1.0 INTRODUCTION

1.1 Summary of Test Program

Gammie Air Monitoring, LLC (GamAir) was retained by Ypsilanti Community Utilities Authority (YCUA) to perform an air emissions compliance test program on one fluidized bed sewage sludge incinerator (FBSSI). The purpose of this emission measurement test program was to quantify the controlled emissions of: mercury, polychlorinated biphenyls (PCB), carbon dioxide, and oxygen. The applicable Michigan Department of Environment, Great Lakes, & Energy (EGLE) and United States Environmental Protection Agency (USEPA) emission limits are as follows:

Table 1-1
Applicable Emission Limits
Ypsilanti Community Utilities Authority
Fluidized Bed Incinerator
Ypsilanti, Michigan

Michigan EGLE/ USEPA Emission Limits

Parameter	Units	Emission Limit
Polychlorinated Biphenyls (PCB)	pound/dry ton sludge	1.2E-06
Mercury	mg/kg dry sludge (material limit) pound/dry ton of sludge (emission limit) gram/24-hr	3.7 6.9E-04 3200

Compliance emission tests were performed on the parameters listed above. The tests were conducted in accordance with the conditions and monitoring requirements for compliance testing as set forth with the EGLE/ USEPA guidelines for source emission testing. Compliance tests were conducted in accordance with USEPA Methods 1-5, 23, and 29, as published in Title 40, Code of Federal Regulations, Part 60 (40CFR60). Testing of the FBSSI occurred on 26 May 2021. Representatives from YCUA and GamAir were responsible for coordinating the testing with the EGLE. YCUA personnel was responsible for collecting all process data and biosolids samples; biosolids sample analysis was performed by contract labs, Brighton Analytical, LLC. Gammie Air Monitoring, LLC (GamAir) was responsible for collecting all air emission samples and their contract lab, Bureau Veritas Laboratories (BV Labs) was responsible for analysis of those samples.

The EGLE has identified this source as the following:

State Registration Number: B6237

Permit Number: MI-ROP-B6237-2015

Section 2.0 of this report presents a description of the source, sampling locations, and summarizes the process operational parameters. Section 3.0 summarizes the test results. Sampling and analysis methodologies are presented in Section 4.0. Quality assurance and quality control (QA/QC) procedures specific to this test program are described in Section 5.0.

1.2 Test Program Organization

The following is a list of those individuals responsible for the organization of this test program.

Mr. Sree Mullapudi, PE Email: smullapudi@ycua.org	YCUA	(734) 484-4600
Mrs. Karen Kajiya-Mills Email: kajiya-millsk@michigan.gov	Michigan EGLE	(586) 753-3745
Mr. Leigh Gammie Email: lag@gamair.com	GamAir	(860) 757-3340
Mr. Clayton Johnson Email: clayton.johnson@bvlabs.com	BV Labs	(905) 817-5769

2.0 SOURCE SAMPLING AND PROCESS DESCRIPTION

2.1 Outlet Flue Gas Sampling Location

The inside diameter of the incinerator exhaust stack was 41.5 inches. The conventional EPA test ports are located after the induced draft fan and prior to the top of the exhaust stack. Two EPA test ports are spaced 90 degrees apart and are located 293 inches (7.0 duct diameters) from the nearest upstream disturbance and 173 inches (4.2 duct diameters) from the nearest downstream disturbance. Based on EPA Method 1 this location required twelve (12) traverse points, six (6) per each test port. A schematic diagram showing the sample port locations are shown below and again in the Appendix A.

Table 2-1
Wet Method Sample Traverse Points
Ypsilanti Community Utilities Authority
Fluidized Bed Sewage Sludge Incinerator

Traverse Point	% of Stack Diameter	Distance (inches)
1	0.044	1.63
2	0.146	5.50
3	0.296	11.13
4	0.704	26.38
5	0.854	32.00
6	0.956	58.88

2.1.1 Continuous Emissions Monitoring Sampling Location

Continuous emissions monitoring (CEM) sampling occurred at the same Venturi Scrubber outlet stated above in a separate port. CEM sampling took place through a single port. Prior to the start of the CEM sampling a three-point stratification check was performed. The individual traverse point locations are shown below and ductwork schematic are in the Appendix A.

Table 2-2
Gaseous Sample Traverse Points
Ypsilanti Community Utilities Authority
Fluidized Bed Sewage Sludge Incinerator

Traverse Point	% of Stack Diameter	Distance (inches)
1	0.167	6.93
2	0.50	20.75
3	0.833	34.57

2.2 Process and Air Pollution Control Description

YCUA operates a fluidized bed biosolids incinerator (FBI) which is rated at 6,300 dry pounds per hour (3.15 tons per hour) of biosolids. The FBI operated at 2.61 dry tons of sludge per hour which equates to 83.0% of the maximum capacity rating (MCR) which equates ≥4,699 pounds per hour. The fluidized bed temperature was 1346°F.

Air emissions from the FBI were controlled by a venturi/impingement tray scrubber operating at an average scrubber pressure drop range of 35.7" inches of water column (in. w.c.). Total water injection to the venturi scrubber was 336.2 gallons per minute (gpm); the water injection rate to the impingement tray was 585.7 gpm. Following the scrubber was a wet electrostatic precipitator (WESP) followed by a granular activated carbon (GAC) filter.

2.3 Process Monitoring

During the test program the incinerator operated at an optimized feed rate. The process parameters to be monitored during each test consisted of the following:

Hourly sludge tonnage input
Sludge moisture content (%)
Bed combustion temperatures
Incinerator oxygen content (% wet)
Scrubber water flowrates
Scrubber system pressure drop
Granular Activated Carbon Pressure Drop
Temperature Differential between GAC inlet and WESP outlet
WESP secondary voltage
WESP secondary amperage

Table 2-3summarizes the operational process parameters monitored during testing. Copies of YCUA's process monitoring can be found in Appendix D.

