TEST REPORT

Solid Fuel Boiler MACT Test Program

Prepared for:

BORALEX STRATTON ENERGY LP
Route 27, P.O. Box 140
Stratton, Maine 02982

Contact Name: David Ettinger, Plant Manager
Contact No. (207) 246-1511

Prepared by:

AIR TOX ENVIRONMENTAL COMPANY, INC.
479 Tolland Turnpike
Willington, Connecticut 06279

Contact Name: Jason Ward, Environmental Engineer
Contact No. (860) 487-5606 ext.100

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1.0 INTRODUCTION

Air Tox Environmental Company, Inc. (Air Tox) of Willington, CT was retained by Boralex, Inc. to perform Solid Fuel Boiler MACT emission assessments at the Boralex Stratton Energy LP (BSE) main exhaust stack. The facility is located in Stratton, Maine and is addressed in the Maine Department of Environmental Protection (ME-DEP) Air Emission License No. A-368-70-A-I. And, more recently in amendment A-368-70-E-A with BSE's minor modification approval to reduce NO_x. The purpose of this program was to fulfill the emission requirements under section 114 of the Clean Air Act as implemented by the United States Environmental Protection Agency (USEPA).

Specifically, the emission testing provided data for carbon monoxide (CO), oxides of nitrogen (NOx), sulfur dioxide (SO_2), non-methane hydrocarbons, formaldehyde, total suspended particulates (TSP), PM 2.5 & condensable particulate, dioxins and furans (PCDD/PCDF), hydrogen chloride (HCl), fluoride and multiple metals. The sampling and analyses during this test program was carried out in conformance with the 40CFR60, Appendix A, EPA Reference Methods, as applicable of the USEPA. Additionally, Air Tox performed all sampling and analysis in accordance with the ME DEP Stack Sampling Guidelines.

The test program described herein was performed during the week of October 19, 2009. The program was performed under the supervision of Jason D. Ward, Environmental Engineer of Air Tox. Jason supervised all field operations during the performance of this test program. Mr. David Ettinger, Plant Manager at the Boralex Stratton facility and Bill Parker, Environmental Manager provided site coordination and production information during this test program.

This report details the methodology that Air Tox used to determine system information with the required performance specifications. Section 2.0 contains the Scope of the Sampling Program description. Section 3.0 describes the Process and Operations. Section 4.0 details the Test Methodologies used during the emissions testing program. Section 5.0 contains Air Tox's Quality Assurance procedures.

2.0 SCOPE OF THE SAMPLING PROGRAM

This section details the scope of the proposed emissions testing program, including the sampling parameters, proposed test methodologies, sampling location, and operating conditions. All sampling and analyses were carried out in accordance with the regulations of the US EPA and the ME-DEP. Specifically this testing provided data specific for carbon monoxide (CO), oxides of nitrogen (NOx), sulfur dioxide (SO_2), non-methane hydrocarbons, formaldehyde, PM 2.5 & condensable particulate, dioxins and furans (PCDD/PCDF), hydrogen chloride (HCl), fluoride and multiple metals. A detailed summary of the test methodologies are presented below.

2.1 Sampling Parameters

Emission measurements were performed at the stack exhaust outlet for the parameters listed below in Table 2-1, in accordance with the respective test methodologies.

TABLE 2-1
SAMPLING PARAMETERS & METHODS

EMISSION PARAMETER	REFERENCE METHOD
• Volumetric Flowrate (SCFM)	• EPA Methods 1 & 2
• Molecular Weight (O_2 & CO_2)	• EPA Method 3A
• Moisture (H_2O)	• EPA Method 4
• Sulfur Dioxide (SO_2)	• EPA Method 6C
• Oxides of Nitrogen (NOx)	• EPA Method 7E
• Carbon Monoxide (CO)	• EPA Method 10
• Dioxins (PCDD's) & Furans (PCDF's)	• EPA Method 23
• Non-methane Hydrocarbons	• EPA Method 25A
• Hydrogen Chloride & Fluoride (HCl & HF)	• EPA Method 26A
• Multiple Metals	• EPA Method 29
• $PM_{2.5}$ & Condensable Particulate	• EPA OTM 027/Method 202
• Formaldehyde	• SW846 - 0011

2.2 Criteria Pollutant Sampling

Methods 1, 2, and 4 were utilized for the boiler's sampling to calculate the SO_2, NOx, THC, CO and Formaldehyde emission concentrations in parts per million volume dry (ppmvd) corrected to 7 percent oxygen (O_2). These methods were also utilized for the boiler sampling to calculate the HCL, metals, $PM_{2.5}$ and condensables, and Hg emission rates in pounds per million British thermal units (lb/MMBtu).

2.2.1 Particulate Matter ($PM_{2.5}$) & Condensable Results

Three (3) one hour $PM_{2.5}$ test runs (nominal) were performed at the outlet of the Stratton boiler exhaust stack. Three (3) test runs were conducted under normal operating conditions. Sampling for the $PM_{2.5}$ was performed in strict accordance with 40 CFR Part 60, Appendix A and 40 CFR Part 51, Method 5/202. Current with the OTM 27 sample, flowrate, O_2, CO_2, and percent moisture were determined in accordance with 40 CFR Part 60, Appendix A, EPA Reference Method 1, 2, 3A, and 4, respectively, as required by the methods.

Triplicate (3) test runs were performed to demonstrate emission limits for particulate matter while the boiler operated at normal load conditions while firing solid fuel. The demonstration program was performed on October 21, 2009 during the hours of 14:00 – 20:00 hrs. Results of the test program are presented in Table 2-2.

Table 2-2

Boralex Stratton Energy LP
Stratton, Maine
October 21, 2009

CONSTIUENT	UNITS	Test Run No. 1	Test Run No. 2	Test Run No. 3	Average	Limit
Time	**-**	14:00-15:15	16:35-17:46	18:48-20:00		
Date	**-**	10/21/2009	10/21/2009	10/21/2009		
O_2	**%**	6.3	5.9	5.9	**6.0**	
CO_2	**%**	14.6	14.8	15.0	**14.8**	
H_2O	**%**	18.7	18.6	18.2	**18.5**	
Flowrate	**DSCFM**	106226	108053	108815	**107698**	
Sample Volume	**DSCF**	20.200	20.379	20.271	**20.283**	
Stack Temeperature	**Degrees F**	354.3	355.5	359.5	**356.4**	
Isokinetic Ratio	**%**	107.9	97.0	92.0	**99.0**	
Particulate Matter $_{2.5}$	lbs/MMBtu	0.000	0.000	0.000	0.000	
Particulate Matter (Filterable)	lbs/MMBtu	0.000	0.000	0.000	0.000	
Particulate Matter (Condensable)	lbs/MMBtu	0.000	0.000	0.000	0.000	

2.2.2 SO_2, NOx, THC, and CO Emission Results

Three (3) one-hour (nominal) test runs were performed for SO_2, THC, NOx, and CO in strict accordance with 40CFR60 Appendix A, Reference Methods 6C, 7E, 10, and 25A. Sampling was performed on the boiler's exhaust stack, while the facility operated at normal load conditions.

Triplicate (3) test runs were performed to demonstrate emission limits for CO, NO_X, THC, and SO_2 while the boiler operated at normal load conditions while firing solid fuel. The demonstration test program was performed on October 21, 2009 during the hours of 08:56 – 12:20 hrs. Results of the test program are presented in Table 2-3.

Table 2-3

Boralex Stratton Energy LP
Stratton, Maine
October 21, 2009

CONSTIUENT	UNITS	Test Run No. 1	Test Run No. 2	Test Run No. 3	Average	Limit
Time	**-**	8:56-9:56	10:08-11:08	11:20-12:20		
Date	**-**	10/21/2009	10/21/2009	10/21/2009		
O_2	**%**	7.0	7.2	7.1	**7.1**	
CO_2	**%**	13.7	13.5	13.8	**13.7**	
CO	ppm@15%O2	363.7	322.6	329.1	338.5	
NO_X	ppm@15%O2	38.4	38.5	38.4	38.4	
THC	ppm@15%O2	0.1	0.1	0.1	0.1	
SO2	ppm@15%O2	0.0	1.0	0.6	0.5	

2.2.3 PCDD's and PCDF's Emission Results

Three (3) three-hour (nominal) test runs were performed for PCDD and PCDF in strict accordance with 40CFR60 Appendix A, Reference Methods 23. Sampling was performed on the boiler's exhaust stack, while the facility operated at normal load conditions.

Triplicate (3) test runs were performed to demonstrate emission limits for PCDD's and PCDF's while the boiler operated at normal load conditions while firing solid fuel. The demonstration test program was performed on October 20-21, 2009 during the hours of 9:05 – 17:55 hrs on the 20th and 8:35 – 11:55 on the 21st. Results of the test program are presented in Table 2-4.

