

COMPLIANCE TEST REPORT

April 2020

GamAir Project No.: 825-1909

Ypsilanti Community Utilities Authority Fluidized Bed Sewage Sludge Incinerator Ypsilanti, Michigan

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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: particulate matter (PM), beryllium, cadmium, mercury, and lead, hydrochloride (HCl), polychlorinated dibenzo-p-dioxins (PCDD)/polychlorinated dibenzofurans (PCDF), oxides of nitrogen, 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		
<u>USEPA Emission Limits</u>		
Parameter	Units	Emission Limit
Oxides of Nitrogen (NO _x)	ppmvd @ 7% O ₂	150
Particulate Matter (PM)	milligrams per dry standard cubic meter @ 7% O ₂	18
Hydrogen Chloride (HCl)	ppmvd @ 7% O ₂	0.51
PCDD/PCDF	nanograms per dry standard cubic meter @ 7 % O ₂ (total mass basis) or	1.2
Cadmium (Cd)	milligrams per dry standard cubic meter @ 7% O ₂	0.0016
Lead (Pb)	milligrams per dry standard cubic meter @ 7% O ₂	0.0074
Mercury (Hg)	milligrams per dry standard cubic meter @ 7% O ₂	0.037
Beryllium	lb/ton	2.5 E-5

**Table 1-2
Applicable Emission Limits
Ypsilanti Community Utilities Authority
Fluidized Bed Incinerator
Ypsilanti, Michigan**

<u>Michigan EGLE Emission Limits</u>		
Parameter	Units	Emission Limit
Particulate Matter (PM)	lb per dry ton sludge	0.35
Beryllium	lb per dry ton sludge	2.5E-05
Beryllium	gram per 24-hr period	10
Cadmium	lb per dry ton sludge	8.5E-03
Mercury	lb per dry ton sludge	6.9E-04
Mercury	gram per 24-hr period	3200
Hydrogen Chloride (HCl)	pound per dry ton of sludge	0.8
Metals	Units	Sewage Sludge Metal Concentration - PTI Limit
Arsenic	mg/kg dry sludge	13
Beryllium	mg/kg dry sludge	0.25
Cadmium	mg/kg dry sludge	85
Total Chromium	mg/kg dry sludge	450
Mercury	mg/kg dry sludge	3.7

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 guidelines for source emission testing. Compliance tests were conducted in accordance with USEPA Methods 1-5, 7E, 23, 26A, and 29, as published in Title 40, Code of Federal Regulations, Part 60 (40CFR60). Testing of the FBSSI occurred on 12 February 2020. Testing was originally scheduled for December 19, 2019. However, due unforeseen conditions in the sludge conveyance system to the EU-FBSSI system which required immediate maintenance. Consequently, testing was rescheduled for February 12, 2020. 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 and Paragon Laboratories. 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.

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Mr. Clayton Johnson Email: clayton.johnson@bvlab.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.

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.

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 2.37 dry tons of sludge per hour which equates to 74.6% of the maximum capacity rating (MCR) which equates $\geq 4,699$ pounds per hour. The fluidized bed temperature was 1485°F.

Air emissions from the FBI were controlled by a venturi/impingement tray scrubber operating at an overall scrubber pressure drop range of 30"-40" inches of water column (in. w.c.). Total water injection to the venturi scrubber was approximately 350 gallons per minute (gpm); the water injection rate to the impingement tray was approximately 525 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 2-3 summarizes 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
12 February 2020
Ypsilanti, Michigan

Method/Component	Units	Run 1 0830-0956	Run 2 1015-1140	Run 3 1205-1332	Run 4 1350-1517	Run 5 1530-1656	Average
Biosolids Feed Rate	dry pounds/hour	4679	4718	4783	4525	4745	4699
Percent Blended Solids	%	1.65	1.67	1.60	1.50	1.50	1.58
Fluidized Bed Temperature	°F	1484	1486	1486	1479	1490	1485
Free Board Temperature	°F	1741	1743	1764	1753	1768	1754
Venturi Water Flow	gallon/minute	350	348	345	348	354	349
Venturi Pressure Drop	inches w.c.	36.0	36.0	36.3	36.1	36.0	36.1
Tray Scrubber Water Flow	gallon/minute	526	526	525	525	525	525
Tray Scrubber Pressure Drop	inches w.c.	8.08	8.18	8.38	8.28	8.43	8.36
GAC Pressure Drop	inches w.c.	3.4	3.3	3.3	3.4	3.4	3.4
WESP Secondary Voltage	kV	42.5	40.5	41.6	43.6	42.9	42.2
WESP Amperage	mA	46.8	21.1	50.2	82.4	88.1	57.3
Temperature Diff. GAC inlet WESP outlet	°F	79	82	86	89	91	85