Table 2-3
Summary of Process Data
Compliance Test Program
Ypsilanti Community Utilities Authority
Fluidized Bed Incinerator
26 May 2021
Ypsilanti, Michigan

Method/Component	Units	Run 1 0830-1034	Run 2 1110-1314	Run 3 1355-1600	Average
Biosolids Feed Rate	dry pounds/hour	4863	5385	5442	5206
Percent Blended Solids	%	1.67	1.83	1.63	1.71
Fluidized Bed Temperature	°F	1351	1342	1346	1346
Free Board Temperature	°F	1676	1672	1668	1672
Venturi Water Flow	gallon/minute	333.2	336.3	339.0	336.2
Venturi Pressure Drop	inches w.c.	36.0	36.2	35.0	35.7
Tray Scrubber Water Flow	gallon/minute	587.4	583.4	586.2	585.7
Tray Scrubber Pressure Drop	inches w.c.	9.28	9.32	8.96	9.19
GAC Pressure Drop	inches w.c.	4.5	4.4	4.3	4.4
WESP Secondary Voltage	kV	43.8	43.7	42.0	43.2
WESP Amperage	mA	42.2	41.5	18.4	34.0
Temperature Diff. GAC inlet WESP outlet	°F	36	36	36	36
YCUA - Carbon Monoxide @ 7% Oxygen	ppmvd	0	0	0.42	0.14
YCUA - Sulfur Dioxide	ppmvd	6.46	6.15	5.33	5.98
Oxygen	%	6.28	6.47	6.70	6.48

3.0 SUMMARY AND DISCUSSION OF RESULTS

3.1 Objectives and Test Matrix

The purpose of this test program was to measure air emissions from the FBSSI exhaust. Three emissions test runs were conducted for each parameter, with the average result of the three test runs reported. Table 3-1 lists the parameters that were measured along with their respective USEPA test method and sample time for each run for the FBSSI. Emissions testing was conducted in accordance with EPA approved test procedures to be used at the stack sampling location.

TABLE 3-1
Test Matrix
Ypsilanti Community Utilities Authority
Fluidized Bed Sewage Sludge Incinerator

Outlet Pollutant Sampling Parameters	EPA Test Methods	Sample Times (min.)	Analytical Laboratory	Number of Runs
USEPA and ELGE Compliance				
Oxygen (O_2)	Method 3A	120	GamAir	3
Carbon Dioxide (CO_2)	Method 3A	120	GamAir	3
Polychlorinated Biphenyls (PCB)	Method 23	120	BV	3 + 1 blank
Mercury (Hg)	Method 29	120	BV	3 + 1 blank

3.2 Summary of Test Results

Table 3-2 presents the summary of emissions data for each pollutant tested.

Table 3-2
Summary of Emissions Data
EGLE Compliance Test
Ypsilanti Community Utilities Authority
Fluidized Bed Incinerator
26 May 2021
Ypsilanti, Michigan

Method/ Component	Units	Run 1	Run 2	Run 3	Average	Limit	Percent of Limit
Method 23 – PCB	lb/ dry ton of sludge	4.09E-08	4.37E-08	5.96E-08	4.81E-08	1.20E-06	4.0
Method 29 – Mercury	mg/ dscm @ 7% O_2	9.52E-03	6.40E-03	4.85E-03	6.92E-03	0.037	18.7
Method 29 – Mercury	lb/ dry ton of sludge	2.03E-04	1.22E-04	8.98E-05	1.38E-04	6.9E-04	20.1
Method 29 – Mercury	g/ 24-hr period	5.39	3.58	2.66	3.88	3200	0.12
SW846 7471A – Mercury	mg/kg dry sludge	NA	NA	NA	0.31	3.7	8.4

PCB - polychlorinated biphenyls
mg/dscm @ 7% O_2 – milligrams per dry standard cubic meter at seven percent oxygen
lb/ dry ton of sludge – pound per dry ton of sludge
g/ 24-hr period – gram per 24 hour period
mg/kg dry sludge – milligram per kilogram of dry sludge
SW846 7471A – EPA Method 7471B (SW-846): Mercury in Solid or Semisolid Wastes (Manual Cold-Vapor Technique)

3.3 Field Test Changes

During the recovery of Method 23-1 the heated filter was removed from the filter housing and placed in its recovery sample jar. The recovery of the glass housing was rinsed with a small amount acetone into the filter recovery sample jar (M23-1-1). The EGLE representative noticed the mistake immediately. The filter housing was fully recovered into the proper sample recovery sample jar (M23-1-2, solvent rinses). All glassware was rinsed with acetone and toluene and all components were combined at the lab. The mistake in recovery should not have any effect on the validity of the PCB's reported by BV Labs as all components are combined together.

4.0 SAMPLING AND ANALYTICAL METHODOLOGY

The following EPA test methods were utilized during this emissions test program:

EPA Method 1	Sample and velocity traverses for stationary sources
EPA Method 2	Determination of stack gas velocity and volumetric flow rate (type S Pitot tube)
EPA Method 3A	Determination of oxygen and carbon dioxide concentrations in emissions from stationary sources (instrumental analyzer procedure)
EPA Method 4	Determination of moisture content in stack gases
EPA Method 5	Determination of particulate emissions from stationary sources
EPA Method 23	Determination of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) emissions from stationary sources
EPA Method 29	Determination of metals emissions from stationary sources

The following sections describe the sampling and analytical procedures to that were used during the emissions testing. All tests were performed in triplicate unless otherwise noted. All sampling and analytical procedures were followed those outlined in 40CFR60, Appendix A.

4.1 Volumetric Flow Rate Tests

The volumetric flowrate of the exhaust gases, at the scrubber outlet test location was determined using EPA Methods 1-4. In accordance with EPA Method 1 twelve traverse points were utilized for flue gas velocity measurements. The locations of the traverse points, as determined by EPA Method 1, are listed in the Appendix A. Flue gas velocity measurements were taken at each traverse point during each test run using an S-type Pitot tube and an inclined water manometer in accordance with EPA Method 2. Stack temperature measurements were taken at each traverse point using a Type-K thermocouple and digital temperature readout. The stack static pressure was measured during each test run using the Pitot tube and manometer setup. Pitot tube leak checks were performed before and after each test run in accordance with EPA Method 2.