Table 2-4

Boralex Stratton Energy LP
Stratton, Maine
October 20-21, 2009

CONSTIUENT	UNITS	Test Run No. 1	Test Run No. 2	Test Run No. 3	Average	Limit
Time	-	9:05-12:29	14-40-17:55	8:35-11:55		
Date	-	10/20/2009	10/20/2009	10/21/2009		
O_2	%	7.0	6.6	6.9	3.5	
CO_2	%	13.4	14.1	12.5	9.9	
Moisture	%	6.73	6.00	6.12	6.28	
Flow Rate	DSCFM	98840	99630	99090	99186	
Sample Volume	DSCF	121.97	122.21	123.62	122.60	
Stack Temeperature	Degrees F	355.7	348.3	356.7	353.6	
Isokinetic Ratio	%	101.1	100.5	102.2	101.3	
2,3,7,8-TCDD	ng/DSCM @ 7% O_2	ND	0.0001095	0.0006324	0.0002473	
Other TCDD	ng/DSCM @ 7% O_2	0.0066874	0.0065188	0.0030543	0.0054202	
1,2,3,7,8 PeCDD	ng/DSCM @ 7% O_2	ND	0.0004241	0.0001305	0.0001849	
Other PeCDD	ng/DSCM @ 7% O_2	0.0058479	0.0048842	0.0041234	0.0049518	
1,2,3,4,7,8 HxCDD	ng/DSCM @ 7% O_2	ND	4.213E-05	ND	1.404E-05	
1,2,3,6,7,8 HxCDD	ng/DSCM @ 7% O_2	ND	0.0004353	ND	0.0001451	
1,2,3,7,8,9 HxCDD	ng/DSCM @ 7% O_2	ND	ND	ND	0	
Other HxCDD	ng/DSCM @ 7% O2	0.0045451	0.0061228	0.0028643	0.0045107	
1,2,3,4,6,7,8 HpCDD	ng/DSCM @ 7% O2	0.0043078	0.0053869	0.0018348	0.0038432	

Other HpCDD	ng/DSCM @ 7% O2	ND	0.0066901	0.0030996	0.0032632	
1,2,3,4,6,5,7,8 OCDD	ng/DSCM @ 7% O2	0.018279	0.0170875	0.0074414	0.0142693	
2,3,7,8-TCDF	ng/DSCM @ 7% O2	0.0031677	0.0021154	0.0007521	0.0020117	
Other TCDF	ng/DSCM @ 7% O2	0.0266507	0.0338347	0.0043242	0.0216032	
1,2,3,7,8 PeCDF	ng/DSCM @ 7% O2	0.0004893	0.0014071	ND	0.0006321	
2,3,4,7,8 PeCDF	ng/DSCM @ 7% O2	0.0006253	0.0018172	3.97E-05	0.0008274	
Other PeCDF	ng/DSCM @ 7% O2	0.0093074	0.0203399	0.0017866	0.010478	
1,2,3,4,7,8 HxCDF	ng/DSCM @ 7% O2	0.0004632	0.0017638	ND	0.0007423	
1,2,3,6,7,8 HxCDF	ng/DSCM @ 7% O2	0.0005761	0.0018144	ND	0.0007968	
1,2,3,7,8,9 HxCDF	ng/DSCM @ 7% O2	ND	0.0001432	ND	4.775E-05	
2,3,4,6,7,8 HxCDF	ng/DSCM @ 7% O2	0.0003763	0.0021542	ND	0.0008435	
Other HxCDF	ng/DSCM @ 7% O2	0.0032163	0.012268	0.0017129	0.0057324	
1,2,3,4,6,7,8 HpCDF	ng/DSCM @ 7% O2	0.0036619	0.0081025	0.0001642	0.0039762	
1,2,3,4,7,8,9 HpCDF	ng/DSCM @ 7% O2	8.135E-05	0.0012782	0.0001988	0.0005194	
Other HpCDF	ng/DSCM @ 7% O2	ND	0.0027805	ND	0.0009268	
1,2,3,4,6,5,7,8 OCDF	ng/DSCM @ 7% O2	0.0046552	0.0083078	0.0007941	0.0045857	
TOTAL	ng/DSCM @ 7% O2	0.092938	0.1458283	0.0329531	0.0905732	

2.2.4 HCl and HF Emission Results

Three (3) one-hour (nominal) test runs were performed for HCL and HF in strict accordance with 40CFR60 Appendix A, Reference Methods 26A. Sampling was performed on the boiler's exhaust stack, while the facility operated at normal load conditions.

Triplicate (3) test runs were performed to demonstrate emission limits for HCL and HF while the boiler operated at normal load conditions while firing solid fuel. The demonstration test program was performed on October 21, 2009 during the hours of 14:00 – 20:00 hrs. Results of the test program are presented in Table 2-5.

Table 2-5

Boralex Stratton Energy LP
Stratton, Maine
October 21, 2009

CONSTIUENT	UNITS	Test Run No. 1	Test Run No. 2	Test Run No. 3	Average	Limit
Time	-	14:00-15:15	16:37-17:37	18:49-20:00		
Date	-	9/3/2009	9/3/2009	9/3/2009		
O_2	%	6.3	5.9	5.9	6.0	
CO_2	%	14.6	14.8	15.0	14.8	
H_2O	%	19.0	18.5	19.6	19.0	
Flowrate	DSCFM	102730	102550	100410	101897	
Sample Volume	DSCF	42.4	42.6	42.2	42.4	
Stack Temeperature	Degrees F	345.1	346.9	349.0	347.0	
Isokinetic Ratio	%	100.7	101.3	102.6	101.5	
HF	**ppm @ 7% O_2**	**0.4**	**0.4**	**0.4**	**0.4**	
HCL	**ppm @ 7% O2**	**0.1**	**0.1**	**0.1**	**0.1**	

2.2.5 Multiple Metals Emission Results

Three (3) four-hour (nominal) test runs were performed for metals in strict accordance with 40CFR60 Appendix A, Reference Methods 29. Sampling was performed on the boiler's exhaust stack, while the facility operated at normal load conditions.

The following list of metals will be measured:

antimony (Sb)	cobalt (Co)	phosphorous (P)
arsenic (As)	copper (cu)	selenium (Se)
barium (Ba)	lead (Pb)	silver (Ag)
beryllium (Be)	manganese (Mn)	thallium (Tl)
cadmium (Cd)	mercury (Hg)	
chromium (Cr)	nickel (Ni)	

Triplicate (3) test runs were performed to demonstrate emission limits for Multiple metals while the boiler operated at normal load conditions while firing solid fuel. The demonstration test program was performed on October 20-21, 2009 during the hours of 8:35-18:25 hrs on the 20th and 8:05 – 12:25 on the 21st. Results of the test program are presented in Table 2-6.

Table 2-6

Boralex Stratton Energy LP
Stratton, Maine
October 20-21, 2009

CONSTIUENT	UNITS	Test Run No. 1	Test Run No. 2	Test Run No. 3	Average	Limit
Time	-	8:38-12:59	13:48-18:25	8:05-12:25		
Date	-	10/20/2009	10/20/2009	10/21/2009		
O_2	%	7.1	6.7	7.0	6.9	
CO_2	%	13.1	14.1	13.4	13.5	
Moisture	%	18.2	19.3	20.2	19.24	
Flow Rate	DSCFM	100680	104750	100470	101967	
Sample Volume	DSCF	168.803	169.648	157.135	165.20	
Stack Temeperature	Degrees F	346.8	351.0	347.7	348.51	
Isokinetic Ratio	%	102.2	98.7	95.3	98.8	
Antimony (Sb)	Lbs/MMBtu	1.929E-07	1.919E-07	2.072E-07	1.974E-07	
Arsenic (As)	Lbs/MMBtu	1.929E-07	1.929E-07	1.929E-07	1.929E-07	
Beryllium (Be)	Lbs/MMBtu	4.823E-08	4.823E-08	4.823E-08	4.823E-08	
Cadmium (Cd)	Lbs/MMBtu	1.025E-07	8.199E-08	6.631E-08	8.359E-08	
Chromium (Cr)	Lbs/MMBtu	1.845E-07	2.689E-07	1.483E-07	2.005E-07	

Cobalt (Co)	Lbs/MMBtu	5.305E-08	5.279E-08	5.181E-08	5.255E-08	
Lead (Pb)	Lbs/MMBtu	2.069E-06	2.694E-06	3.09E-06	2.618E-06	
Manganese (Mn)	Lbs/MMBtu	0	0	0	0	
Mercury (Hg)	Lbs/MMBtu	3.421E-07	2.409E-07	3.166E-07	2.998E-07	
Nickel (Ni)	Lbs/MMBtu	3.05E-07	3.275E-07	3.147E-07	3.158E-07	
Phosphorus (P)	Lbs/MMBtu	6.033E-06	2.284E-06	4.02E-06	4.113E-06	
Selenium (Se)	Lbs/MMBtu	4.823E-07	4.823E-07	4.823E-07	4.823E-07	

2.2.6 Formaldehyde Emission Results

Three (3) two-hour (nominal) test runs were performed for formaldehyde in accordance SW846 method 0011. Sampling was performed on the boiler's exhaust stack while the facility operates at normal load conditions.