YCUA - Carbon Monoxide @ 7% Oxygen	ppmvd	37.0	36.7	44.0	49.5	59.7	45.4
YCUA - Sulfur Dioxide	ppmvd	1.4	1.4	2.0	2.0	2.4	1.8
Oxygen	%	6.66	6.10	5.43	4.91	4.40	5.50

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	84	GamAir	3
Carbon Dioxide (CO ₂)	Method 3A	84	GamAir	3
Particulate Matter (PM)	Method 5	84	BV	3 + 1 blank
Oxides of Nitrogen (NO _x)	Method 7E	84	GamAir	3
Hydrogen Chloride (HCl)	Method 26A	84	BV	3 + 1 blank
PCDD/PCDF	Method 23	84	BV	3
Arsenic (As)	Method 29	84	BV	3 + 1 blank
Beryllium (Be)	Method 29	84	BV	3 + 1 blank
Cadmium (Cd)	Method 29	84	BV	3 + 1 blank
Chromium (Cr)	Method 29	84	BV	3 + 1 blank
Lead (Pb)	Method 29	84	BV	3 + 1 blank
Mercury (Hg)	Method 29	84	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
Subpart MMM and EGLE Compliance Test
Ypsilanti Community Utilities Authority
Fluidized Bed Incinerator
12 February 2020
Ypsilanti, Michigan

Method/ Component	Units	Run 1	Run 2	Run 3	Average	Limit	Percent of Limit
Method 5- PM	mg/dscm @ 7% O ₂	3.39	2.11	2.50	2.66	18	14.8
Method 5- PM	lb/ dry ton of sludge	0.05	0.03	0.03	0.04	0.35	10.5
Method 7E – NO _x	ppmvd @ 7% O ₂	60.75	57.66	55.38	57.93	150	38.6
Method 23 – 2,3,7,8 TCDD TEQ	ng/ dscm @ 7% O ₂	0.0	0.0	0.0	0.0	1.4E-09	0.0
Method 23 – PCDD/PCDF	ng/ dscm @ 7% O ₂	0.1153	0.2499	0.8189	0.3947	1.2	32.9
Method 26A – HCl	ppmvd @ 7% O ₂	<0.165	<0.174	<0.152	<0.164	0.51	32.1
Method 26A – HCl	lb/ dry ton of sludge	<5.67E-03	<6.00E-03	<5.50E-03	<5.72E-03	0.8	0.72
Method 29 – Arsenic	lb/ dry ton of sludge	1.13E-05	1.11E-05	1.19E-05	1.19E-05	1.3E-03	0.88
SW849 6020A – Arsenic	mg/kg dry sludge	NA	NA	NA	8.8	13	67.7
Method 29 – Beryllium	lb/dry ton of sludge	<2.09E-05	<2.09E-05	<2.11E-05	<2.10E-05	2.5E-05	83.9

Method 29 – Beryllium	g/ 24-hr period	<6.49E-02	<6.51E-02	<6.57E-02	6.53E-02	10	0.65
SW846 6020A – Beryllium	mg/kg dry sludge	NA	NA	NA	0.26	0.25	100.4
SW846 6020A – Beryllium	mg/kg dry sludge	NA	NA	NA	0.14	0.25	56.0
SW846 6020A – Beryllium	mg/kg dry sludge	NA	NA	NA	<0.05	0.25	<20.0
Method 29 – Cadmium	mg/dscm @ 7% O ₂	<1.22E-04	<1.13E-04	<1.08E-04	<1.14E-04	0.0016	7.1
Method 29 – Cadmium	lb/ dry ton of sludge	<2.55E-06	<2.50E-06	<2.67E-06	<2.57E-06	8.5E-03	0.03
SW846 6020A – Cadmium	mg/kg dry sludge	NA	NA	NA	2.3	85	2.7
Method 29 – Chromium	lb/ dry ton of sludge	8.07E-05	8.76E-05	5.49E-05	7.44E-05	4.5E-02	0.17
SW846 6020A – Chromium	mg/kg dry sludge	NA	NA	NA	24	450	5.3
Method 29 – Lead	mg/ dscm @ 7% O ₂	9.94E-04	6.82E-04	5.24E-04	7.34E-04	0.0074	9.9
Method 29 – Mercury	mg/ dscm @ 7% O ₂	7.92E-04	8.31E-04	4.19E-04	6.81E-04	0.037	1.8
Method 29 – Mercury	lb/ dry ton of sludge	1.66E-05	1.85E-05	1.03E-05	1.51E-05	6.9E-04	2.2
Method 29 – Mercury	g/ 24-hr period	4.22E-01	4.81E-01	2.54E-01	3.86E-01	3200	0.01
SW846 7471A – Mercury	mg/kg dry sludge	NA	NA	NA	0.22	3.7	5.9