The molecular weight of the outlet exhaust gases was determined by measuring the oxygen (O_2) and carbon dioxide (CO_2) concentrations using an oxygen and carbon dioxide analyzer as described in EPA Method 3A. Carbon dioxide and oxygen concentrations were determined from integrated gaseous samples collected during each of the test using the sample train described in EPA Method 3A. The flue gas moisture content was determined from the moisture catch of the sampling train during the emissions testing in accordance with EPA Method 4. Each individual impinger was weighed before and after each test. All exterior moisture present on post-test impingers was thoroughly dried before any weight measurement. A minimum sample volume of 2 dry cubic meters was collected during each of the metals and PCB tests. The moisture content of the flue gas was calculated as the ratio of the moisture catch corrected to standard conditions to the sum of the dry sample volume and the moisture catch, both corrected to standard conditions.

4.2 Mercury Tests

Mercury was sampled and analyzed in accordance with EPA Method 29. These metals tests were performed in triplicate on the FBSSI at the exhaust stack location during 120-minutes test runs. A schematic of the multiple metals sampling train is shown in the Appendix A. The following is a description of the metals sampling train and the procedures to be used to quantify multiple-metals during the test program. The multiple-metals sampling train consisted of a glass nozzle, a heated glass lined probe, a quartz filter/holder in a heated box, a set of six glass impingers connected in series, a control module consisting of a leak free sampling pump, a calibrated critical orifice, an inclined manometer, and a calibrated dry gas meter. A Teflon fitting was connected the nozzle to the probe liner. All of the sampling train glassware was cleaned and soaked in nitric acid according to the procedure described in EPA Method 29 prior to testing. The sample probe and oven box were maintained at a temperature of 248 ± 25^0F during sampling to prevent moisture condensation. The first and second impingers contained 100 ml of 5% nitric acid/10% hydrogen peroxide ($5\%HNO_3/10\%H_2O_2$). The third impinger was empty. The fourth and fifth impingers contained 100 ml of 4% potassium permanganate/10% sulfuric acid ($4\%KMnO_4/10\%H_2SO_4$). The acidic permanganate solution was prepared fresh on-site. The sixth impinger contained a known quantity of silica gel. The second impinger was a Greenburg-Smith impinger with a standard tip, while the other impingers had modified tips. The temperature at the outlet of the sixth impinger was maintained below 68°F during sampling by adding ice to the water bath. A vacuum line was connected to the outlet of the sixth impinger to the control module.

Before each test and after test run, the sampling train was leak checked to ensure no leakage greater than 0.02 cubic feet per minute at 15" Hg vacuum. The probe was placed in the stack and stack gas was withdrawn isokinetically for an equal period of time at each traverse point. The velocity differential pressure, critical orifice differential pressure, dry gas meter volume, dry gas meter inlet and outlet temperatures, probe temperature, stack temperature, oven box temperature, impinger outlet temperature, and sample vacuum were recorded at each traverse point during sampling. Before port changes and at the completion of each test, the sampling train was leak checked to ensure no leakage greater than 0.02 cubic feet per minute at the highest recorded test vacuum. After the post-test leak check, the sampling train was disassembled, all open ends were sealed, and the sampling train components were moved to the cleanup area for recovery. The recovery procedure for the multiple-metals sampling train is described as follows. The filter was carefully removed from the filter holder with Teflon coated forceps and placed in a labeled plastic Petri dish (Container 1). Any particulate matter or filter fragments that adhere to the filter holder gasket was transferred to the Petri dish using a dry, acid cleaned nylon bristle brush. The Petri dish was then sealed for transport to the laboratory.

The nozzle, probe liner, and filter holder front half was then rinsed and brushed thoroughly with 100 ml of 0.1 N nitric acid (HNO_3) using a Teflon coated brush. These rinses were collected in a labeled glass sample jar (Container 3). The sample jars were sealed and the liquid level marked. The nozzle, probe liner, and filter holder front half were then rinsed with deionized water followed by acetone. These rinses were discarded. The moisture gain in the first two impingers was measured gravimetrically and their contents were transferred to a labeled glass sample jar (Container 4). The first two impingers, the filter support, the back half of the filter holder, and the connecting glassware between the back half of the filter holder and the second impinger was then rinsed with 100 ml of 0.1 N HNO_3. These rinses were combined with the impinger contents and the sample jar were sealed and the liquid level was marked.

The moisture gain in the third impinger was measured gravimetrically and its contents was transferred to a labeled glass sample jar (Container 5A). This impinger was then rinsed with 100 ml of 0.1 N HNO_3. The rinses were combined with the impinger contents and the sample jar was sealed and the liquid level marked.

The moisture gain in the permanganate impingers was measured gravimetrically and the contents were transferred to a labeled glass sample jar (Container 5B). The impinger and connecting glassware was then rinsed with 100 ml of fresh 4%$KMnO_4$/10%H_2SO_4 followed by a rinse with 100 ml of deionized water. The permanganate and deionized water rinses were combined with the impinger contents and the sample jar were sealed and the liquid level marked. This sample jar was not completely filled and was vented to relieve excess pressure. If any visible permanganate deposits remain after the water rinses, the permanganate impinger was rinsed with a total of 25 ml of 8N HCl. The walls and stem of the permanganate impingers were rinsed and collected in a labeled sample jar containing 200 ml of deionized water (Container 5C). The sample jar was then sealed and the liquid level marked. The silica gel impinger was weighed for moisture gain. The silica gel was then returned to its original storage container to be dried for reuse. The following is a list of the sample recovery containers.