Triplicate (3) test runs were performed to demonstrate emission limits for formaldehyde while the 150 furnace operated at normal load conditions while firing natural gas. The demonstration test program was performed on September 4, 2009 during the hours of 10:36 – 18:58 hrs. Results of the test program are presented in Table 2-7.

Table 2-7

Boralex Stratton Energy LP
Stratton, Maine
October 22, 2009

CONSTIUENT	UNITS	Test Run No. 1	Test Run No. 2	Test Run No. 3	Average	Limit
Time	-	7:52-10:02	10:33-12:45	13:11-15:17		
Date	-	10/22/2009	10/22/2009	10/22/2009		
O_2	%	5.5	5.9	5.5	5.6	
CO_2	%	14.9	12.2	14.4	13.8	
H_2O	%	19.6	18.3	19.1	19.0	
Flowrate	DSCFM	105750	106940	109250	107313	
Sample Volume	DSCF	86.3	87.5	91.3	88.4	
Stack Temeperature	Degrees F	351.9	355.8	356.6	354.8	
Isokinetic Ratio	%	99.5	99.8	101.8	100.4	
Formaldehyde	**ppm @ 7% O_2**	**0.2**	**0.2**	**0.2**	**0.2**	

Stack emissions were sampled through ports located on the exhaust stack. The ports are located approximately >8 duct diameters downstream from the nearest flow disturbance and greater than >2 duct diameters upstream from the nearest flow disturbance.

3.0 PROCESS AND OPERATIONS

Boralex, Inc. owns an electric generating facility located in Stratton, Maine. The Boralex Stratton Energy LP facility is licensed by the Maine Department of Environmental Protection (ME DEP) under Air Emissions License # A-368-70-A-I to operate a single wood-fired boiler with a maximum continuous heat input capacity of 672 MMBtu/hr.

3.1 Wood Fired Boiler

The wood-fired boiler supplies steam to a turbine, which generates 39-50 megawatts (gross) of electricity. While BSE is authorized to combust processed Construction & Demolition Wood (up to 50% (%w/w annual average) the facility has not combusted this material since July of 2006. The facility is controlled by a system of local instrumentation and a central programmable controller. The control system is configured to allow plant operation down to 50% of the maximum net electrical output.

The generating plant consists of one travelling-grate membrane water wall boiler, that is capable of producing 465,000 pounds of steam per hour, one condensing steam turbine generator, one condenser, two feedwater heaters, one cooling tower, one electrostatic precipitator, an electrical distribution system, and instrumentation and control systems.

Fuels, consisting of wood chips and sawmill residues are delivered to the site in tractor-trailers. The trucks are weighed on a scale, and then unloaded via one of two back-in tilt dumpers. The as-received fuel is conveyed to a disc screen for size classifying and then reduced in size by an in-line wood hog, if required. The sized fuel is then conveyed to an HPDE lined fuel storage yard. Fuel is reclaimed from the fuel storage yard, conveyed to the boiler' surge bin and fed to the furnace via six variable speed screw feeders. High-pressure transport air and trajectory plates distribute fuel on the travelling-grate. Fine fuel particles are burned in suspension while heavier particles are evenly spread on the back of the travelling-grate surface.

Superheated steam from the boiler is routed to the steam turbine generator, which is supplied with two uncontrolled extractions to supply steam for deaeration and condensate heating. Exhaust steam from the turbine is condensed in the surface condenser and the resulting condensate is pressurized, heated, deaerated, and routed back to the boiler for reuse. The circulating water leaving the condenser is cooled in a two-cell cooling tower and pumped back to the condenser. Hot flue gas from the steam generator is used to preheat combustion air in a tube preheater. Pre-heated combustion air is divided into overfire air and undergrate air. Undergrate air is evenly distributed through the active grate area to begin the combustion process while overfire air jets provide mixing of fuel and air to complete the combustion process. After leaving the preheater, the flue gas is stripped of particulate matter in a mechanical dust collector followed by an 4-cell electrostatic precipitator. Cleaned flue gas is then discharged to the atmosphere through the stack.

3.2 NOx Control Program

Boralex Stratton Energy has installed the following NO_x controlling equipment in their efforts to be a renewable energy generator.

The Ecotube System consists of four liquid cooled, automatically retractable tubes. These tubes are inserted into the boiler through openings in the walls. Ambient air is added through the Ecotubes with high pressure and high speed using changeable nozzles in order to improve the mixing of the combustion gases and the air. The result is an efficient combustion process with overall reduced emissions. In addition, thermal efficiency is also increased which results in lower fuel consumption. A 30% liquid urea reagent or 19% aqueous can also be introduced into the Ecotube System to enhance NO_x reduction.

The Regenerative - Selective Catalytic Reduction system (R-SCR_is a system that removes NO_x from flue gas using a catalytic reduction process requiring a 19% aqueous ammonia reagent to be added to the flue gas stream to reduce NO_x. The reagent is added upstream of the catalyst and well-mixed with the flue gas prior to contacting the R-SCR catalyst to ensure optimum NO_x removal efficiency and low ammonia (NH3) concentrations in the outlet gas stream (NH3 slip).

4.0 SAMPLING AND ANALYTICAL METHODOLOGY

Emission measurements were performed during this emissions test program at the boiler's main exhaust stack to determine concentrations and/or emission rates of total suspended particulates (TSP), sulfur dioxide (SO_2), oxides of nitrogen (NO_X), total hydrocarbons (THC), carbon monoxide (CO), dioxins/furans (PCDD/PCDF), hydrogen chloride (HCl), metals including, antimony (Sb), arsenic (As), barium (Ba), berylium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), phosphorous (P), selenium (Se), sliver (Ag), thallium (Ti), particulate matter$_{2.5}$ and condensable particulate, formaldehyde, carbon dioxide (CO_2), and oxygen (O_2). Presented below are the sampling and analytical methodologies that will be used to measure the constituents listed above.

4.1 Instrument Reference Method Sampling

Stack gas was drawn through a heated sintered stainless steel probe, heated Teflon sample line (300°F nominal), and a stainless steel sample conditioner by a leakless Teflon diaphragm pump. The sample will then be pumped through a manifold under slightly positive pressure with a bypass to atmosphere. Samples were continuously drawn from this manifold to the instruments listed below:

TABLE 4-1
REFERENCE METHOD (RM) ANALYZERS

Analyzer	Parameter	Model No.	Instrument Range
Thermo/Fisher	O_2	60i	0 - 25%
Thermo /Fisher	CO_2	60i	0 – 25%
Thermo Environmental	NOx	42CHL	0 - 100 ppm
Thermo/Fisher	CO	60i	0 - 200 ppm
Western Research	SO2	721.AT	0 – 100 ppm
California Analytical	VOC	600 HFID	0 – 100 ppm

The model 42CHL NO_X analyzer is equipped with a NO_X converter. The converter efficiency was checked prior to the testing program according to the procedure listed in 40 CFR 60, Appendix A, Section 8.2.4.1, EPA Reference Method 7E. A schematic of the gaseous reference method sampling configuration is presented in Figure 4-1.

The analyzer outputs were continuously recorded using an ESC 8816 data logger supported by ESC's software on a PC. The signals from the analyzers were "viewed" by the data logger at 1-second intervals, from which one-minute averages were formed. The ESC software was then used to generate reports for discrete test periods. Printouts of these periods will be contained in the Appendix of this test report.

4.1.1 Calibrations

Calibrations of instrumental analyzers utilized for Methods 3A, 6C, 7E, 10, and 25A were performed at the beginning and end of each test using EPA Protocol 1 calibration gases.