PM – particulate matter

mg/dscm @ 7% O₂ – milligrams per dry standard cubic meter at seven percent oxygen

lb/ dry ton of sludge – pound per dry ton of sludge

ppmvd @ 7% O₂ – parts per million at seven percent oxygen

ng/ dscm @ 7% O₂ – nanograms per dry standard cubic meter at seven percent oxygen

SW849 6020A – EPA Method 6020A (SW-846): Inductively Coupled Plasma- Mass Spectrometry

SW846 7471A – EPA Method 7471B (SW-846): Mercury in Solid or Semisolid Wastes (Manual Cold-Vapor Technique)

3.3 Field Test Changes

Biosolids samples were collected during emissions testing on February 12, 2020. A biosolids sample submitted to Brighton Analytical LLC on 14 February 2020 indicated a Beryllium (Be) concentration of 0.26 mg/Kg . Per YCUA's operational procedure; biosolid samples are always persevered and stored after compliance testing. Consequently, two additional biosolids samples collected during the emissions testing were submitted to Paragon Laboratories and Brighton Analytical on 2 March 2020.. These analysis for beryllium were reported as 0.14 mg/Kg by Paragon Laboratories and <0.05 mg/Kg by Brighton Analytical Services respectively (both below the 0.25 mg/Kg limit). In addition to the requirements for the 2019 metals testing arsenic and total chromium were added to the BV Labs analysis and were reported Table 3-2. Copies of the laboratory reports can be found in Appendix E.

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 7E	Determination of oxides of nitrogen emissions from stationary sources (instrumental analyzer procedure)
EPA Method 23	Determination of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) emissions from stationary sources
EPA Method 26A	Determination of hydrogen chloride 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 (O₂) and carbon dioxide (CO₂) 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 1 dry cubic meter was collected during each of the metals, hydrogen chloride, and particulate matter tests and a minimum sample volume of 3 dry cubic meters was collected during the three dioxin and furan runs. 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 Hydrogen Chloride and Particulate Matter Tests

The hydrogen chloride (HCl) and particulate matter (PM) emissions were sampled and analyzed in accordance with EPA Methods 5 and 26A. Three 84 minute tests were performed for compliance determination of the FBSSI. This sampling train is shown in Appendix A. The Method 5/26A sampling train consisted of a Pyrex® glass nozzle, a heated glass lined sample probe, a heated Teflon filter (tared), a set of four tared glass impingers connected in series in an ice bath, a control module consisting of a leak free sampling pump, a calibrated critical orifice, an inclined manometer, and a calibrated dry gas meter.

The first two impingers each contained 100 ml of 0.1 N sulfuric acid (H₂SO₄) while the third impinger contained 100 ml of sodium hydroxide (NaOH). The fourth impinger contained a known quantity of silica gel. The sampling train glassware was cleaned prior to testing with soap and water and rinsed thoroughly with water. The sample probe and oven box were maintained at a temperature of 250 to 273°F during sampling to prevent moisture condensation. The impinger outlet temperature was maintained below 68°F during sampling by adding ice to the cold box. A vacuum line was connected from the outlet of the fourth impinger to the control module.

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 then placed in the stack and stack gas was withdrawn isokinetically for an equal period of time at each traverse point with a sampling rate not exceeding 1.0 cfm.

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 end 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.

Sample recovery consisted of rinsing the nozzle, probe, and filter holder front half three times with acetone. These acetone rinses were collected in Container 2. The tared Teflon filter was recovered in a clean laboratory area and placed in Container 1. Both the acetone and filter were desiccated and weighed (constant weight) in accordance with EPA Method 5. The contents of the four impingers were measured gravimetrically for moisture gain then transferred to sample Container 3. Impingers 1 and 2 and their connecting glassware were then be rinsed with deionized distilled (DI) water twice. These rinses were added to Container 3. The third impinger contents were discarded. The sample containers are sealed and the liquid levels marked. The HCl samples were shipped to a contract laboratory for analysis. The HCl analysis was performed by ion chromatography as described in EPA Method 26A.

4.3 Multiple Metals Tests

Multiple metals (arsenic, beryllium, cadmium, chromium, mercury, and lead) were 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 84-minute 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 $248 \pm 25^{\circ}\text{F}$ during sampling to prevent moisture condensation. The first and second impingers contained 100 ml of 5% nitric acid/10% hydrogen peroxide ($5\% \text{HNO}_3/10\% \text{H}_2\text{O}_2$). The third impinger was empty. The fourth and fifth impingers contained 100 ml of 4% potassium permanganate/10% sulfuric acid ($4\% \text{KMnO}_4/10\% \text{H}_2\text{SO}_4$). 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 HNO₃. 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%KMnO₄/10%H₂SO₄ 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 HNO₃ 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 HNO₃ and save
- Container 5A measure contents of impinger 3 then rinse three times with 100 ml of 0.1N HNO₃ and save
- Container 5B measure contents of impingers 4&5 then rinse three times with 100 ml of acidified KMnO₄ 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 HNO₃/H₂O₂ reagent blank (200 ml)
- Container 10 acidified KMnO₄ 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.