Container 1	filter is removed from filter holder and stored in sealed Petri dish
Container 2	not used in this procedure, used for FPM procedure
Container 3	nozzle, sample probe, and front half of filter housing are brushed and rinsed three times with 100 ml of 0.1N HNO_3 and save
Container 4	measure contents of impingers 1 and 2 and save; filter support, back half of filter housing, and flexible Teflon line are rinsed three times with 100 ml of 0.1N HNO_3 and save
Container 5A	measure contents of impinger 3 then rinse three times with 100 ml of 0.1N HNO_3 and save
Container 5B	measure contents of impingers 4&5 then rinse three times with 100 ml of acidified $KMnO_4$ and 100 ml of deionized distilled water and save.
Container 5C	rinse impingers 4&5 with 25 ml of 8N HCl solution followed by 100 ml of deionized distilled water and save
Container 6	weigh contents of impinger 6 for moisture gain
Container 7	not used in this procedure
Container 8A	0.1N HNO3 reagent blank (300 ml)
Container 8B	deionized distilled water blank (100 ml)
Container 9	HNO_3/H_2O_2 reagent blank (200 ml)
Container 10	acidified $KMnO_4$ reagent blank (100 ml)
Container 11	8N HCl reagent blank (200 ml)

Container 12 filter blanks (3)

One unused filter and aliquots of each of the impinger and rinse solutions, in the volumes specified in Method 29, were collected and submitted with the field samples as reagent blanks. Where applicable metals results were reagent blank corrected. Front half and back half fractions were combined before analysis. Containers 1 through 4 were digested in concentrated acid before being analyzed for the target metals (except mercury) by inductively coupled plasma-mass spectrometry (ICP/MS). The mercury analysis (Containers 5A, B, and C) was conducted on each of the sample fractions following digestion with acid and permanganate by cold vapor atomic absorption spectroscopy (CVAAS). All collected reagent blanks were analyzed using the same methodologies as the collected samples.

4.3 Polychlorinated Biphenyls Tests

Polychlorinated biphenyls (PCB) sampling was sampled and analyzed in accordance with EPA Method 23. Three PCB tests were performed on the FBSSI with each test being 120-minutes in duration. The Method 23 sampling train is shown in Appendix A. The following is a description of the sampling train and the procedures used to quantify PCB.

The sampling train consisted of precleaned acid soaked, DI water soaked, and tap water rinsed glassware, a Pyrex® glass button hook nozzle, a heated glass lined sample probe, a heated filter in a glass filter holder, a water cooled glass coil condenser, an water cooled adsorbent module (spiked pre-weighed XAD-2 trap), a set of four glass impingers connected in series in an ice bath, and a control module consisting of a leak free sampling pump, a calibrated critical orifice, an inclined manometer, and a calibrated dry gas meter. A Teflon fitting connected the nozzle to the probe liner. The probe and oven box were maintained at a temperature of 248±25°F during sampling to prevent moisture condensation. The first impinger was empty with the next two impingers each containing 100 ml of deionized water. The fourth impinger contained a known quantity of silica gel. The second impinger used a standard Greenburg-Smith tip, while the other impingers had modified straight tips. The glass components of the sampling train including the adsorbent module were cleaned in strict accordance with the procedures of EPA Method 23. Silicone grease was not used on any GamAir sampling trains. The adsorbent traps were loaded with XAD resin by the subcontracted analytical laboratory prior to being shipped to the test site. The fourth impinger outlet temperature was maintained below 68°F during sampling by adding ice. The coil condenser was cooled by circulating water to and from the cold box using a peristaltic pump. The adsorbent module was also maintained at a temperature less than 68°F during sampling.

Before each test the sampling train was leak checked to ensure no leakage greater than 0.02 cubic feet per minute at 10" Hg vacuum. The probe was placed in the stack and stack gas was withdrawn isokinetically for an equal period of time at each traverse point. The velocity differential pressure, critical orifice differential pressure, dry gas meter volume, dry gas meter outlet temperatures, probe temperature, stack temperature, oven box temperature, impinger outlet temperature, and sample vacuum were recorded at each traverse point during sampling. At the completion of each test, the sampling train was leak checked to ensure no leakage greater than 0.02 cubic feet per minute at the highest recorded test vacuum.

Following the post test leak check, the train was disassembled and all open ends are sealed with cleaned Teflon tape then again with hexane rinsed aluminum foil. The moisture gain was determined by gravimetrically weighing the XAD module and the first three impingers prior to their recovery. The silica gel impinger was also weighed for moisture gain.

The sample recovery and analysis procedures were as follows. The filter was carefully removed from the filter holder with PTFE forceps and placed in a labeled glass sample container (Container 1). Any particulate matter or filter fragments, which adheres to the filter holder gasket, were placed into Container 1. The adsorbent module (Container lA) was post weighed, wrapped in Teflon tape and hexane rinsed aluminum foil and stored on ice for transport to the analytical laboratory. The nozzle, probe liner, filter holder front half, Teflon frit, and filter holder back half were rinsed three times each with acetone then toluene and collected in Container 2. The connecting glassware and the coil condenser were soaked with three separate rinses of toluene for 5 minutes each. After all toluene rinses and soaks, one rinse of acetone was performed to remove any residual toluene left in the glassware. These rinses are combined in Container 2. Contents of the first three impingers and the distilled deionized water rinses of the impingers and connecting glassware were collected in Container 3. The first three impingers and connecting glassware were then rinsed with acetone and toluene, these rinses are collected in Container 2. All sample containers were sealed and the liquid level marked.

The collected samples were submitted to a Bureau Veritas Labs for analysis. The solvent rinses (acetone and toluene), filters and XAD resins were extracted prior to analysis. PCB analysis was performed in accordance with EPA Method 1668A. PCB were separated by high resolution gas chromatography (HRGC) and measured by high resolution mass spectrometry (HRMS). Total PCB consisted of the 10 homolog group (mono to deca) and were reported as the sum of that group. Non-detect isomers were reported at the detection limit identified in the laboratory report.

