a NIST reference meter or orifice.

The dry gas meter orifice is calibrated before its initial use and then annually. This calibration is performed during the calibration of the dry gas test meter. The unit is checked in the field after every series of tests using a field gas-meter check procedure.

Analytical balances are internally calibrated prior to use following the manufacturer's instructions. The balances are further checked using Class S-1 analytical weights prior to daily usage. Field top loading balances are checked with a field analytical weight prior to usage.

Table 5-2. Field Equipment Calibration Summary

Equipment	Calibrated Against	Allowable Factor
Method 5 Meter Box	Orifice Set	Y $\pm$ 0.02Y >H@ $\pm$ 0.20 post test Y $\pm$ 0.05Y
Micro Dry Gas Meter	Reference Test Meter	Y $\pm$ 0.02Y >H@ $\pm$ 0.20 post test Y $\pm$ 0.05Y
O ₂ /CO ₂	Certified Gas Cylinder	$\pm$ 0.5%
Pitot Tube*	Geometric Specifications	See EPA Method 2
Thermocouple	Type K Thermocouple	$\pm$ 3 deg C
Impinger	Type K Thermocouple	$\pm$ 1 deg C
Dry Gas Thermometer	Type K Thermocouple	$\pm$ 3 deg C
Probe Nozzles*	Electronic Caliper	High-Low 0.004
Barometer	Calibrated Barometer	$\pm$ 0.1 in. Hg

*Checked in field to ensure no damage has occurred. Nozzles measured with Electronic Caliper.

6.0 AIR DYNAMICS DATA REDUCTION VALIDATION AND REPORTING

The data presented in final reports has been reviewed three (3) times. First, the analyst reviews and certifies that the raw data complies with technical controls, documentation requirements, and standard group procedures. Second, the Senior Project Manager reviews and certifies that data packages comply with specifications for sample holding conditions, chain of custody, data documentation, and the final report is free of transcription errors. Third, a QA review is performed by additional senior personnel. This review thoroughly examines the entire completed data report. Once the review process is completed, the report is approved by Air Dynamics senior personnel and issued. All raw laboratory data and final reports are stored for a minimum of five (5) years.

7.0 LIMITATIONS AND SIGNATURES

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Air Dynamics has striven to perform the services in a manner consistent with that level of care and skill ordinarily exercised by other environmental consultants practicing in the same locality and under similar conditions existing at the time we performed our services. No other warranty is either expressed or implied in this report or any other document generated in the course of performing Air Dynamics's services.

Sincerely,
Air Dynamics Testing, LLC.

Dave Williams

Dave Williams
Project Manager

Mike Murphy

Mike Murphy
Technical Director

Appendix A

Sample Calculations

SAMPLE CALCULATIONS

The tables presenting the results are generated electronically from raw data. It may not be possible to exactly duplicate these results using a calculator. The reference method data, results and all calculations are carried to sixteen decimal places throughout. The final table is formatted to an appropriate number of significant figures.

1. Volume of water collected (*wscf*)

$$V_{wstd} = (0.04707)(V_{lc})$$

Where:

V_{lc}	total volume of liquid collected in impingers and weighed silica gel (<i>ml</i>)
V_{wstd}	volume of water collected at standard conditions (<i>ft</i> ³)
0.4707	conversion factor (<i>ft</i> ³ / <i>ml</i>)

2. Volume of gas metered, standard conditions (*dscf*)

$$V_{mstd} = \frac{(17.64)(V_m)(P_{baro} + \frac{\Delta H}{13.6})(Y_d)}{(459.67 + T_m)}$$

Where:

P_{baro}	barometric pressure (<i>in. Hg</i>)
T_m	average dry gas meter temperature (<i>°F</i>)
V_m	volume of gas sample through dry gas meter at meter conditions (<i>ft</i> ³)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (<i>ft</i> ³)
Y_d	gas meter correction factor (<i>dimensionless</i>)
ΔH	average pressure drop across meter box orifice (<i>in. H₂O</i>)
17.64	conversion factor (<i>°R</i> / <i>in. Hg</i>)
13.6	conversion factor (<i>in. H₂O</i> / <i>in. Hg</i>)
459.67	conversion constant (<i>°F</i> to <i>°R</i>)

3. Sample gas pressure (*in. Hg*)

$$P_s = P_{baro} + \left(\frac{P_g}{13.6} \right)$$

Where:

P_{baro}	barometric pressure (<i>in. Hg</i>)
P_g	sample gas static pressure (<i>in. Hg</i>)
P_s	absolute sample gas pressure (<i>in. H₂O</i>)
13.6	conversion factor (<i>in. H₂O / in. Hg</i>)

4. Actual vapor pressure (*in. Hg*)

$$P_v = P_s$$

Where:

P_v	vapor pressure, actual (<i>in. Hg</i>)
P_s	absolute sample gas pressure (<i>in. Hg</i>)

5. Moisture Content (%)

$$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$$

Where:

B_{wo}	proportion of water vapor in gas stream by volume
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (<i>ft³</i>)
V_{wstd}	volume of water collected at standard conditions (<i>ft³</i>)

6. Saturated moisture content (%)

$$B_{ws} = \frac{(P_v)}{(P_s)}$$

Where:

B_{ws}	proportion of water vapor in gas stream by volume at saturated conditions (%)
P_v	vapor pressure, actual (<i>in. Hg</i>)
P_s	absolute sample gas pressure (<i>in. Hg</i>)

7. Molecular weight of dry gas stream (*lb / lb – mole*)

$$M_d = M_{CO_2} \frac{(CO_2)}{(100)} + M_{O_2} \frac{(O_2)}{(100)} M_{CO+N_2} \frac{(CO+N_2)}{(100)}$$

Where:

M_d	dry molecular weight of sample gas (<i>lb / lb – mole</i>)
M_{CO_2}	molecular weight of carbon dioxide (<i>lb / lb – mole</i>)
M_{O_2}	molecular weight of oxygen (<i>lb / lb – mole</i>)
M_{CO+N_2}	molecular weight of carbon monoxide and nitrogen (<i>lb / lb – mole</i>)
CO_2	proportion of carbon dioxide in the gas stream by volume (%)
O_2	proportion of oxygen in the gas stream by volume (%)
$CO + N_2$	proportion of carbon monoxide and nitrogen in gas stream by volume (%)
100	conversion factor, (%)

8. Molecular weight of sample gas (*lb / lb – mole*)

$$M_s = (M_d)(1 - B_{ws}) + (M_{H_2O})(B_{ws})$$

Where:

M_d	dry molecular weight of sample gas (<i>lb / lb – mole</i>)
B_{ws}	proportion of water vapor in the gas stream by volume
M_{H_2O}	molecular weight of water (<i>lb / lb – mole</i>)
M_s	molecular weight of sample gas, wet basis (<i>lb / lb – mole</i>)

9. Velocity of sample gas (*ft* / *sec*)

$$V_s = (K_p)(C_p)(\sqrt{\Delta P})\left(\sqrt{\frac{T_s + 459.67}{(M_s)(P_s)}}\right)$$

Where:

K_p	velocity pressure coefficient (<i>dimensionless</i>)
C_p	pitot tube constant
M_s	molecular weight of sample gas, wet basis (<i>lb</i> / <i>lb – mole</i>)
P_s	absolute sample gas pressure (<i>in. Hg</i>)
T_s	average sample gas temperature ($^{\circ}F$)
V_s	average sample gas velocity (<i>ft</i> / <i>sec</i>)
459.67	conversion constant ($^{\circ}F$ to $^{\circ}R$)

10. Total flow of sample gas (*acfm*)

$$Q_a = (60)(A_s)(V_s)$$

Where:

A_s	cross section area of sampling location (ft^2)
Q_a	volumetric flow rate at actual conditions (<i>acfm</i>)
V_s	average sample gas velocity (<i>ft</i> / <i>sec</i>)
60	conversion factor (<i>seconds</i> to <i>minutes</i>)

11. Total flow of sample gas per minute (*dscfm*)

$$Q_{std} = \frac{(Q_a)(P_s)(17.64)(1 - B_{wo})}{(T_s + 459.67)}$$

Where:

B_{wo}	proportion of water vapor in the gas stream by volume
P_s	absolute sample gas pressure (<i>in. Hg</i>)
Q_a	volumetric flow rate at actual conditions (<i>acfm</i>)
Q_{std} / <i>hr</i>	volumetric flow rate at standard conditions (<i>dscfm</i> * 60)
T_s	average sample gas temperature ($^{\circ}F$)
17.64	conversion factor ($^{\circ}R$ / <i>in. Hg</i>)
459.67	conversion constant ($^{\circ}F$ to $^{\circ}R$)

12. Total flow of sample gas per hour (*dscfh*)

$$Q_{std/hr} = \frac{(Q_a)(P_s)(17.64)(1 - B_{wo})}{(T_s + 459.67)}$$

Where:

B_{wo}	proportion of water vapor in gas stream by volume
P_s	absolute sample gas pressure (<i>in. Hg</i>)
Q_a	volumetric flow rate at actual conditions (<i>acfm</i>)
$Q_{std/hr}$	volumetric flow rate at standard conditions (<i>dscfm</i> * 60)
T_s	average sample gas temperature ($^{\circ}F$)
17.64	conversion factor ($^{\circ}R / in. Hg$)
459.67	conversion constant ($^{\circ}F$ to $^{\circ}R$)

13. Percent Isokinetic (%)

$$I = \frac{(0.9450)(T_s)(V_{mstd})}{(P_s)(V_s)\left(\frac{(D_n)^2(\pi)}{(144)(4)}\right)(\ell)(1 - B_{wo})}$$

Where:

D_n	diameter of nozzle, inches
B_{wo}	proportion of water vapor in gas stream by volume
I	percent of isokinetic sampling (%)
P_s	absolute sample gas pressure (<i>in. Hg</i>)
T_s	average sample gas temperature ($^{\circ}F$)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
V_s	average sample gas velocity (<i>ft</i> / sec)
ℓ	total sample time in minutes
0.09450	constant

14. Pollutant concentration (*gr / dscf*)

$$C_{gr / dscf} = \frac{(15.43)(M_n)}{V_{mstd}}$$

Where:

$C_{gr / dscf}$	measured concentration in the gas stream, (<i>gr / dscf</i>)
M_n	pollutant collected, corrected for reagent blank, in grams
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (<i>ft</i> ³)
15.43	conversion factor (<i>grams to grains</i>)

15. Pollutant Emissions, Mass Emissions Rate (*lbs / hr*)

$$E_{lbs / hr} = \frac{(\mu g_{HCl})(2.2046e-9)(Q_{std})(60)}{(V_{std})}$$

Where:

$E_{lbs / hr}$	mass emissions rate, pounds per hour
μg_{HCl}	micrograms of pollutant emissions
Q_{std}	volumetric flow rate at standard conditions, dry basis (<i>dscfm</i>)
V_{std}	volume at standard conditions
$2.2046e-9$	conversion factor (<i>pounds per microgram</i>)
60	conversion factor (<i>minutes per hour</i>)

Appendix B

Field Data Spreadsheets

Air Dynamics Testing

GLWA

Unit 12

Run 1 Average:

Date/Time	O ₂	CO ₂	SO ₂	CO			
7/23/2024 10:03	8.4	10.6	0.3	94.5			
7/23/2024 10:04	8.2	10.7	0.3	121.7			
7/23/2024 10:05	8.1	10.8	0.3	88.5			
7/23/2024 10:06	8	10.9	0.3	80.9			
7/23/2024 10:07	8	10.8	0.3	84.3	Point 1	8.13	0.08 0.9%
7/23/2024 10:08	8.1	10.8	0.3	86.7	Point 2	8.32	-0.11 1.3%
7/23/2024 10:09	8.3	10.6	0.3	67	Point 3	8.18	0.03 0.3%
7/23/2024 10:10	8.1	10.7	0.5	87.4	Average	8.21	0.9% Not Stratified
7/23/2024 10:11	8.2	10.6	0.3	87.4			
7/23/2024 10:12	8.5	10.4	0.3	87.5			
7/23/2024 10:13	8.3	10.5	0.5	104.2			
7/23/2024 10:14	8.5	10.4	0.3	90.1			
7/23/2024 10:15	8.8	10.2	0	116			
7/23/2024 10:16	8.3	10.6	0.3	116.2			
7/23/2024 10:17	8.1	10.8	0	97.1			
7/23/2024 10:18	8.1	10.8	-0.3	85.9			
7/23/2024 10:19	8	10.9	0	99.2			
7/23/2024 10:20	7.8	11.1	-0.3	113.1			
7/23/2024 10:21	7.9	11	0.3	84.8			
7/23/2024 10:22	7.9	11	0.3	71.8			
7/23/2024 10:23	7.8	11.1	0.5	80.6			
7/23/2024 10:24	8	11	0.3	76			
7/23/2024 10:25	7.8	11.1	0.3	60.2			
7/23/2024 10:26	7.2	11.6	0	62.6			
7/23/2024 10:27	8.2	10.8	0.3	56.3			
7/23/2024 10:28	8	10.9	0.3	56.6			
7/23/2024 10:29	7.8	11.1	0	55			
7/23/2024 10:30	7.1	11.6	0.3	55.3			
7/23/2024 10:31	7	11.7	0	67			
7/23/2024 10:32	7.8	11	0.3	67.8			
7/23/2024 10:33	9	10.2	0.2	90.6			
7/23/2024 10:34	9.4	9.9	0	128.1			
7/23/2024 10:35	8.7	10.4	0.3	130.7			
7/23/2024 10:36	8.7	10.3	0.3	118.5			
7/23/2024 10:37	8.5	10.6	0	128.6			
7/23/2024 10:38	11.4	11.2	0	8.1			
7/23/2024 10:39	11.4	11.3	4.2	-0.1			
7/23/2024 10:40	11.4	11.3	2.6	-0.1			
7/23/2024 10:41	11	10.9	1.3	-0.2			
7/23/2024 10:42	8.7	10.7	0.8	9.7			
7/23/2024 10:43	0.1	0.2	0.3	51.1			
7/23/2024 10:44	0	0.1	0.4	52.4			
7/23/2024 10:45	7.6	10.1	0.5	51.4			
7/23/2024 10:46	7.8	10.3	0.3	52.9			
7/23/2024 10:47	7.6	10.4	0.4	59.9			
7/23/2024 10:48	7.4	10.5	1.6	66.8			
7/23/2024 10:49	7.1	10.8	0.8	65			
7/23/2024 10:50	7.2	10.7	0.5	60.5			
7/23/2024 10:51	7.3	10.7	0.5	65			
7/23/2024 10:52	7.7	10.4	0.6	58.4			
7/23/2024 10:53	8.2	10.2	0.3	48			
7/23/2024 10:54	8.2	10.1	0	44.3			
7/23/2024 10:55	8.3	10.2	0.3	45.5			
7/23/2024 10:56	8.5	10	0.3	44			
7/23/2024 10:57	8.7	9.8	0.3	40			