4.4 Polychlorinated Dibenzo-p-dioxins and Dibenzofurans Tests

Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF) sampling was conducted in accordance with EPA Method 23. Three PCDD/PCDF tests were performed on the FBSSI with each test being 84-minutes in duration. The Method 23 sampling train is shown in the Appendix A. The following is a description of the sampling train and the procedures used to quantify PCDD and PCDF.

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 $248 \pm 25^\circ\text{F}$ 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 is 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 sample recovery and analysis procedures were as follows. The filter was carefully removed from the filter holder with forceps and placed in a labeled glass sample container (Container 1). Any particulate matter or filter fragments, which adhered to the filter holder gasket, were placed

into Container 1. The adsorbent module (Container 1A) 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, and filter holder front half were rinsed three times with acetone (Container 2) then toluene (Container 3). The probe liner was then rinsed three times each with acetone (Container 2) then toluene (Container 3). These rinses were collected in a labeled sample jar (Containers 2 and 3). The filter holder back half, the connecting line between the filter and the condenser, and the condenser were rinsed three times with acetone (Container 2), then toluene (Container 3). The connecting glassware and the coil condenser were soaked with three separate rinses of toluene for 5 minutes each. These rinses were combined in Container 3, which was sealed and the liquid level marked.

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 collected samples were submitted to a contract laboratory for analysis. The solvent rinses (acetone and toluene), filters and XAD resins were extracted prior to analysis. The PCDD's and PCDF's were separated by high resolution gas chromatography (HRGC) and measured by high resolution mass spectrometry (HRMS).

4.5 Biosolids Tests

During the course of each test run (84 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 PCDD/PCDF/metals tests, three biosolids samples were analyzed for the three HCl/FPM tests. The percent solids and the average wet biosolids feed rate, for each 84 minute test run, was used in calculating the dry tons per hour feed rate for that particular test run. In addition to the percent solids analyses one biosolids sample was analyzed for five metals (arsenic, beryllium, cadmium, total chromium, and mercury) and two biosolid samples were analyzed for beryllium. The results of the biosolid metals analyses are shown in Appendix E. YCUA was responsible for the collection of all biosolid samples and for the percent solids analysis.

4.6 Continuous Emissions Monitoring Tests

Oxides of nitrogen (NO_x), 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 84-minute test runs for NO_x , CO_2 and O_2 were performed with the data recorded in one-minute averages. The average concentration over the 84 minute test period constituted a single test run.

The NO_x analyzer was a Teledyne API Model T200H. The NO_x analyzer is based on the principles of chemiluminescence and was equipped with a NO_2 to NO converter.

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 NO_x, CO₂, and O₂ 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. The NO_x stratification test was performed at three sample points as described in Section 4.2.

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	25 %
CO ₂	API	T300M	20 %
NO _x	API	T200H	209.7 ppm

Using Equation 7E-5 (Title 40, CFR, 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:

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

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

4.7 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 and Paragon Laboratories.

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 the USEPA and 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 from 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 5, 23, 26A, 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 7E		
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 26		
Method Blank	Concentration of analytes	Below detection limit
Spiked Blank	Percent recovery	90 to 110 percent
Reagent Blank	One per test program	Report as analyzed
Matrix Spike	Percent recovery	80 to 120 percent
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.

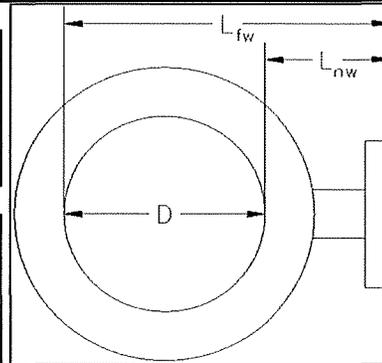
Appendix A
Figures and Diagrams

METHOD 1 - SAMPLE AND VELOCITY TRAVERSES FOR CIRCULAR SOURCES

Plant Name	Ypsilanti Community Utilities Authority	Date	02/12/20
Sampling Location	FBI Exhaust	Project #	825-1907
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})	49.70	in
Distance to Near Wall of Stack	(L_{nw})	10.00	in
(= $L_{fw} - L_{nw}$) Diameter of Stack	(D)	39.70	in
(= $3.14(D/2/Cunits)^2$) Area of Stack	(A_s)	8.60	ft ²

Distance from Port to Disturbances			
Distance Upstream	(B)	293.00	in
(= B/D) Diameters Upstream	(B_D)	7.38	diameters
Distance Downstream	(A)	173.00	in
(= A/D) Diameters Downstream	(A_D)	4.36	diameters