4.4 Biosolids Tests

During the course of each test run (120 minute sampling duration) four biosolids grab samples were collected (half hour prior to run, start of run, middle of run, and end of run) into a 250 milliliter sample jar. Each composite sample was thoroughly mixed and then refrigerated until analysis. Each sample was analyzed for total solids content in accordance with Standard Method 2540B. A total of three biosolids samples were analyzed for the three PCB/mercury tests. The percent solids and the average wet biosolids feed rate, for each 120 minute test run, was used in calculating the dry tons per hour feed rate for that particular test run. YCUA was responsible for the percent solid analysis.

4.5 Continuous Emissions Monitoring Tests

Carbon dioxide (CO_2) and oxygen (O_2) were measured with a properly calibrated, transportable, continuous emissions monitoring system (CEMS). Sampling and analysis occurred at the outlet stack from the FBSSI. A daily instrument calibration check and individual test run system calibration check was performed on each analyzer in accordance with EPA Methods 3A and 7E. A schematic diagram of the CEM sampling train is shown in Appendix A. Triplicate 120-minute test runs for CO_2 and O_2 were performed with the data recorded in one-minute averages. The average concentration over the 120 minute test period constituted a single test run.

The carbon dioxide analyzer was be a Teledyne API Model T300M. The theory of operation for the CO_2 analyzer is based on the principle that every gas has a unique absorption line spectrum in the infrared region. The instrument consisted of an infrared light source, a chopper, a measurement cell, and a detector.

Continuous oxygen measurements was performed with a Teledyne API Model T200H analyzer. The Model T200H uses a paramagnetic concept where oxygen molecules are attracted by a magnetic field.

Instrument calibrations were performed with NIST certified compressed gas mixtures of CO_2 and O_2 in nitrogen. A three or four point analyzer calibration error (<2%) check must be conducted, prior to testing, by injecting the calibration gases directly into the gas analyzers and recording the responses. Zero and upscale calibration checks were conducted both before and after each test run in order to quantify measurement system calibration drift (<3%) and sampling system bias (<5%). During these checks, the calibration gases were introduced into the sampling system at the probe outlet so that the calibration gases are analyzed in the same manner as the flue gas samples. Drift was the difference between the pre- and post-test run calibration check responses. Sampling system bias was the difference between the test run calibration check responses (direct analyzer calibration) and the initial calibration error responses (direct analyzer calibration) to the zero and upscale calibration gases. For a test run to be valid, the system bias and calibration drift results must meet the specifications in EPA Method 7E.

Instrument spans are shown in the following Table 4-1:

Table 4-1
Continuous Emissions Monitoring Instrumentation

Parameter	Manufacturer	Model Number	Span Values
O_2	API	T200H	21.02 %
CO_2	API	T300M	18.18 %

Using Equation 7E-5 (Title 40, <u>CFR</u>, Part 60, Appendix A), the parts per million (ppm) and percent values were corrected to account for the zero and span instrument drift as follows:

$$C_{gas} = (\overline{C} - C_o)\, x\, \frac{C_{ma}}{C_m - C_o},$$

Where: C_{gas} = emissions concentration (ppm or %)

$\overline{C}$ = average emissions reading (ppm or %)

C_o = average zero reading (ppm or %)

C_m = average span reading (ppm or %)

C_{ma} = span gas concentration (ppm or %)

4.6 Sample Handling and Custody

Sample preservation and chain of custody procedures for this program were based on EPA recommended guidelines. Table 5-1 identifies the storage container and analytical tracking of the various samples. The project manager was responsible for ensuring that proper custody and documentation procedures were followed for the field sampling and field analytical efforts. The project manager was assisted in this effort by key sampling personnel involved in sample recovery.

All sampling data, including information regarding sampling times, locations, and any specific considerations associated with sample acquisition were recorded in black ink on pre-formatted data sheets. A master sample logbook was used to document all sample collection activities.

Following sample collection, all samples were given a unique alphanumeric sample identification code. Sample labels and integrity seals were completed and affixed to the sample container. The sample volumes were recorded and the liquid level on each bottle was marked. All samples were packed and shipped according to Department of Transportation (DOT) guidelines. As the samples were packed for shipment to the appropriate laboratories, chain-of-custody forms were completed for each shipment box, these forms were enclosed in each respective box. Copies of all chain of custody forms are shown in Appendix E.

Sample hold times were met using the BV Labs courier driven service. This alleviates any damaged, lost or redirected shipments which sometimes occurs with overnight couriers. Daily sludge samples were saved and sent to Brighton Analytical, LLC.

5.0 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

5.1 QC Procedures

Specific quality control (QC) procedures were followed to ensure the continuous production of useful and valid data throughout the course of this test program. The QC checks and procedures described in this section represent an integral part of the overall sampling and analytical scheme. Strict adherence to prescribed procedures is quite often the most applicable QC check. A discussion of both the sampling and analytical QC checks that were utilized during this program is presented below.

5.1.1 Equipment Inspection and Maintenance

Each item of field test equipment purchased by GamAir was assigned a unique, permanent identification number. An effective preventative maintenance program is necessary to ensure data quality. Each item of equipment that was returned from the field was inspected before it is returned to storage. During the course of these inspections, items are cleaned, repaired, reconditioned, and recalibrated where necessary. Each item of equipment transported to the field for this test program was inspected again before being packed to detect equipment problems, which may originate during periods of storage. This minimizes lost time on the job site due to equipment failure. Occasional equipment failure in the field is unavoidable despite the most rigorous inspection and maintenance procedures. For this reason, GamAir routinely transports to the job site replacement equipment for all critical sampling train components.

5.1.2 Equipment Calibrations

Prior to the start of the test program EGLE received copies of all sampling equipment calibrations and CEM calibration gas standards as described in their stack testing guidelines.

New items for which calibration are required were calibrated before initial field use. Equipment whose calibration status may change with use or time was inspected in the field before testing begins and again upon return form each field use. When an item of equipment is found to be out of calibration, it is repaired and recalibrated or retired from service. All equipment is periodically recalibrated in full, regardless of the outcome of these regular inspections.