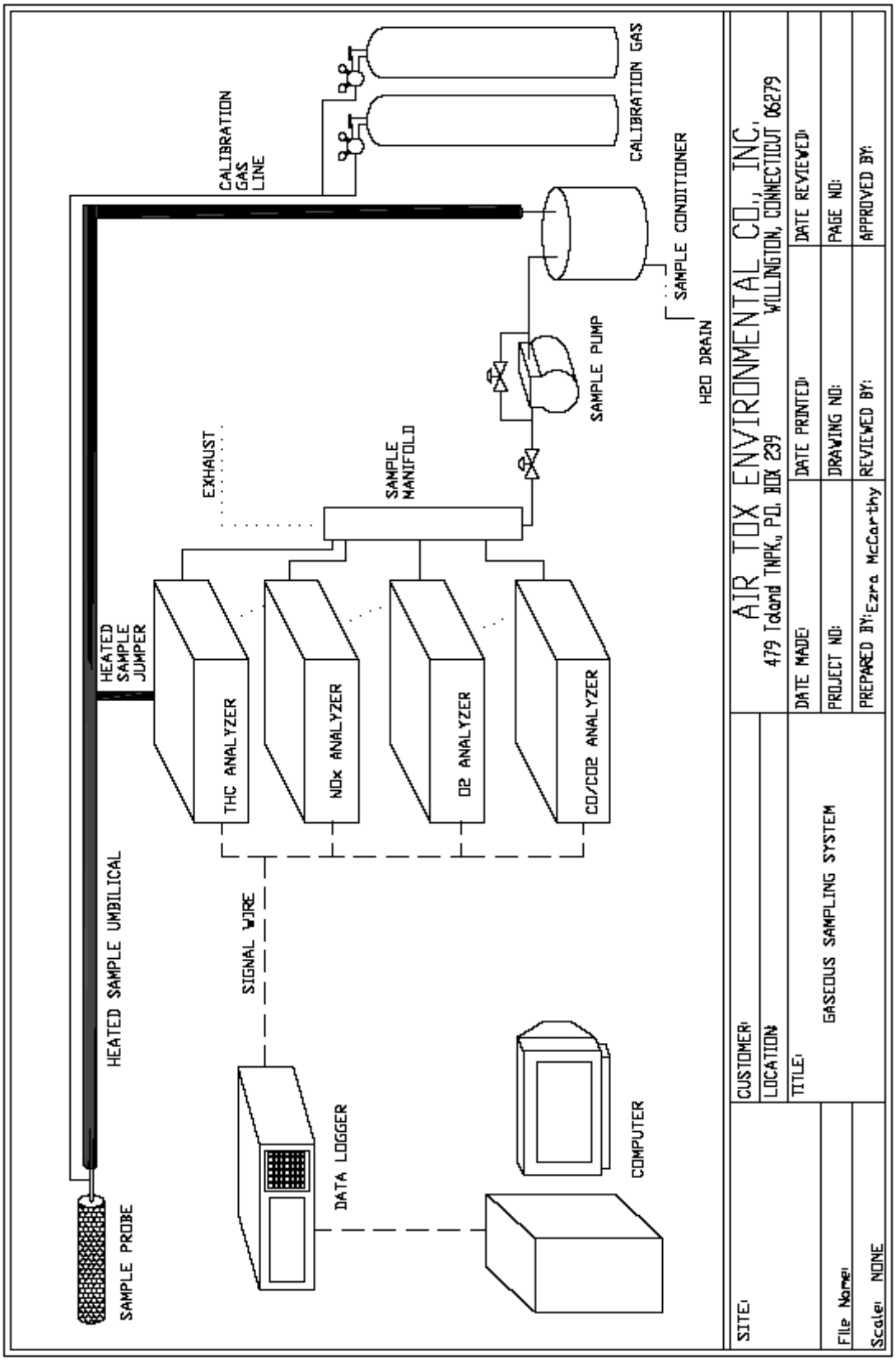

Figure 4-1 Gaseous Reference Method Sampling Schematic

Calibration gases (zero, low (method 10 only), mid, and span) were introduced directly to the analyzers (by-passing the sampling system) at the beginning of the test day to verify that calibration error of < 2.0% is acceptable and to establish instrument linearity. Additionally Air Tox determined system bias, a zero and upscale gas for each instrument. Calibration checks of the reference method instrumental analyzers were introduced to the sample probe at the beginning and end of each test run. The average test concentration were corrected for the line bias, if any, according to procedures contained in Method 7E, Section 12.0.

4.1.2 Stack Molecular Weight Determination

Molecular weight was determined using calculations listed in EPA Reference Method 3. As detailed above, the composition of the gas stream was continuously analyzed for carbon dioxide concentration, concurrent with each test run, in accordance with EPA Reference Method 3A. This data, together with the measured carbon monoxide and oxygen concentrations, allowed the stack gas molecular weight to be calculated.

4.1.3 Stack Gas Moisture Content Measurement

A minimum of three (3) sixty-minute moisture runs were performed in conjunction with each test run. Stack gas moisture content was determined according to EPA Method 4. This method consisted of extracting a known volume of gas sample and quantifying the removed moisture portion of this sample. Four impingers were loaded according to the method with 100ml of deionized water in the first two, the third was empty, and the fourth was charged with 200grams of non-indicating (as per IBM's request) silica gel. A diagram of the moisture sampling train is provided in Figure 4-2.

Following assembly the train was then leak checked by plugging the sample inlet and challenging the train with a vacuum of 15 inches of mercury. All leak rates were less than 0.02 CFM. The initial meter volume will be recorded and the probe was positioned at a single traverse point for the entire test program.

Sampling was conducted at the meter box ΔH@ for the entire sixty (60) minute test. At the completion of each test run the final meter volume was recorded and another leak check was conducted. The impingers were then recovered and their final volumes were recorded.

4.1.4 Volumetric Flow Measurement

Exhaust stack volumetric flow rate was determined in accordance with EPA Reference Methods 1 and 2. Velocity measurements were recorded at each of twelve traverse points in the 96" I.D. stack (six per each of two sampling ports located 90° apart). Measurements were performed during each of the test runs.

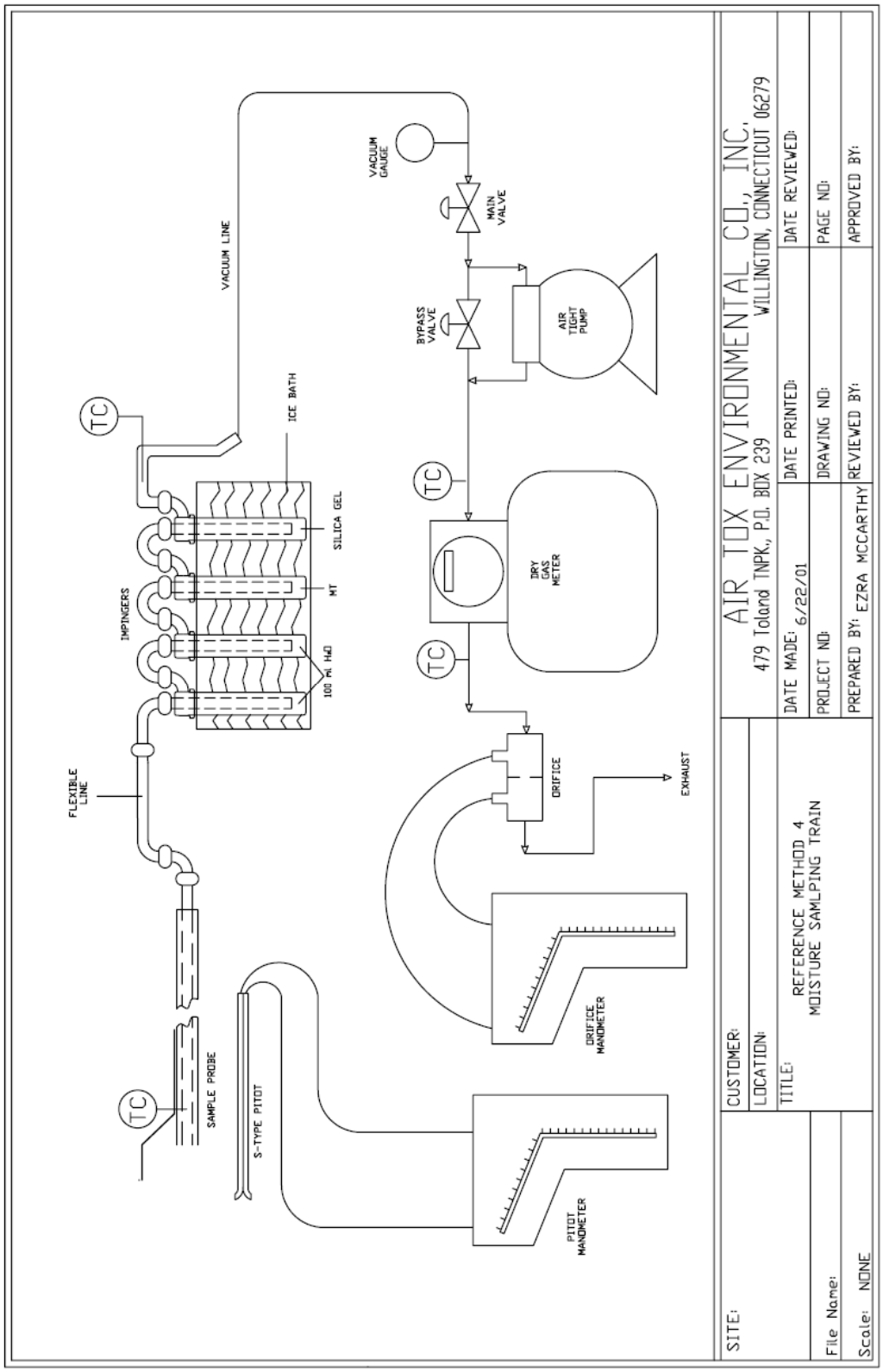

Figure 4-2 Moisture Sampling Train

4.2 PCDD/PCDF Emission Measurements

Measurement of Polychlorinated Dibenzo-p-Dioxins (PCDD's) and Polychlorinated Dibenzofurans (PCDF's) was performed in accordance with EPA Reference Method 23. A total of three 3-hour isokinetic test runs were performed for this test program. This method is essentially a modified version of Reference Method 5. The train consists of a calibrated quartz nozzle, a heated quartz-lined probe, a heated glass fiber (pre-cleaned) filter encased in a glass holder with a Teflon frit, a flexible heated Teflon sample line, a Graham spiral-type condenser, a water jacketed sorbent module containing cleaned XAD-2 resin, and five Greenburg-Smith impingers. The sorbent module is positioned vertically and sample gas flows downward to prevent channeling. The first impinger is modified to serve as a moisture knockout by shortening the stem. Impingers two and three are each charged with 100 ml HPLC water. The fourth impinger is empty, while the fifth contains 200 grams of indicating silica gel.