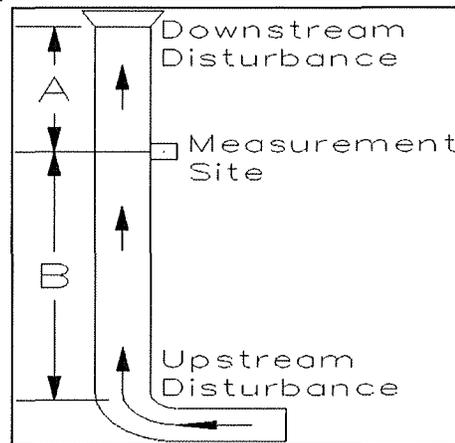


Number of Traverse Points Required			
Diameters to Flow Disturbance		Minimum Number of ¹ Traverse Points	
Up Stream	Down Stream	Particulate Points	Velocity Points
2.00-4.99	0.50-1.24	24	16
5.00-5.99	1.25-1.49	20	16
6.00-6.99	1.50-1.74	16	12
7.00-7.99	1.75-1.99	12	12
>= 8.00	>=2.00	8 or 12 ²	8 or 12 ²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

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

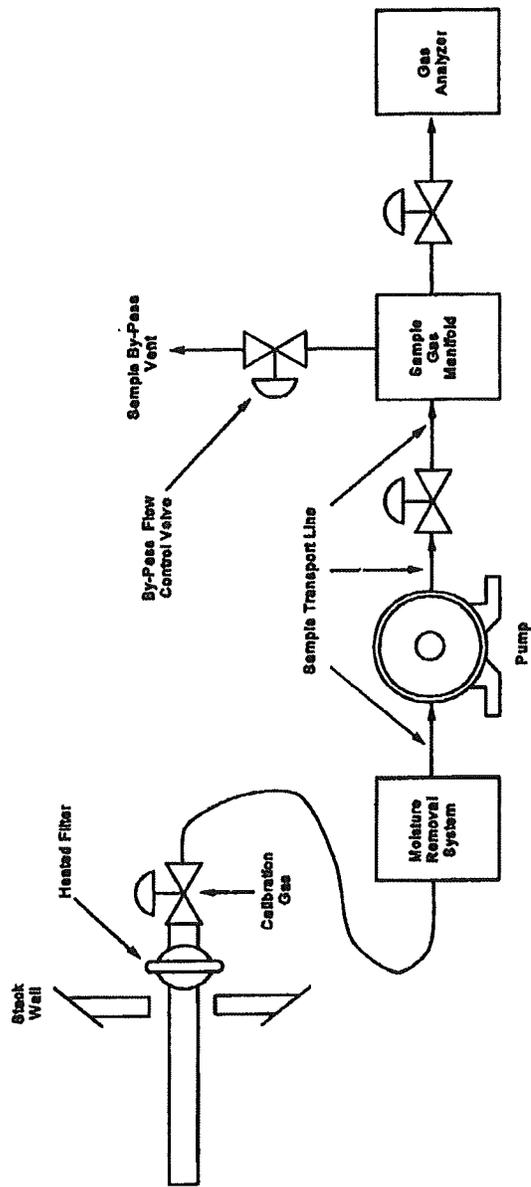
12 for Circular Stacks over 24 inches



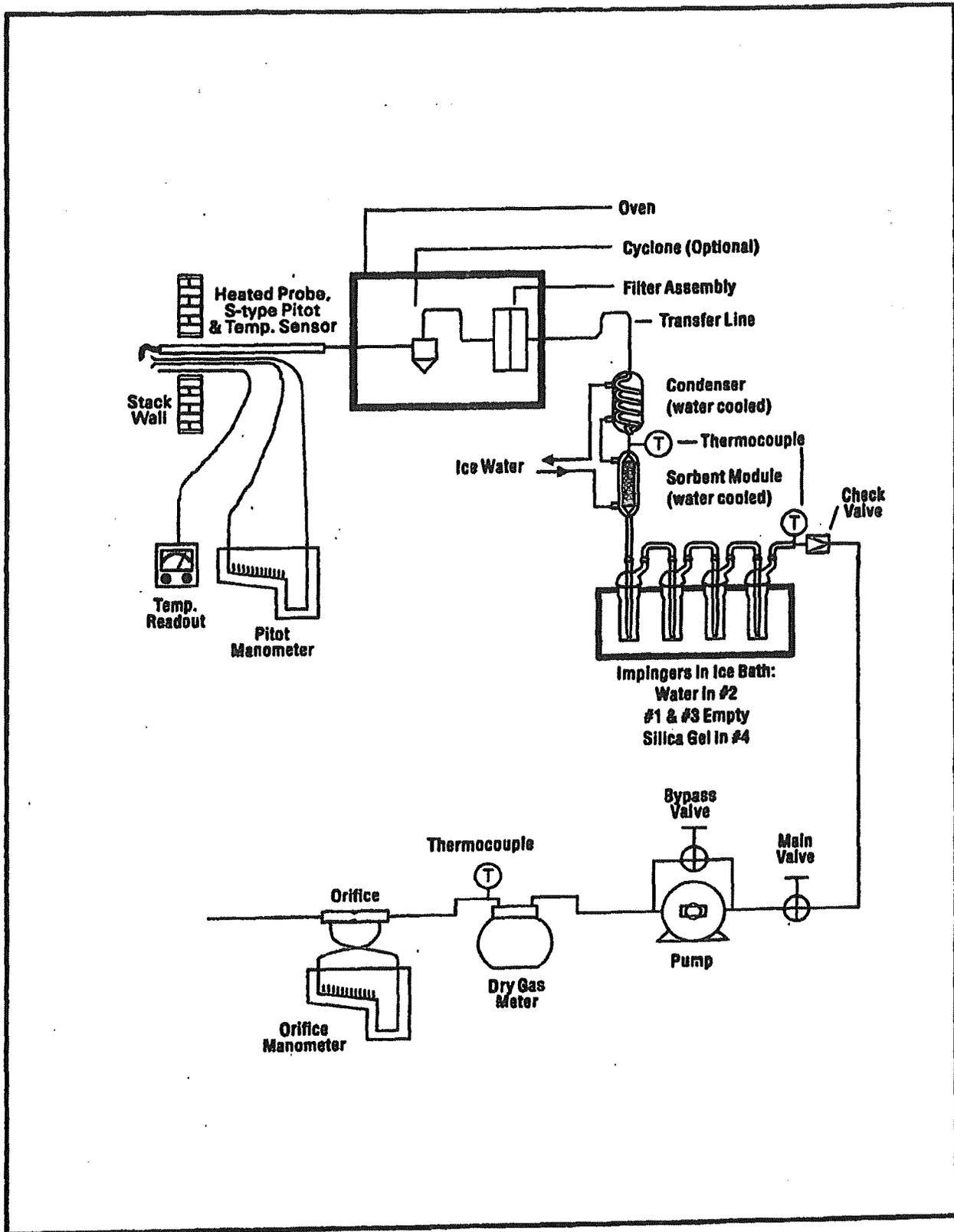
Number of Traverse Points Used			