Calibrations were conducted in a manner and at a frequency, which meets or exceeds USEPA specifications. GamAir follows the calibration procedures outlined in the EPA Methods, and those recommended within the Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III (EPA-600/R94-038c). When these methods were inapplicable, GamAir uses methods such as those prescribed by the American Society for Testing and Materials (ASTM). Data obtained during calibrations were recorded on standardized forms, which are checked for completeness and accuracy by GamAir. Data reduction and subsequent calculations were performed using GamAir computer facilities. Calculations are checked at least twice for accuracy. Copies of calibration forms are shown in Appendix F.

Emissions sampling equipment requiring calibration includes sampling nozzles, Pitot tubes, pressure gauges, thermometers, dry gas meters, and barometers

5.1.3 Analytical Quality Control Procedures

All analyses for this program were performed using accepted laboratory procedures in accordance with the specified analytical protocols. Adherence to prescribed QC procedures for the EPA methods used for this test program ensured data of consistent and measurable quality. Analytical QC was focused on the use of control standards to provide a measure of analytical precision and accuracy. The metals samples were analyzed following the procedures of EPA Method 29. Reagent blanks and laboratory blanks were used to check for contamination. Calibration procedures vary by analyzer. CVAAS standards were prepared to calibrate the spectrometer. Each standard curve was run in duplicate and the mean values are used to calculate the calibration line. The CVAAS instrument was recalibrated approximately once every 10 to 12 samples. Also, specific acceptance criteria were defined below for various analytical operations, including calibrations, control standard analyses, drift checks, blanks, etc.

Table 5-1
Summary of Quality Assurance/Quality Control
Ypsilanti Community Utilities Authority
Fluidized Bed Incinerator
Ypsilanti, Michigan

Test Method and QC Sample	Quality Control	Acceptable QC Limits
EPA Methods 23 & 29	Sampling rate	90 to 110 percent
EPA Method 23		
Internal Standards Recoveries	Percent recovery	40 to 130 percent and 25 to 130 percent
Surrogates	Percent recovery	70 to 130 percent
EPA Methods 3A		
Analyzer Calibration Error	Less than 2% difference	Less than 2% difference
System Calibration Bias	Less than 5% difference	Less than 5% difference
Zero/Span Drift	Less than 3% difference	Less than 3% difference
Calibration Gas	EPA Protocol 1	EPA Protocol 1
EPA Method 29		
Method Blank	Concentration of analytes	Below detection limit
Reagent Blank	One per test program	Report as analyzed
Duplicate Analysis	Relative percent difference	20% of average
Matrix Spikes (MS, MSD 1 each)	Percent recovery	80-120% recovery

5.1.4 Calculations Quality Control Procedures

Calculations for determining flow rates, moisture contents, isokinetics, particulate and gaseous concentrations were made using a computer program developed by the GamAir. This program utilizes the calculation procedures and equations specified in EPA Methods 2, 4, and 5. The program has been successfully used for numerous test efforts and has been validated by independent performance audits. Sample calculations were performed by the software program. Data was transported to the software directly from the field data sheets.

5.2 QA/QC Checks of Data Reduction

The project manager ran an independent check (using a validated computer program) of the calculations with predetermined data before the field test. This ensures that calculations done in the field were accurate. The project manager also conducted a spot check on-site to assure that data was being recorded accurately. After the test, the QA/QC manager checked the data input to assure that the raw data have been transferred to the computer accurately.

5.3 Sample Identification and Custody

Sample custody procedures for this program were based on EPA recommended procedures. The project manager was responsible for ensuring that proper custody and documentation procedures were followed for the field sampling and field analytical efforts. The project manager was assisted in this effort by key sampling personnel involved in sample recovery.

All sampling data, including information regarding sampling times, locations, and any specific considerations associated with sample acquisition were recorded in black ink on pre-formatted data sheets. Copies of completed field data sheets are provided at the end of each day of testing.

Following sample collection, all samples were given a unique alphanumeric sample identification (ID) code. Sample labels and integrity seals are completed and affixed to the sample container. An example sample ID was as follows:

Test Method – Run Number – Sample Container (component)
M29 -- 3 -- 5C (HCl)

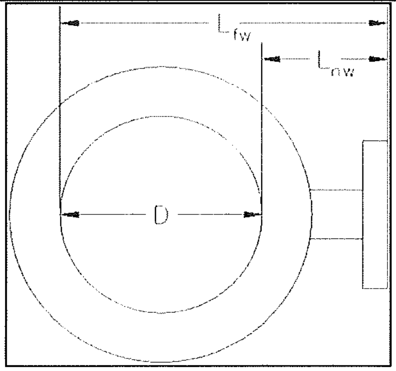
The remaining samples were stored in a secure area until shipment. The sample volumes were determined and recorded and the liquid levels on each bottle are marked. All samples were packed and shipped according to U.S. Department of Transportation guidelines. As the samples were packed for shipment to the appropriate laboratories, chain-of-custody forms were completed for each shipment box, and these forms were enclosed in each respective box. Samples are held by the laboratories for the maximum holding periods.

Appendix A

Figures and Diagrams

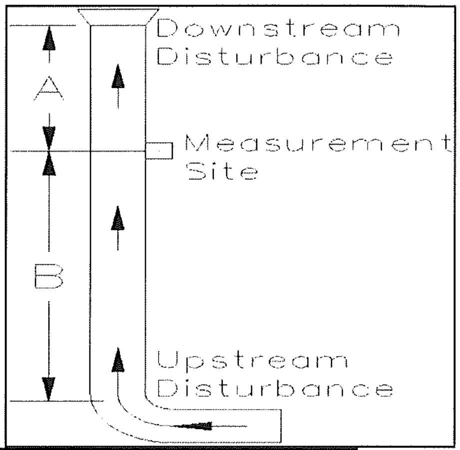
METHOD 1 - SAMPLE AND VELOCITY TRAVERSES FOR CIRCULAR SOURCES

Plant Name	YCUA	**Date**	05/26/21
Sampling Location	Reference Method Sampling Location	**Project #**	825-2104
Operator	JFG	**# of Ports Available**	2
Stack Type	Circular	**# of Ports Used**	2
Stack Size	Large	**Port Inside Diameter**	6