7/23/2024 10:58	8.8	9.7	0.3	48
7/23/2024 10:59	8.8	9.7	0.3	50.6
7/23/2024 11:00	8.7	9.7	0.3	52.1
7/23/2024 11:01	8.5	9.9	0.3	56.1
7/23/2024 11:02	8.4	9.9	0.3	68.9
7/23/2024 11:03	8.3	10	0.3	63.3
7/23/2024 11:04	8.2	10	0.3	63.6
7/23/2024 11:05	8.4	10	0	52.9
7/23/2024 11:06	8.4	9.9	0.3	46.1
7/23/2024 11:07	8.4	9.9	0.3	45.9
7/23/2024 11:08	8.7	9.8	0.3	54
7/23/2024 11:09	9	9.5	0.3	66.8
7/23/2024 11:10	8.5	9.8	0.3	108.3
7/23/2024 11:11	8.2	10.1	0	72
7/23/2024 11:12	8.2	10.1	0.3	57.1
7/23/2024 11:13	8.2	10.1	0.3	50.1
7/23/2024 11:14	8.2	10.1	0	55.3
7/23/2024 11:15	9.4	8.6	0	14.1
7/23/2024 11:16	8	10.1	0.3	90.4
7/23/2024 11:17	7.9	10.3	0	95.8
7/23/2024 11:18	7.8	10.4	0	94.5
7/23/2024 11:19	7.9	10.3	0.3	102.1
7/23/2024 11:20	7.7	10.4	-0.3	88.5
7/23/2024 11:21	7.8	10.4	0	73.1
7/23/2024 11:22	7.7	10.5	0.3	62.1
Run 1 Average:	8.10	10.21	0.35	69.41

Air Dynamics Testing

GLWA

Unit 12

Run2

Date/Time	O ₂	CO ₂	SO ₂	CO
7/23/2024 12:29	7.9	10.1	0.4	21.3
7/23/2024 12:30	8	10.1	0.5	24.9
7/23/2024 12:31	8.1	10	0.2	28.1
7/23/2024 12:32	8.3	9.9	0.2	26
7/23/2024 12:33	8.5	9.8	0	27.3
7/23/2024 12:34	8.9	9.6	0.5	20.2
7/23/2024 12:35	9	9.6	0.5	19.1
7/23/2024 12:36	8.9	9.5	0.2	18.6
7/23/2024 12:37	8.7	9.7	0.5	21.8
7/23/2024 12:38	8.9	9.5	1	21.5
7/23/2024 12:39	8.8	9.5	0.5	34.6
7/23/2024 12:40	9	9.3	0.2	40.5
7/23/2024 12:41	8.5	9.6	0.5	34.1
7/23/2024 12:42	8.4	9.7	0.5	23.4
7/23/2024 12:43	8.6	9.6	0.2	23.1
7/23/2024 12:44	8.7	9.6	0.2	25.2
7/23/2024 12:45	8.8	9.5	0.2	27.3
7/23/2024 12:46	9.1	9.3	0.4	37.2
7/23/2024 12:47	9.2	9.3	0.2	31.4
7/23/2024 12:48	9.3	9.3	0.5	24.9
7/23/2024 12:49	9.2	9.3	0.5	25.7
7/23/2024 12:50	8.8	9.6	0.4	32.4
7/23/2024 12:51	8.4	9.7	0.5	33.6
7/23/2024 12:52	8.1	10	0.5	42.1
7/23/2024 12:53	8	10	0.2	43.2
7/23/2024 12:54	8	10.1	0.7	36.1
7/23/2024 12:55	8	10.1	0.5	31.9
7/23/2024 12:56	8	10	0.2	26.7
7/23/2024 12:57	8	10.1	0.2	27.8
7/23/2024 12:58	8.5	9.7	0.4	30.6
7/23/2024 12:59	8.9	9.5	0.2	33.6
7/23/2024 13:00	8.9	9.5	0.4	28.3
7/23/2024 13:01	9	9.4	0.5	27.3
7/23/2024 13:02	9	9.4	0.2	29.8
7/23/2024 13:03	8.8	9.4	0.5	35.6
7/23/2024 13:04	8.5	9.6	0.5	47.4
7/23/2024 13:05 *	7.9	9.9	0.2	57.8
7/23/2024 13:06	7.7	10	0.5	58.4
7/23/2024 13:07	7.6	10.2	0.2	55.3
7/23/2024 13:08	7.9	10	0.2	57.1
7/23/2024 13:09	8.5	9.7	0.2	46.1
7/23/2024 13:10	8.6	9.6	0.4	37.9
7/23/2024 13:11	8.8	9.5	0.5	35.9
7/23/2024 13:12	9	9.4	0.5	32.7
7/23/2024 13:13	8.9	9.4	0.5	48.6
7/23/2024 13:14	8.9	9.5	0.2	40
7/23/2024 13:15	9.3	9.2	0	34.1
7/23/2024 13:16	9.3	9.1	0	39
7/23/2024 13:17	9.4	9.1	0.2	44.5
7/23/2024 13:18	9.5	9.1	0.2	43.2
7/23/2024 13:19	9.5	9	0.2	40.5
7/23/2024 13:20	9.5	9	0.7	62.6
7/23/2024 13:21	9.2	9.3	0.5	56.6
7/23/2024 13:22	9.2	9.3	0.5	43.4
7/23/2024 13:23	9.3	9.3	0.5	50.6