2	Ports by	6	Across
12	Pts Used	12	Required
<input checked="" type="checkbox"/>	Particulate	<input type="checkbox"/>	Velocity

Traverse Point Number	Location of Traverse Points in Circular Stacks					
	(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

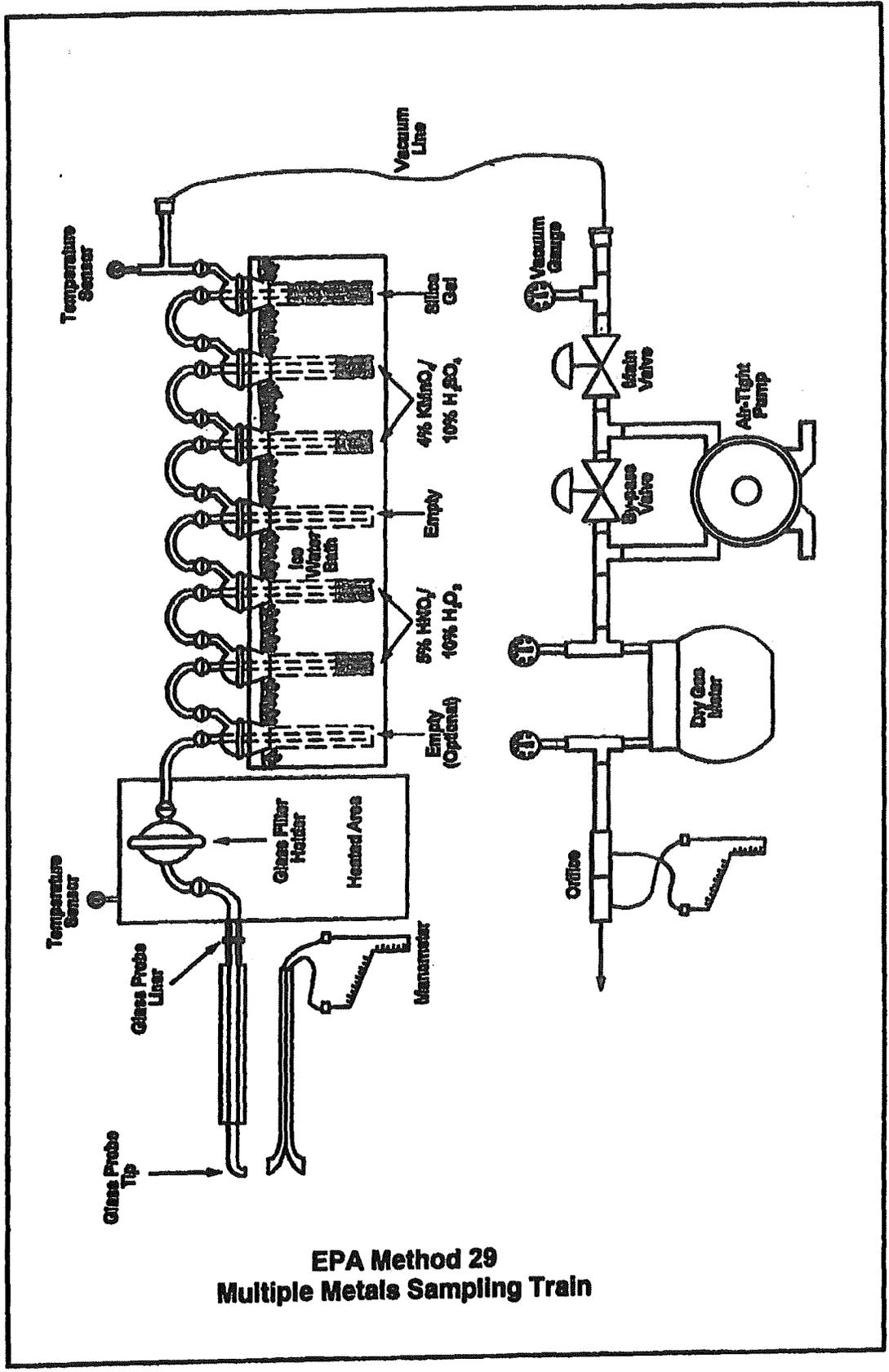
Traverse Point Locations			
Traverse Point Number	Fraction of Stack Diameter	Distance from Inside Wall	Distance Including Nipple Length
		in	in
1	0.044	1 6/8	11 6/8
2	0.146	5 6/8	15 6/8
3	0.296	11 6/8	21 6/8
4	0.704	28	38
5	0.854	33 7/8	43 7/8
6	0.956	38	48
7			
8			
9			
10			
11			
12			