Circular Stack or Duct Diameter			
Distance to Far Wall of Stack	(L_{fw})	45.50	in
Distance to Near Wall of Stack	(L_{nw})	4.00	in
(=Lfw - Lnw) **Diameter of Stack**	(D)	41.50	in
(=3.14(D/2/Cunits)2) **Area of Stack**	(A_s)	9.39	ft^2

Distance from Port to Disturbances			
Distance Upstream	(B)	293.00	in
(=B/D) **Diameters Upstream**	(B_D)	7.06	diameters
Distance Downstream	(A)	173.00	in
(=A/D) **Diameters Downstream**	(A_D)	4.17	diameters



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		12	12
Downstream Spec		12	12
Traverse Pts Required		12	12

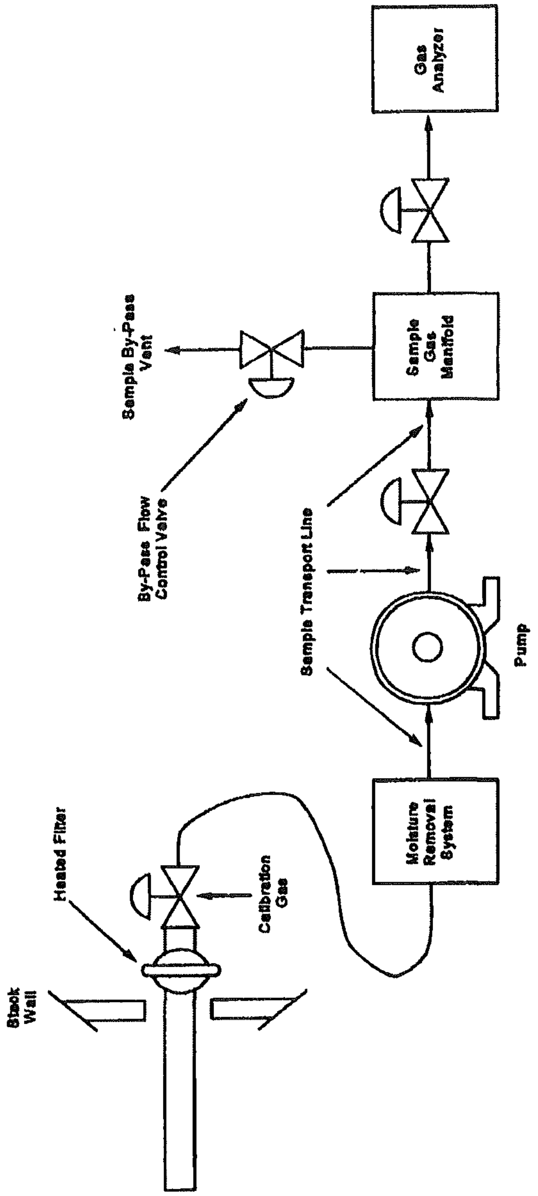
[1] Check Minimum Number of Points for the Upstream and Downstream conditions, then use the largest.

[2] 8 for Circular Stacks 12 to 24 inches
12 for Circular Stacks over 24 inches

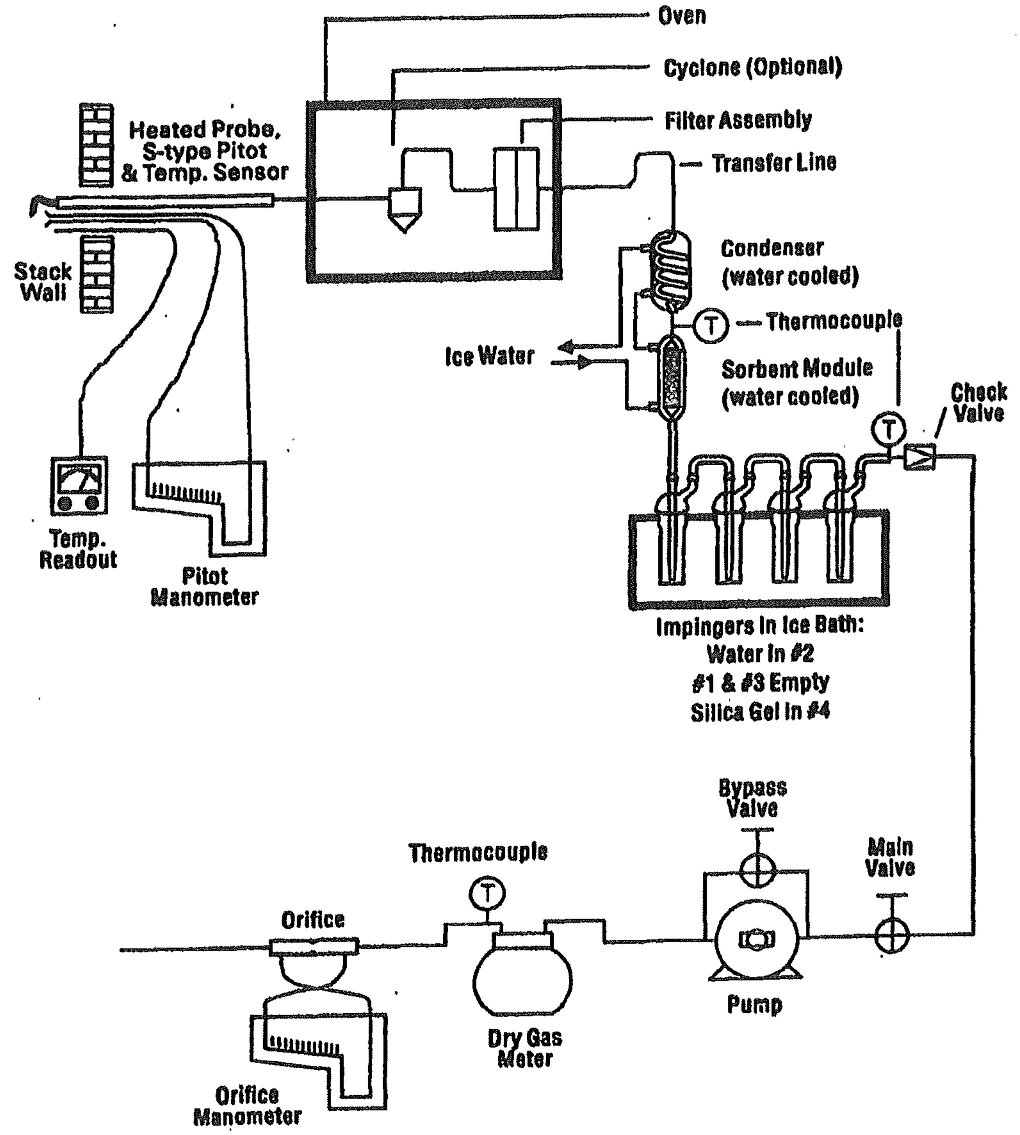
Number of Traverse Points Used			
2	**Ports by**	6	**Across**
12	**Pts Used**	12	**Required**
☑	**Particulate**	☐	**Velocity**