Prior to testing, all sample train components were cleaned and assembled in accordance with Section 4.1 of Reference Method 23. Glassware connections utilize Teflon/silicon O-rings to provide a leak-free seal without the use of silicone grease. Prior to and following sampling, the sample train was sealed with hexane rinsed aluminum foil to prevent contamination. Upon completion of each four-hour sample run, the train components was moved to a relatively clean area to minimize the chances of contamination during sample recovery. A schematic of the sampling train is presented in Figure 4-3.

The sample train wais then inspected for abnormal conditions and completely disassembled. Samples are recovered and placed in five sample containers, as follows:

Container No. 1	Filter
XAD-2 Adsorbent Module	Module was removed from sample train, immediately sealed with hexane rinsed aluminum foil, and stored on ice for transport to the laboratory.
Container No. 2	Acetone/methylene chloride washes of probe and front half of filter holder. The probe and nozzle are washed and brushed three times, followed by three rinses (no brushing) with methylene chloride. The back half of the filter holder, the transfer line (if used), and the spiral condenser are also rinsed three times with acetone and three times with methylene chloride. These rinses are deposited in this container. The container was sealed, labeled, and the liquid level is marked.
Container No. 3	The transfer line, and condenser are washed three times with toluene and deposited in this container. The container was sealed, labeled, and the liquid level is marked.

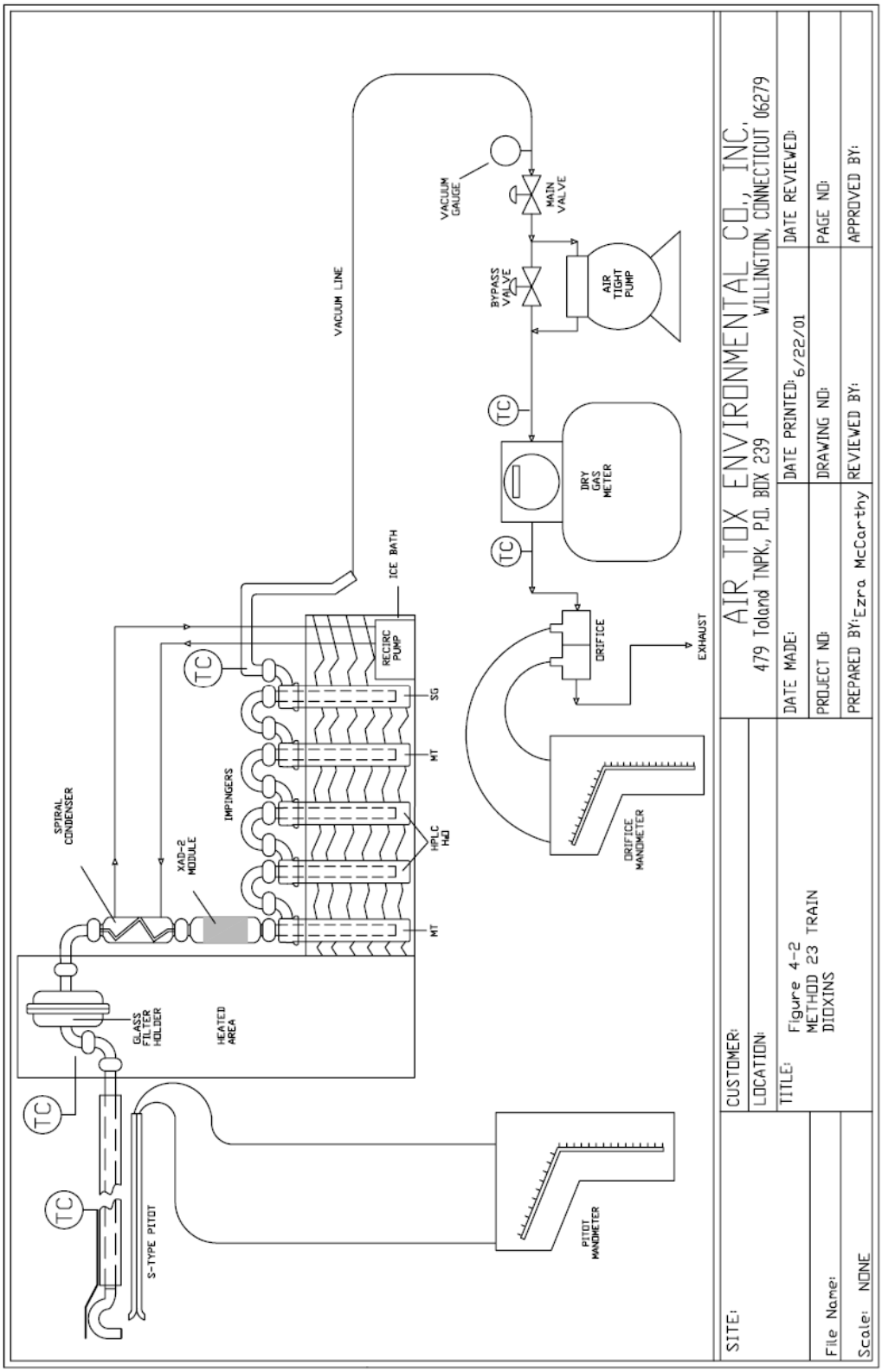

Figure 4-3 PCDD/PCDF Sampling Schematic

The contents of the first four impingers were measured to the nearest 1.0 ml to determine moisture gain and discarded. The silica gel from the fifth impinger is weighed to the nearest 0.5 grams following each test run and saved for future use.

The samples were transported to the laboratory where the following analyses was performed:

Container Nos. 1 -3, & XAD-2	Perform analysis by gas chromatography/mass spectrometry in accordance with Section 5 of Reference Method 23.

4.3 Hydrogen Chloride and Fluoride Measurement

The stack concentration of hydrogen chloride (HCL) and Fluoride (HF) were determined utilizing Reference Modified Method 26A. Three 1-hour isokinetic test runs were performed for this test program. Hydrogen chloride and Fluoride emissions were expressed in pounds per million British thermal units (lbs/MMBtu, using the arithmetic mean of the three one-hour test runs.

A glass-lined probe was attached to a heated Teflon filter and sealing gasket to prevent condensation. This method is essentially a modified version of Reference Method 5. The remainder of the sample train consists of five large impingers in an ice bath, flexible tubing, vacuum gauge, needle valves, leakless vacuum pump, bypass valve, and a dry gas meter. The first impinger is empty to serve as a moisture knockout. Impingers two and three each contain 100 ml 0.1N H_2SO_4 (sulfuric acid), the fourth impinger contains 100 ml 0.1N NaOH (sodium hydroxide) to act as a scrubber, and the fifth impinger contains silica gel. Prior to testing, all sample train components are cleaned and assembled in accordance with Section 5.1.1 of Reference Method 26A. Glassware connections utilize Teflon/silicon O-rings to provide a leak-free seal without the use of silicone grease. Prior to and following sampling, the sample train will be sealed with Parafilm to prevent contamination. A schematic of the sampling train is presented in Figure 4-4.

Upon completion of each one-hour sample run, the train components was moved to a clean area to minimize the chances of contamination during sample recovery. Samples are recovered and placed in one sample container, as follows:

Container No. 1	Contents of impingers 1, 2 & 3. Rinse each impinger and connecting glassware with DI water. Also deposit rinses in this container. Container is labeled and sealed for transport.
Container No. 2	Contents of impingers 4. Rinse each impinger and connecting glassware with DI water. Also deposit rinses in this container. Container is labeled and sealed for transport.

The contents of impingers four and five are discarded. The recovered samples were transported to the laboratory where the following analyses was performed:

Container No. 1 & 2	Perform analysis by ion chromatography in accordance with Section 4.4 of Reference Method 26A.