7/23/2024 13:24	9.1	9.4	0.2	55.5
7/23/2024 13:25	9	9.5	-0.1	59.2
7/23/2024 13:26	9	9.5	0.2	83.3
7/23/2024 13:27	9	9.5	0.5	67.3
7/23/2024 13:28	9.1	9.4	0.2	50.1
7/23/2024 13:29	8.9	9.5	0.2	73.3
7/23/2024 13:30	8.9	9.6	0.2	89.8
7/23/2024 13:31	8.7	9.7	-0.1	79.3
7/23/2024 13:32	8.5	9.8	0.2	70.2
7/23/2024 13:33	8.7	9.6	0.4	103.4
7/23/2024 13:34	9	9.3	0.2	102.6
7/23/2024 13:35	8.2	9.9	0.2	79.3
7/23/2024 13:36	8	10.1	0.2	57.4
7/23/2024 13:37	8.2	10	0.2	52.9
7/23/2024 13:38	8.3	9.9	0.5	59.4
7/23/2024 13:39	8.4	9.8	0.4	53.9
7/23/2024 13:40	8.5	9.6	-0.1	46.1
7/23/2024 13:41	8.7	9.3	0.7	50.1
7/23/2024 13:42	8.6	9.4	0.2	60.2
7/23/2024 13:43	8.6	9.5	0.5	69.2
7/23/2024 13:44	8.9	9.2	0.2	53.7
7/23/2024 13:45	9.1	9.1	0.2	72.5
7/23/2024 13:46	9.2	9.1	0.2	98.9
7/23/2024 13:47	9.3	9.1	0.2	110.9
7/23/2024 13:48	9.1	9.3	0.5	111.4
7/23/2024 13:49	9.2	9.3	0.5	102.9
Run 2 Averages:	8.7	9.6	0.33	47.65

Air Dynamics Testing

GLWA

Unit 12

Run 3

Date/Time	O ₂	CO ₂	SO ₂	CO
7/23/2024 16:38	9.3	9.2	0.5	113.8
7/23/2024 16:39	9.3	9.2	0.5	132
7/23/2024 16:40	9.4	9.2	0.5	132
7/23/2024 16:41	9.4	9.2	0.5	130.9
7/23/2024 16:42	9.2	9.3	0.5	126.3
7/23/2024 16:43	9.3	9.2	0.5	146.1
7/23/2024 16:44	9.3	9.2	0.4	153.6
7/23/2024 16:45	9.1	9.3	0.4	154.4
7/23/2024 16:46	9.2	9.4	0.2	136.4
7/23/2024 16:47	9.6	9	0.2	120.4
7/23/2024 16:48	9.1	9.3	0.4	125
7/23/2024 16:49	9	9.3	0.2	115.2
7/23/2024 16:50	9.1	9.3	0.4	123.9
7/23/2024 16:51	9.2	9.2	0.2	112.4
7/23/2024 16:52	9.3	9	0.5	108.3
7/23/2024 16:53	9.5	8.9	0.2	139.8
7/23/2024 16:54	9.5	8.9	0.2	159.7
7/23/2024 16:55	9.3	9	0.5	158.9
7/23/2024 16:56	9.1	9.1	0.4	161.2
7/23/2024 16:57	9.1	9.1	0.2	89.8
7/23/2024 16:58	9.2	9.1	0.2	87.2
7/23/2024 16:59	9.2	9.1	0.5	92.1
7/23/2024 17:00	8.6	9.7	0.2	84.8
7/23/2024 17:01	8.7	9.5	0.2	111.4
7/23/2024 17:02	8.3	9.8	0.5	121.6
7/23/2024 17:03	8.6	9.6	0.5	123.4
7/23/2024 17:04	8.8	9.4	0.5	120.8
7/23/2024 17:05	8.9	9.3	0.5	116.2
7/23/2024 17:06	9	9.2	0.2	124
7/23/2024 17:07	9	9.4	0.5	123.2
7/23/2024 17:08	9.1	9.3	0.2	101.8
7/23/2024 17:09	9.1	9.2	0.4	90.1
7/23/2024 17:10	9.2	9.2	0.4	86.9
7/23/2024 17:11	9.2	9.1	0.5	103.4
7/23/2024 17:12	9	9.2	0.4	105.2
7/23/2024 17:13	9	9.2	0.2	112.2
7/23/2024 17:14	8.9	9.2	0.4	123.2
7/23/2024 17:15	5.1	13.1	1.2	21.8
7/23/2024 17:16	5.4	12.9	1.2	16.1
7/23/2024 17:17	5.4	12.9	1	14.8
7/23/2024 17:18	5.7	12.7	1	13.3
7/23/2024 17:19	6	12.5	1	13.1
7/23/2024 17:20	6	12.5	0.7	16.3
7/23/2024 17:21	6	12.5	0.7	14.1
7/23/2024 17:22	6.3	12.2	0.7	14.8
7/23/2024 17:23	7.5	11.3	0.4	21.2
7/23/2024 17:24	7.9	10.9	0.4	28.1
7/23/2024 17:25	7.7	11.1	0.4	31.2
7/23/2024 17:26	7.2	11.5	0.5	26.8
7/23/2024 17:27	6.8	11.9	0.5	23.9
7/23/2024 17:28	6.4	12.2	0.4	24.7
7/23/2024 17:29	5.6	12.8	0.7	17.9
7/23/2024 17:30	6.1	12.5	0.5	16.9
7/23/2024 17:31	5.3	13.1	0.4	22.6
7/23/2024 17:32	5.2	13.1	0.2	18.4