Location of Traverse Points in Circular Stacks						
Traverse Point Number	(Fraction of Stack Diameter from Inside Wall to Traverse Point)					
	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

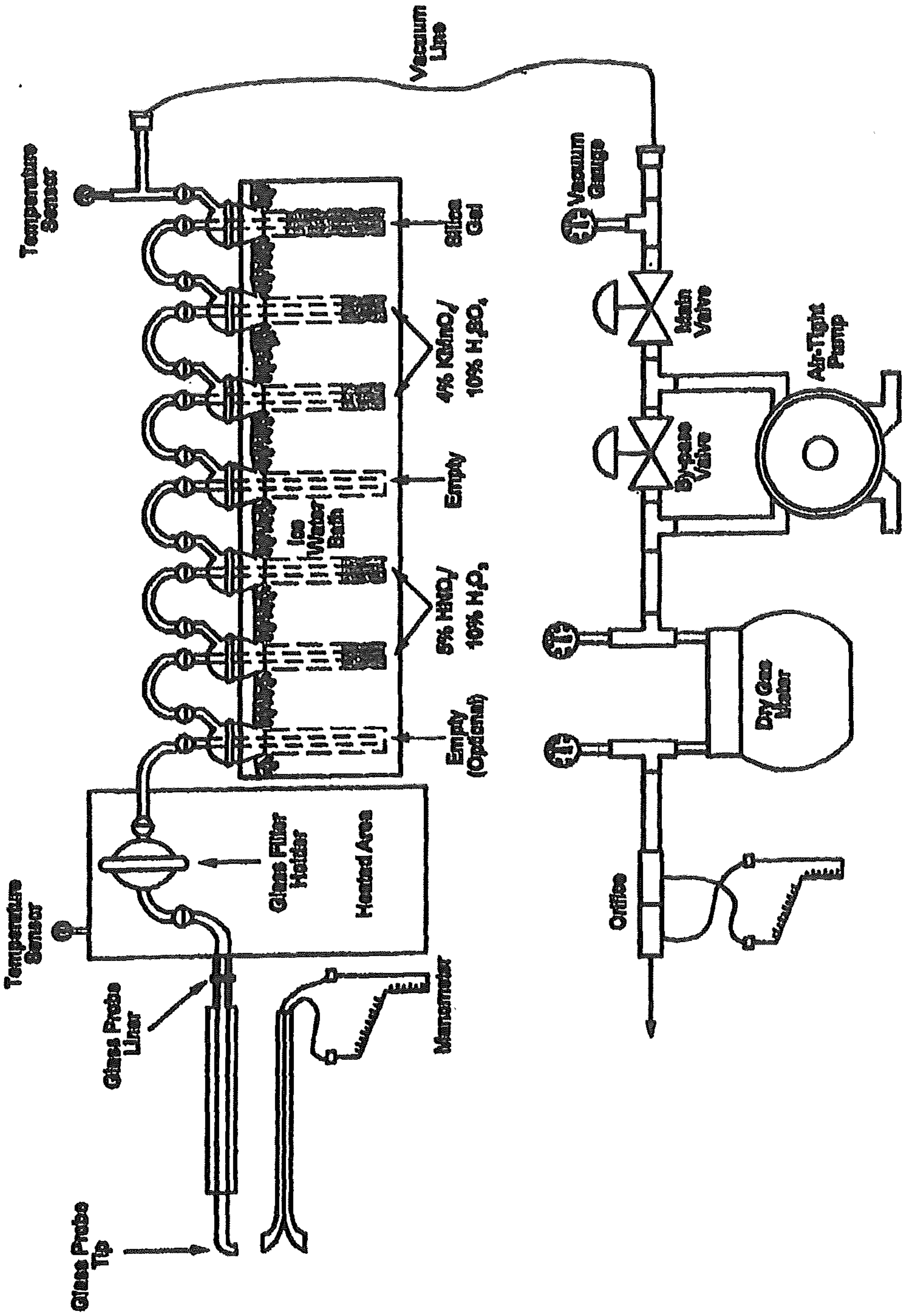
Traverse Point Locations			
Traverse Point Number	**Fraction of Stack Diameter**	**Distance from Inside Wall**	**Distance Including Nipple Length**
		in	in
1	0.044	1 7/8	5 7/8
2	0.146	6	10
3	0.296	12 2/8	16 2/8
4	0.704	29 2/8	33 2/8
5	0.854	35 4/8	39 4/8
6	0.956	39 5/8	43 5/8
7			
8			
9			
10			
11			
12			



EPA Methods 3A, 6C, 7E, and 10
Continuous Emissions Monitoring Sampling Train



EPA Method 23
PCDD/PCDF Sampling Train



EPA Method 29
Multiple Metals Sampling Train