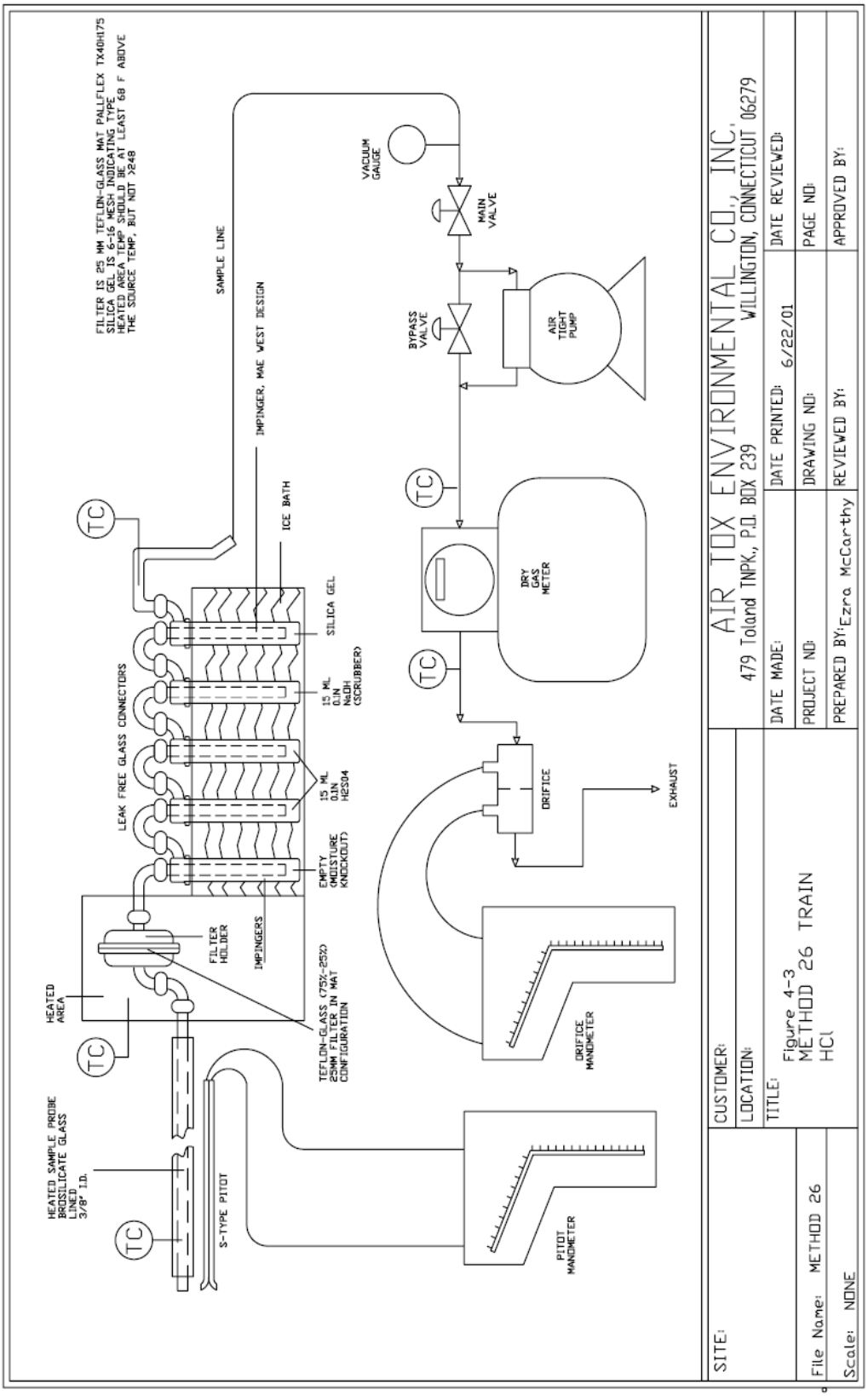

Figure 4-4 Hydrogen Chloride and Fluoride Schematic

4.4 Multiple Metals Measurement

The exhaust stack concentration of heavy metals were determined utilizing Reference Method 29. Three (3) 4-hour isokinetic test runs were performed to determine the emissions of the metals listed in 40 CFR60 section 60.58a; antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel , phosphorous, selenium, sliver, and thallium. This method is essentially a modified version of Reference Method 5. The train consists of a calibrated quartz nozzle, a heated quartz-lined probe, a heated glass fiber (pre-cleaned) filter encased in a glass holder with a Teflon-coated wire frit, and seven impingers. The first impinger is an empty, modified Greenburg-Smith type, used to serve as a moisture knockout. Impingers two (modified Greenburg-Smith) and three (Greenburg-Smith) are each charged with 100 ml of a nitric acid/hydrogen peroxide solution (5% HNO_3/10% H_2O_2). The fourth impinger is empty, while the fifth and sixth impingers (modified) are each charged with 100 ml potassium permanganate/sulfuric acid solution (4% $KMnO_4$/10% H_2SO_4). The seventh impinger contains 200 grams of indicating silica gel to remove any remaining moisture.

Prior to testing, all sample train components are cleaned and assembled in accordance with Section 5.1.1 of Reference Method 29. Glassware connections utilize Teflon/silicon O-rings to provide a leak-free seal without the use of silicone grease. Prior to and following sampling, the sample train were sealed with Parafilm to prevent contamination. Upon completion of each two-hour sample run, the train components were moved to a relatively clean area to minimize the chances of contamination during sample recovery. A schematic of the sampling train is presented in Figure 4-5.

The sample train is then inspected for abnormal conditions and completely disassembled. Samples are recovered and placed in five (optionally six) sample containers, as follows:

Container No. 1	Filter was removed from holder and deposited in 1000 ml sample jar. The nozzle, probe, and front half of the filter holder and brushed and rinsed in triplicate with 100 ml of nitric acid solution. The washes are deposited into this container. Container is labeled and sealed for transport.
Container No. 2	Contents of impingers 1, 2, & 3. Contents are measured to determine moisture gain and deposited into sample jar. The back half of the filter holder, the first three impingers, and connecting glassware are rinsed in triplicate with 100 ml nitric acid solution. Container is labeled and sealed for transport.

Container No. 3	Contents of impinger 4. Contents are measured to determine moisture gain and deposited into sample jar. The impinger is rinsed in triplicate with 100 ml nitric acid solution. Container is labeled and sealed for transport.
Container No. 4	Contents of impingers 5 & 6. Contents of impingers are measured and deposited into sample jar. The impingers and connecting glassware are rinsed in triplicate with potassium permanganate solution. Rinses are deposited into this container. Container is labeled and sealed for transport.
Container No. 5 (optional)	Additional rinses of impingers 5 & 6 are performed with 8N HCl solution if visible deposits remain following the initial rinses. Container is labeled and sealed for transport.

Container No. 6 - Silica Gel.

The samples were transported to the laboratory where the following analyses were performed:

Containers Nos. 1 thru 5	Perform analysis by ion chromatography in accordance with Sections 5.3 and 5.4 of Reference Method 29.
Container No. 6	Contents are weighed to nearest 0.5 g and discarded.