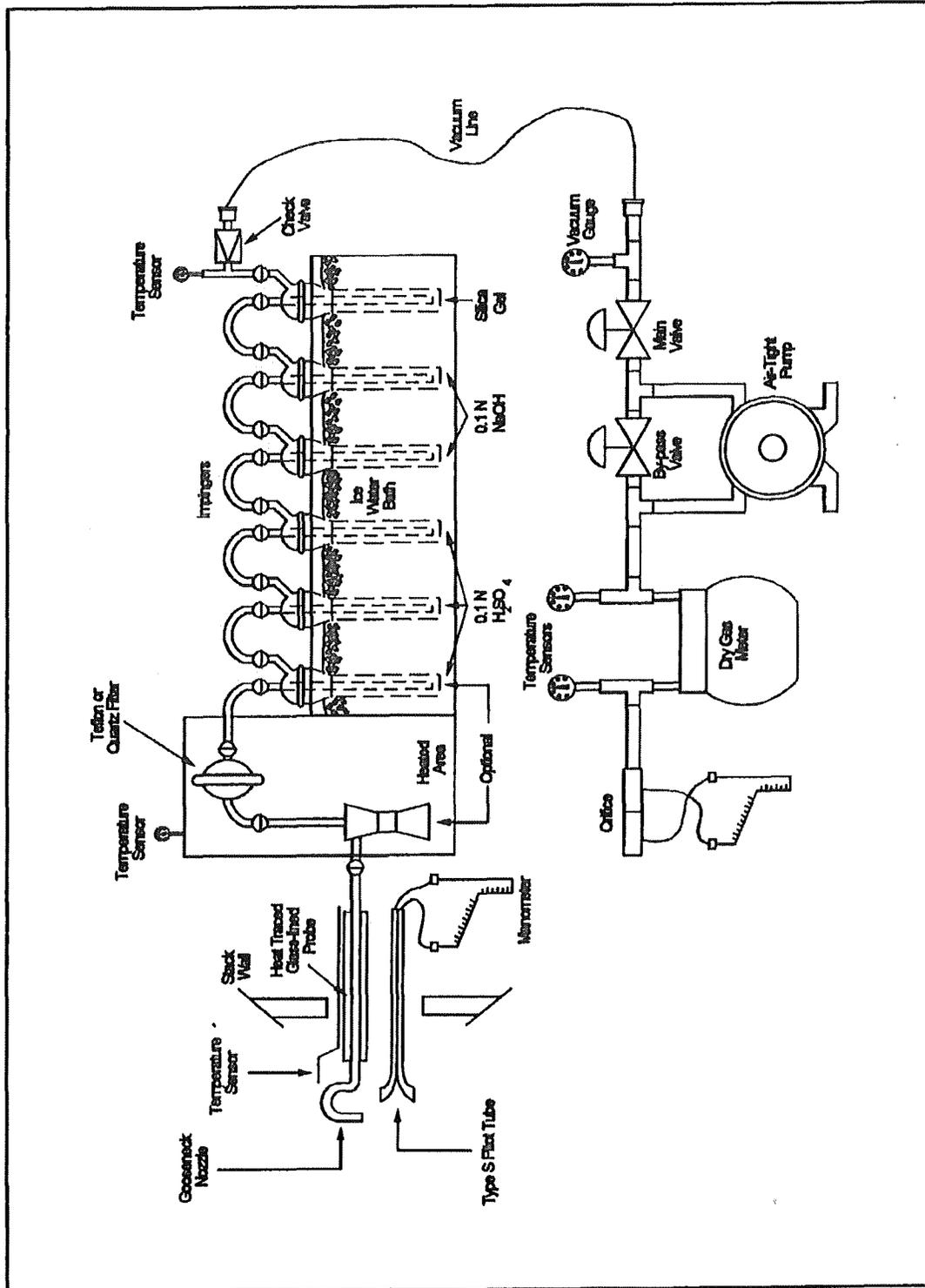
**EPA Methods 3A, 6C, 7E, and 10
Continuous Emissions Monitoring Sampling Train**