7/23/2024 17:33	5.8	12.8	0.4	16.6
7/23/2024 17:34	5.5	13	0.5	15.6
7/23/2024 17:35	5.6	10.7	1.6	62.9
7/23/2024 17:36	5.7	10.5	1.5	89.6
7/23/2024 17:37	5.9	12.5	0.7	9.7
7/23/2024 17:38	5.8	12.6	0.5	10.8
7/23/2024 17:39	5.9	12.5	0.5	11
7/23/2024 17:40	6	12.4	0.5	8.9
7/23/2024 17:41	6.2	12.2	0.2	10
7/23/2024 17:42	6.1	12.4	0.4	8.7
7/23/2024 17:43	6.5	12.1	0.4	8.7
7/23/2024 17:44	6.8	11.9	0.2	9.2
7/23/2024 17:45	7	11.7	0.4	7.9
7/23/2024 17:46	7	11.7	0.2	7.9
7/23/2024 17:47	7.3	11.4	0.2	9.7
7/23/2024 17:48	7.3	11.4	0.2	8.7
7/23/2024 17:49	6.9	11.7	0	11.3
7/23/2024 17:50	6.7	11.8	0.2	12
7/23/2024 17:51	7.1	11.5	-0.1	13.8
7/23/2024 17:52	7.2	11.3	-0.1	17.4
7/23/2024 17:53	7.5	11.1	-0.1	22.3
7/23/2024 17:54	7.4	11.1	-0.1	29.4
7/23/2024 17:55	7.3	11	0.9	36
7/23/2024 17:56	7.4	10.9	0.8	33.1
7/23/2024 17:57	7.5	11.1	0.7	33.2
Run 3 Average:	7.68	10.71	0.45	66.60

Air Dynamics Testing

Summary of Results

Unit 12

7/23/2024

	O ₂	CO ₂	SO ₂	CO	SO ₂ @7%O ₂	CO @7%O ₂
Run 1	8.05	10.16	0.10	66.59	0.11	72.05
Run 2	8.64	9.52	0.03	45.51	0.03	51.58
Run 3	7.61	10.66	0.15	63.84	0.16	66.75
Avg					0.10	63.46
Limits					26	3800

Source Sampling Title Page

Source Information

Plant Name	GLWA
Fuel Type	
Source Name	Unit 12

Test Information

Starting Test Date	7/23/24	
Project #	1078.24	
Operator	MM	
Standard Temperature	68	°F
Standard Pressure	29.92	in Hg
Minimum Required Sample Volume	45	scf
Run Duration	80	Minutes
Base Run Number	1	
# of ports available	2	
# of ports used	2	
Total Number of Traverse Points	24	
Port Inside Diameter	6	in
Circular Stack or Rectangular Stack	Circular	

Test Equipment Information

Meter Box Number	IN-2	
Meter Calibration Factor	1.00	(Y)
Orifice Meter Coefficient	1.8730	DH@
Pitot Tube Coefficient	0.84	
Fyrite Identification	NA	
Nozzle Number	4	
Nozzle Diameter	0.3750	in
Probe Number	M5-6-1	
Probe Length	72	in
Liner Material	Glass	
Glass Ware Case Name		

Testing Company Information

Company Name	Air Dynamics Testing
Address	698 Tower Road Suite 100
City, State, Country, Zip	Plainfield, IN, USA 46168
Phone Number	317-741-7982