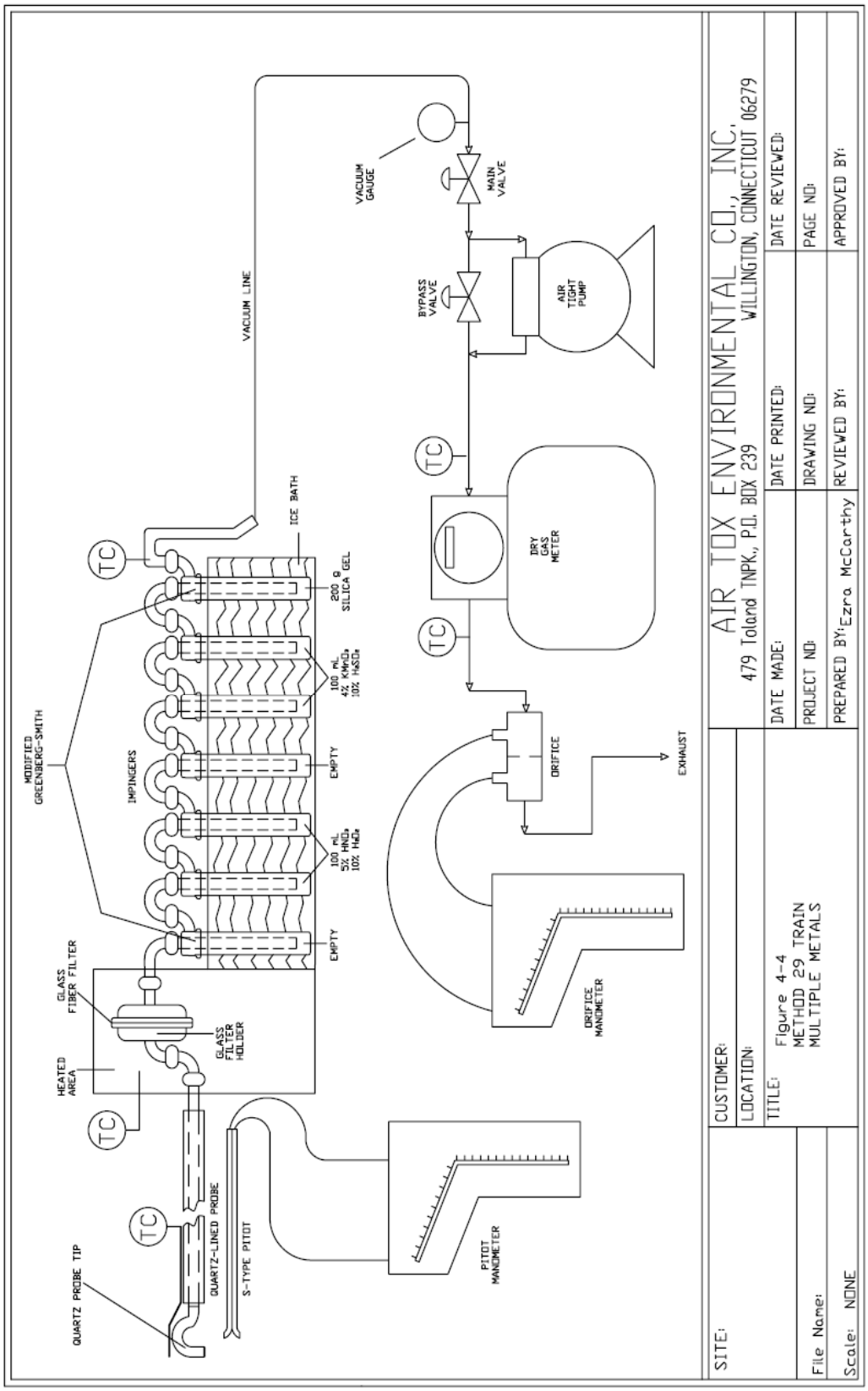

Figure 4-5 Multiple Metals Schematic

4.5 Particulate Matter Emission Measurements

Particulate ($PM_{2.5}$) & Condensables were performed using EPA test method 17 sampling train. A total of three (3) one-hour test runs were performed for this test program in conjunction with the SO_2 , CO, THC, and NO_X emission testing.

The sampling train consisted of a nozzle, probe, filter, four impingers, a flexible umbilical line, vacuum pump, dry gas meter, and an orifice flow meter. The stainless steel nozzle was attached to a stainless steel probe with a stainless steel liner, which was heated to prevent condensation. A 47 mm fiberglass filter paper supported in a 3-1/2 inch glass filter holder was used as the collection media. The filter assembly was enclosed in a heated box to maintain temperatures at 248° F +/- 25° C. An ice bath containing four impingers were attached to the back end of the filter via a flexible umbilical tube. The first, third, and forth impingers was of a modified Greenburg-Smith design, while the second was of a standard Greenburg-Smith design. The first two impingers contained 100 ml of water, and the fourth contained 200 grams of silica gel to remove any remaining moisture. Flexible tubing, vacuum gauge, needle valves, leak less vacuum pump, bypass valve, dry gas meter, calibration orifice and inclined manometer completed the sampling train. The stack velocity pressure was measured using a S-type pitot tube and inclined manometer according to EPA Method 2. The stack temperature was monitored by a thermocouple connected to a potentiometer. A schematic of (OTM 27)/ Method 202 sampling train is presented in Figure 4-6.

A nomograph and/or calculator was used to quickly determine the orifice pressure drop required for a pitot velocity pressure and stack temperature in order to maintain isokinetic sampling conditions. Sampling flow was adjusted by means of the bypass valve. Before and after each particulate test run, the sampling train was leak checked (acceptable at less than 0.02 cubic feet per minute). The moisture content of the exhaust gases was also determined during each particulate test run as part of this sampling train according to EPA Reference Method 4.

Sample recovery was performed in a relatively clean and wind free area. After the probe was removed from the stack and allowed to cool, particulate matter is wiped from the exterior of the nozzle and the nozzle capped to prevent loss (or gain) of sample. The filter outlet is sealed with Para-film. The impinger outlet vacuum line was then removed and the impinger train sealed. The impinger train is inspected and abnormal conditions noted before disassembly.

Test data was recorded on field data sheets presented in the Appendix of the test report. At the end of each test, five sample containers were used as follows:

Container No. 1	$PM_{2.5}$ micrometer filterable particulate. Remove filter from holder and place in Petri dish identified as (container #1). Using a nylon bristle brush, transfer any particulate matter or filter fibers that adhere to the filter holder gasket or filter support screen to the Petri dish. Seal the container.

Container No. 2	Retrieve the acetone rinses of the exit tube of cyclone IV and front half of the filter holder. Seal the container and mark the liquid level on the outside of the container.
Container No. 3	Transfer liquid from the impinger that follows the ambient filter into a clean sample bottle. Mark the liquid level on the bottle. This container holds the remainder of the liquid water from the emission gases.
Container No. 4	Silica gel from the fourth impinger will be emptied into its original labeled sample container following each test run. Contents are weighed during sample analysis.
Container No. 5	Acetone rinse blank. 100 ml of the acetone is taken directly from the wash bottle that is used and placed in (container #5). Labeled acetone rinse blank.

The sample train was inspected prior to and during disassembly for any abnormal conditions. The sample recovery was performed as follows:

Container No. 1	Transfer the filter and any loose particulate matter from the sample container to a tarred glass weighing dish, desiccate for 24 hours, dry to a constant weight. Report results to the nearest 0.1 mg.
Container No. 2	Transfer the acetone washing to a tarred 250 ml beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and dry to a constant weight. Report results to the nearest 0.1 mg.
Container No. 3	Measure the liquid in this container either volumetrically to + or – 1 ml or gravimetrically to + or – 0.5g.
Containers No. 4	Weigh the spent silica gel to the nearest 0.5g using a balance.
Containers No. 5	Acetone rinse blank. Transfer 100ml of acetone to a 250 ml beaker. Evaporate the acetone at room temperature and pressure in a laboratory hood. Following the evaporation, desiccate the residue for 24 hours in a desiccator containing anhydrous calcium sulfate. Weigh and report the results to the nearest 0.1mg.

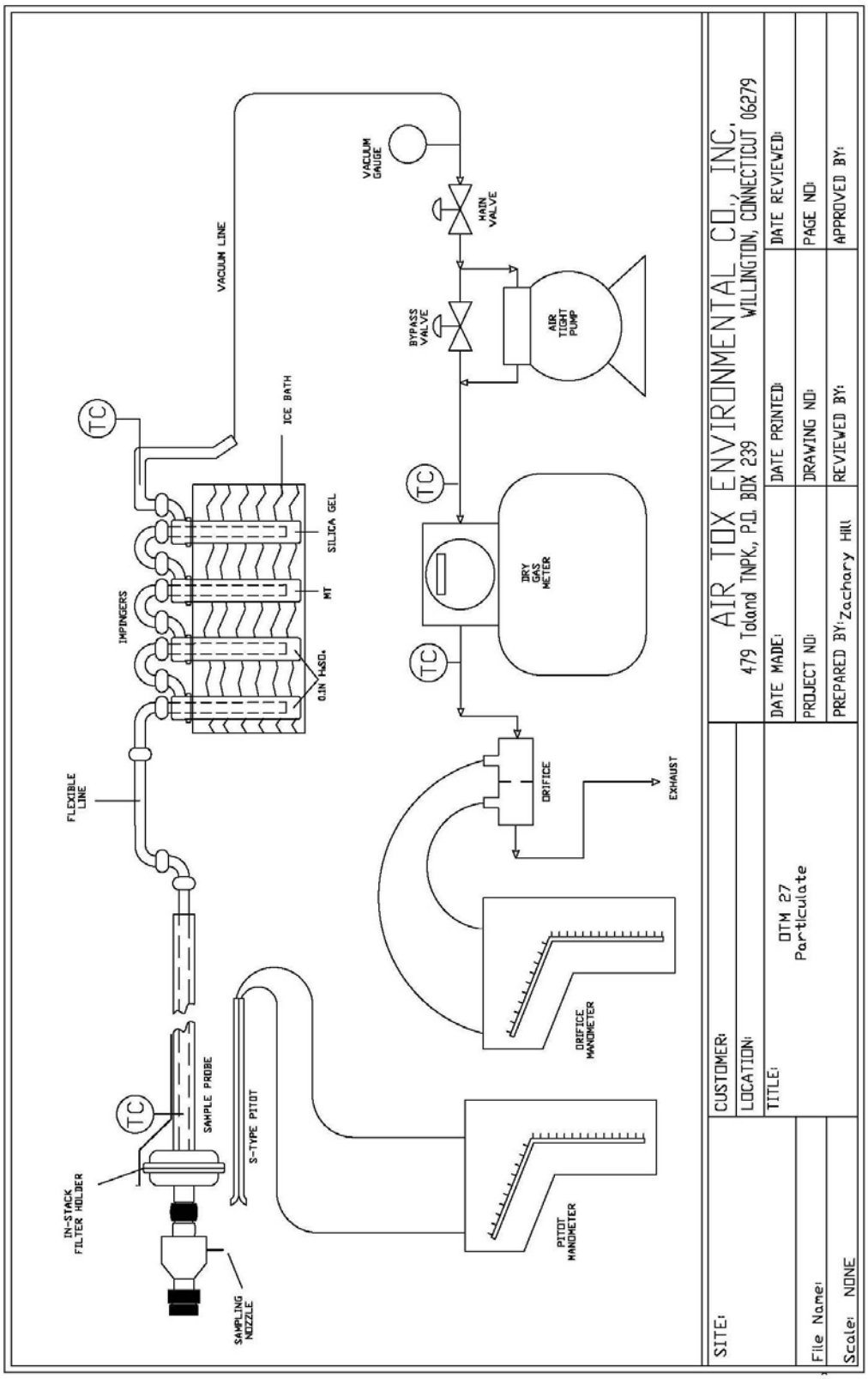

Figure 4-6 Other Test Method 027 Schematic

4.6 Formaldehyde Emission Measurements

Formaldehyde was performed using RCRA test method 0011 sampling train. A total of three (3) two-hour test runs were performed for this test program.