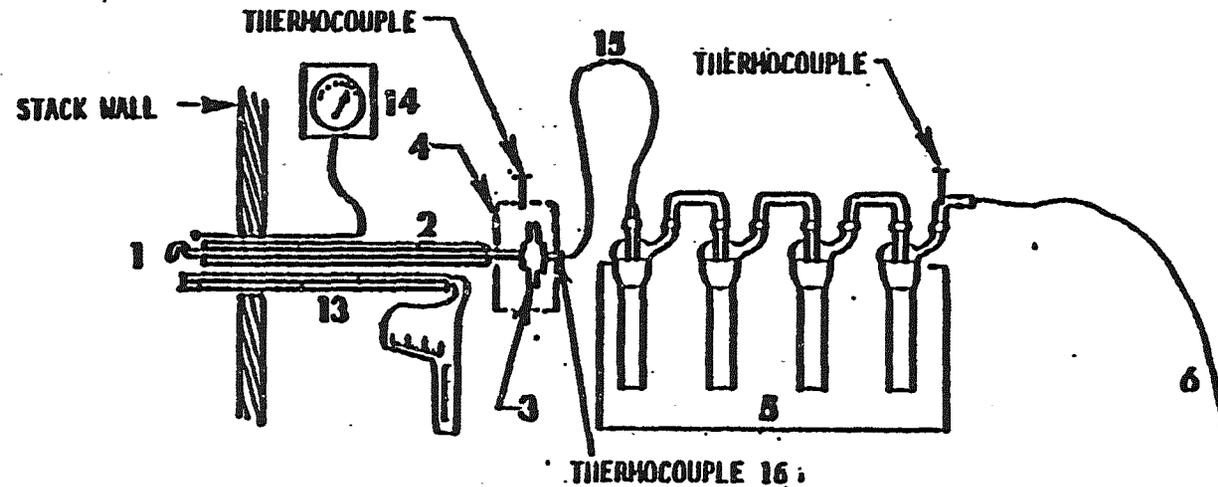
**EPA Method 23
 PCDD/PCDF Sampling Train**



**EPA Method 29
Multiple Metals Sampling Train**



EPA Method 26A
Hydrochloric Acid Sampling Train



LEGEND

- 1 - NOZZLE
- 2 - PROBE
- 3 - FILTER HOLDER
- 4 - FILTER HEATER BOX
- 5 - IMPINGER ICE BATH
- 6 - UMBILICAL CORD
- 7 - VACUUM GAUGE
- 8 - MAIN VALVE TO PUMP
- 9 - PUMP
- 10 - BY-PASS VALVE
- 11 - DRY GAS METER
- 12 - ORIFICE AND MANOMETER
- 13 - PITOT TUBE AND MANOMETER
- 14 - STACK TEMPERATURE READOUT
- 15 - FLEXIBLE TUBING
- 16 - THERMOCOUPLE

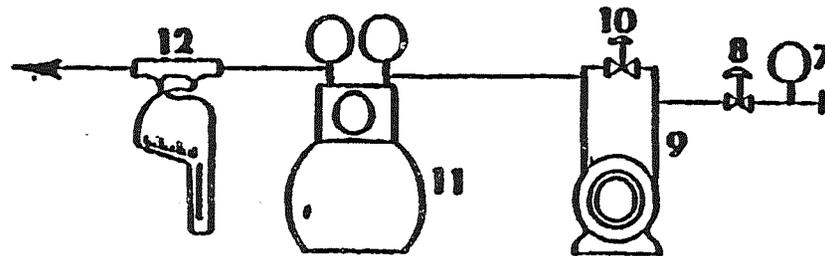


Figure 5-1
Modified EPA Method 5 Particulate Sampling Train