Air Dynamics Testing - Method 1 Circular Sheet

General Stack Information

Stack ID (inches)	53
Nipple Length (inches)	5.00
A Distance (inches)	96
B Distance (inches)	144
Upstream Disturbance Diameters	2.72
Downstream Disturbance Diameters	1.81
Stack Area (ft ²)	15.32

Meets Method 1 Requirements

YES

YES

4 points per port

#	Percentage	Point	Point + Nipple
1	0.067	3.6	8 2/4
2	0.250	13.3	18 1/4
3	0.750	39.8	44 3/4
4	0.933	49.4	54 2/4

6 point per port

#	Percentage	Point	Point + Nipple
1	0.044	2.3	7 1/4
2	0.146	7.7	12 3/4
3	0.296	15.7	20 3/4
4	0.704	37.3	42 1/4
5	0.854	45.3	50 1/4
6	0.956	50.7	55 3/4

8 Points per port

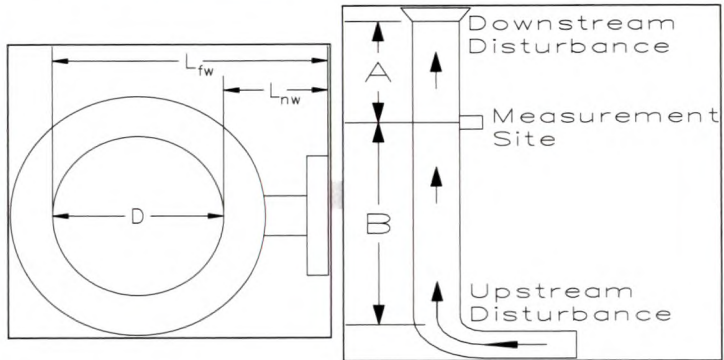
#	Percentage	Point	Point + Nipple
1	0.032	1.7	6 3/4
2	0.105	5.6	10 2/4
3	0.194	10.3	15 1/4
4	0.323	17.1	22
5	0.677	35.9	41
6	0.806	42.7	47 3/4
7	0.895	47.4	52 2/4
8	0.968	51.3	56 1/4

10 points per port

#	Percentage	Point	Point + Nipple
1	0.026	1.38	6 2/4
2	0.082	4.35	9 1/4
3	0.146	7.74	12 3/4
4	0.226	11.98	17
5	0.342	18.13	23 1/4
6	0.658	34.87	39 3/4
7	0.774	41.02	46
8	0.854	45.26	50 1/4
9	0.918	48.65	53 3/4
10	0.974	51.62	56 2/4

12 points per port

#	Percentage	Point	Point + Nipple
1	0.021	1.1	6
2	0.067	3.6	8 2/4
3	0.118	6.3	11 1/4
4	0.177	9.4	14 2/4
5	0.25	13.3	18 1/4
6	0.356	18.9	23 3/4
7	0.644	34.1	39 1/4
8	0.75	39.8	44 3/4
9	0.823	43.6	48 2/4
10	0.882	46.7	51 3/4
11	0.933	49.4	54 2/4
12	0.979	51.9	57



Location of Traverse Points in Circular Stacks

(Fraction of Stack Diameter from Inside Wall to Traverse Point)

Traverse Point Number	Number of Traverse Points on a Diameter					
	2	4	6	8	10	12
1	.146	.067	.044	.032	.026	.021
2	.854	.250	.146	.105	.082	.067
3		.750	.296	.194	.146	.118
4		.933	.704	.323	.226	.177
5			.854	.677	.342	.250
6			.956	.806	.658	.356
7				.895	.774	.644
8				.968	.854	.750
9					.918	.823
10					.974	.882
11						.933
12						.979

Number of Traverse Points Required

Diameters to Flow Disturbance		Minimum Number of ¹ Traverse Points	
Up Stream	Down Stream	Particulate Points	Velocity Points
2.00-4.99	0.50-1.24	24	16
5.00-5.99	1.25-1.49	20	16
6.00-6.99	1.50-1.74	16	12
7.00-7.99	1.75-1.99	12	12
>= 8.00	>= 2.00	8 or 12 ²	8 or 12 ²
Upstream Spec			
Downstream Spec			
Traverse Pts Required			

¹ Check Minimum Number of Points for the Upstream and Downstream conditions, then use the largest.