The sampling train consisted of a nozzle, probe, filter, four impingers, a flexible umbilical line, vacuum pump, dry gas meter, and an orifice flow meter. The quartz or glass nozzle was attached to a borosilicate glass or quartz probe with a borosilicate glass or quartz liner, which was heated to prevent condensation. An ice bath containing five impingers were attached to the back end of the filter via a flexible umbilical tube. The first, third, forth and fifth impingers were of a modified Greenburg-Smith design, while the second was of a standard Greenburg-Smith design. The first impinger contains 200 ml of DNPH, the second and third impingers contained 100 ml of DNPH, the fourth impinger was empty and the fifth contained 200 grams of silica gel to remove any remaining moisture. Flexible tubing, vacuum gauge, needle valves, leak less vacuum pump, bypass valve, dry gas meter, calibration orifice and inclined manometer completed the sampling train. The stack velocity pressure was measured using a S-type pitot tube and inclined manometer according to EPA Method 2. The stack temperature was monitored by a thermocouple connected to a potentiometer. A schematic of RCRA Method 0011 sampling train is presented in Figure 4-7.

A nomograph and/or calculator was used to quickly determine the orifice pressure drop required for a pitot velocity pressure and stack temperature in order to maintain isokinetic sampling conditions. Sampling flow was adjusted by means of the bypass valve. Before and after each particulate test run, the sampling train was leak checked (acceptable at less than 0.02 cubic feet per minute). The moisture content of the exhaust gases was also determined during each particulate test run as part of this sampling train according to EPA Reference Method 4.

Sample recovery was performed in a relatively clean and wind free area. After the probe has been removed from the stack and allowed to cool, the inside of the probe liner and nozzle must be rinsed with methylene chloride. The impinger outlet vacuum line was then removed and the impinger train sealed. The impinger train was inspected and abnormal conditions noted before disassembly.

Test data was recorded on field data sheets presented in the Appendix of the test report. At the end of each test, three sample containers were used as follows:

Container No. 1	Probe and impinger catches. Using a graduated cylinder, measure to the nearest ml, and record the volume of the solution of the first three impingers and probe liner and nozzle rinse. Transfer liquid from the impingers into a clean amber sample bottle. Mark the liquid level on the bottle. .

Container No. 2	Sample Blank. Prepare a sample blank by using and amber sample jar and adding a volume of DNPH reagent and methylene chloride equal to the total volume of container 1.
Container No. 3	Silica gel from the fourth impinger will be emptied into its original labeled sample container following each test run. Contents are weighed during sample analysis.

The sample train was inspected prior to and during disassembly for any abnormal conditions. The dinitrophenylhydrazone derivative is then analyzed by high performance liquid chromatography (HPLC) (Method 8315).

An Excel® spreadsheet was used to calculate emission rates in grains per dry standard cubic foot and pounds per hour. The spreadsheet also calculated percent moisture, molecular weight of the stack gas at stack conditions, and the percent isokinesis.

Complete sampling train calibrations were performed before and after every emission test program. Calibration forms are presented in the Appendix and made available on site. Complete pretest calibration forms are included in the Appendix of this report.

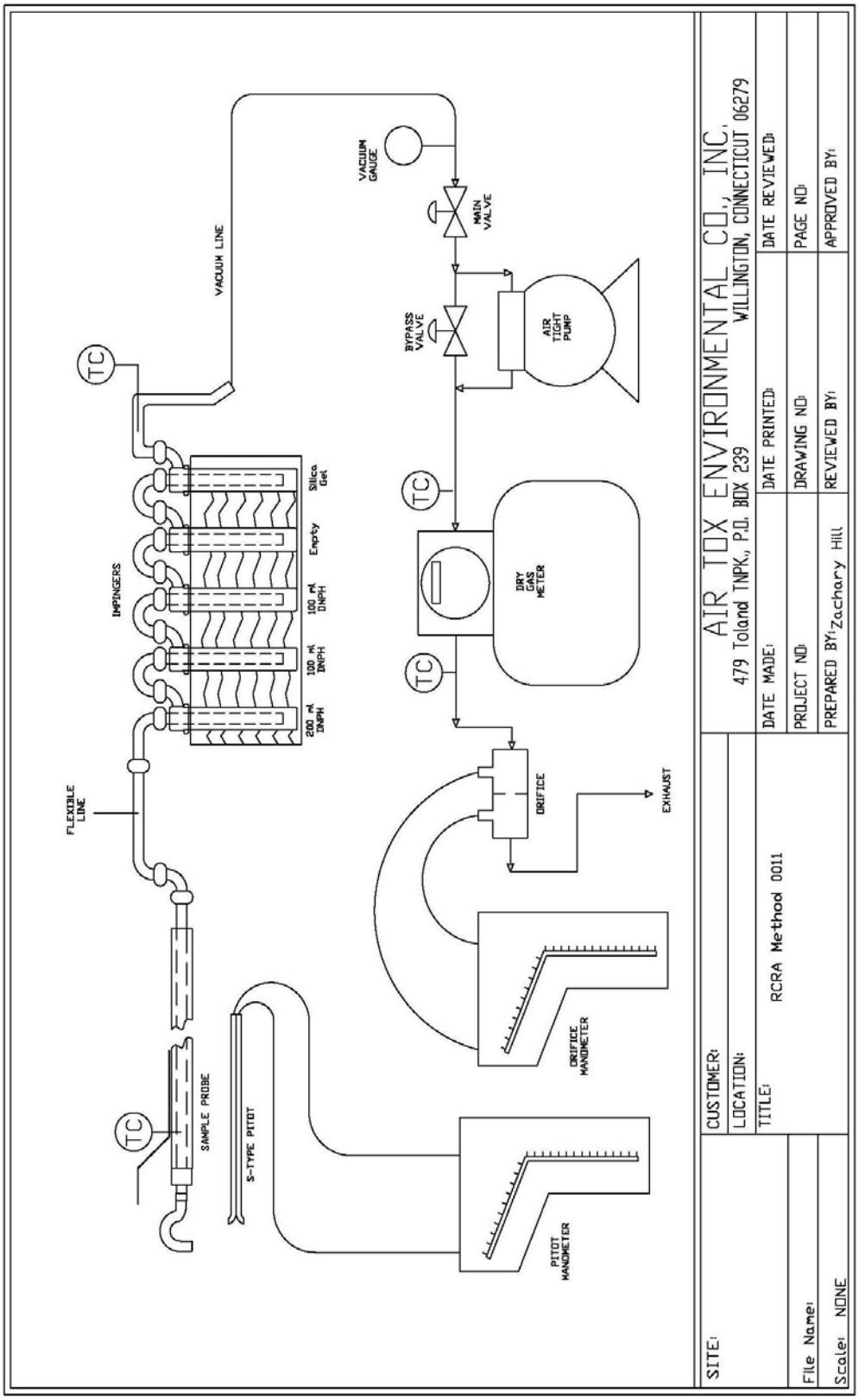

Figure 4-7 RCRA Test Method 0011 Schematic

5.0 QUALITY ASSURANCE

The project manager is responsible for implementation of the quality assurance program as applied to this project. Implementation of quality assurance procedures for source measurement programs is designed so work is done:

- By competent, trained individuals experienced in the methodologies being used.
- Using properly calibrated equipment.
- Using approved procedures for sample handling and documentation.

Measurement devices, pitot tubes, dry gas meters, thermocouples and portable gas analyzers are uniquely identified and calibrated with documented procedures and acceptance criteria before and after each field effort. Records of all calibration data are maintained in the files.

Data are recorded on standard forms. Bound field notebooks are used to record observations and miscellaneous elements effecting data, calculations, or evaluation.

Prior to the test program Air Tox provides the following:

- Calibrations of all pitot tubes, dry gas meters, orifice meters, sampling nozzles, and thermocouples that are used during the test. All calibrations are performed within four months prior to the test date.

Calibration gases utilized for gaseous analysis methods were prepared in accordance with EPA Protocol 1, and were certified to be within ±2% of the cylinder "tag" value concentration. Analyzer linearity, bias, calibration drift, and calibration drift corrections were determined in accordance with Reference Method 6C, as outlined in Section 4.1.6 of this document.

Specific details of Air Tox's QA program for stationary air pollution sources may be found in "Quality Assurance Handbook for Air Pollution Measurement Systems", Volume III (EPA-600/4-7-027b).

APPENDIX