² 8 for Circular Stacks 12 to 24 inches

12 for Circular Stacks over 24 inches

Method 2 - Determination of Stack Gas Velocity and Volumetric Flow Rate

Date	7/23/24
Project Number	1078.24
# Ports Used	2
Pitot Tube ID	M5-6-1
Pitot Coefficient	0.84

Velocity Traverse Data				
Run Number		1		
Run Time				
Traverse Point	Velocity Head (Dp)	Stack Temp (t _s)	Local Velocity (v _s) _i	Cyclonic Check yaw angle
	in H ₂ O	°F	ft/sec	degrees
A-1	0.080	94	16.6	1
A-2	0.080	94	16.6	3
A-3	0.080	94	16.6	1
A-4	0.070	94	15.5	0
A-5	0.060	94	14.4	0
A-6	0.060	94	14.4	3
A-7	0.070	94	15.5	5
A-8	0.110	94	19.5	5
A-9	0.110	94	19.5	4
A-10	0.080	94	16.6	1
A-11	0.080	94	16.6	2
A-12	0.080	94	16.6	3
B-1	0.080	94	16.6	4
B-2	0.080	94	16.6	2
B-3	0.080	94	16.6	2
B-4	0.080	94	16.6	3
B-5	0.080	94	16.6	2
B-6	0.080	94	16.6	1
B-7	0.080	94	16.6	1
B-8	0.080	94	16.6	6
B-9	0.080	94	16.6	5
B-10	0.080	94	16.6	5
B-11	0.080	94	16.6	0
B-12	0.080	94	16.6	2
(Dp) ^{1/2} _{avg} ¹	0.0800	94	17	3

¹ Average of the square roots of Dp
where (Dp)^{1/2}_{avg} = 1/n S(Dp^{1/2})

Stack Gas Composition			
Carbon Dioxide Concentration	(%CO ₂)	10.1	%
Oxygen Concentration	(%O ₂)	10.8	%
Carbon Monoxide Concentration	(%CO)	0.0	%
Nitrogen Concentration	(%N ₂)	79.1	%
Stack Moisture Content	(B _{ws})	5.000	%
Stack Dry Molecular Weight	(M _d)	30.05	lb/lb-mole
Stack Wet Molecular Weight	(M _w)	29.45	lb/lb-mole

Results				
Avg Stack Gas Velocity		(v_s)	16.6	ft/sec
Avg Stack Dry Std Flow Rate		(Q_{sd})	778,445	dscf/hr
Avg Stack Dry Std Flow Rate		(Q_{sd})	12,974	dscf/min
Avg Stack Wet Flow Rate		(Q_{sw})	15,232	ascf/min

	Formulas Used
$A_s = DW/K_u$ for Rectangular Stacks	$T_{s(avg)} = 1/n S t_b + T_u$
$A_s = (p(D/2)^2)/K_u$ for Circular Stacks	where $T_u = 273$ °K for metric units
where $K_u = 1$ for metric units	where $T_u = 460$ °R for English units
where $K_u = 144$ (in ² /ft ²) for English units	$v_s = K_p C_p (Dp)^{1/2}_{avg} (T_{s(avg)}/(P_s M_b))^{1/2}$
$P_s = P_{bar} + P_{static}/13.6$	where $K_p = 34.97$ for metric units
$\%N_2 = 100 - \%CO_2 - \%O_2 - \%CO$	where $K_p = 85.49$ for English units
$M_d = .44(\%CO_2) + .32(\%O_2) + .28(\%N_2 + \%CO)$	$Q_{std} = 3600(1 - B_{ws})/v_s A_s (T_{std}/T_{s(avg)})(P/P_{std})$
$M_s = M_d(1 - B_{ws}) + 18B_{ws}$	where $T_{std} = 293$ °K, $P_{std} = 760$ mm Hg, for metric units
$v_{s(avg)} = 1/n S (Dp)^{1/2}$	where $T_{std} = 528$ °R, $P_{std} = 29.92$ in Hg, for English units

$A_s = DW/K_u$ for Rectangular Stacks

$$A_s = (p(D/2)^2)/K_u \text{ for Circular Stacks}$$

where $K_u = 1$ for metric units

where $K_u = 144 \text{ (in}^2/\text{ft}^2\text{)}$ for English units

$$P_s = P_{\text{bar}} + P_{\text{static}}/13.6$$

$$\%N_2 = 100 - \%CO_2 - \%O_2 - \%CO$$

$$M_d = .44(\%CO_2) + .32(\%O_2) + .28(\%N_2 + \%CO)$$

$$M_s = M_d(1 - B_{ws}) + 18B_{ws}$$

$$\bar{D}_p^{1/2} = 1/n S(D_p^{1/2})$$

$$T_{s(\text{avg})} = 1/n \text{St}_s + T_u$$

where $T_u = 273^\circ\text{K}$ for metric units

where $T_u = 460^\circ\text{R}$ for English units

$$v_s = K_p C_p (Dp)^{1/2}_{avg} (T_{s(avg)} / (P_s M_s))^{1/2}$$

where $K_p = 34.97$ for metric units

where $K_n = 85.49$ for English units

$$Q_{sd} = 3600(1 - B_{ws})v_s A_s (T_{std}/T_{s(avg)})(P_s/P_{std})$$

where $T_{\text{std}} = 293^\circ\text{K}$, $P_{\text{std}} = 760\text{ mm Hg}$, for metric units

where $T_{\text{std}} = 528^\circ\text{R}$, $P_{\text{std}} = 29.92$ in Hg, for English units