TEST REPORT

Wood-Fired Boiler - Hydrogen Chloride, Particulate, Multiple Metals, and Sulfur Dioxide Test Program

Prepared for:

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

Contact Name: Stephen Hall, Plant Manager
Contact No. (207) 246-2255

Prepared by:

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

Contact Name: Ezra McCarthy, Environmental Engineer
Contact No. (860) 487-5606 ext. 106

Air Tox Project No. 5044

April 2005

Table of Contents

1.0 INTRODUCTION....1

2.0 RESULTS AND DISCUSSION....2
2.1 Testing Parameters & Methodologies....2
2.2 Emission Measurement Test Program....2
2.2.1 Multiple Metals Results....2
2.2.2 Particulate Matter Results....3
2.2.3 Hydrogen Chloride Results....4
2.3.4 Sulfur Dioxide Results....4

3.0 PROCESS AND OPERATIONS....5
3.1 Wood Fired Boilers....5

4.0 SAMPLING & ANALYTICAL METHODOLOGY....6
4.1 Instrument Reference Method Sampling....6
4.1.1 Reference Method Sampling System....6
4.1.2 Analyzer Calibrations....6
4.2 Manual Emission Measurements....8
4.2.1 Stack Gas Molecular Weight Determination....8
4.2.2 Stack Gas Moisture Content Measurements....8
4.2.3 Volumetric Flow Measurements....8
4.2.4 Multiple Metals Testing....8
4.2.5 HCl Testing....11

5.0 QUALITY ASSURANCE....13

List of Tables and Figures

Table 2-1 Sampling Parameters....2
Table 2-2 Multiple Metals Test Results....3
Table 2-3 Particulate Matter Test Results....4
Table 2-4 Hydrogen Chloride Test Results....4
Table 2-5 Sulfur Dioxide Test Results....4

Figure 4-1 Gaseous Reference Method Sampling Schematic....7
Figure 4-2 EPA Method 29 MM/PM Sampling Train....10
Figure 4-3 EPA Method 26A HCl Sampling Train....12

Appendix

Field Data Summary Sheets.....Appendix A
Reference Method Data Sheets.....Appendix B
BSE CEMS Data.....Appendix C
Calibration Data & Calibration Gas Certificates .....Appendix D
Laboratory Analysis.....Appendix E

1.0 INTRODUCTION

Air Tox Environmental Company, Inc. (Air Tox) of Willington, CT was retained by Boralex, Inc. to perform Hydrogen Chloride (HCl), Multiple Metals with Particulate Matter (MM/PM) and Sulfur Dioxide (SO_2) testing on the wood fired boiler serving the Boralex Stratton Energy, Inc. (BSE) generating facility in Stratton, Maine. All testing was performed in accordance with the applicable US EPA and Maine Department of Environmental Protection (ME DEP) regulations.

The test plan described herein was conducted during the week of February 21st with testing performed on the 23rd, of 2005. All testing was performed under the supervision of Ezra McCarthy, Environmental Engineer, of Air Tox. The process and operations will be coordinated by Stephen Hall, the facility operations manager, of Boralex Stratton Energy. Ms. Sherry Howard, of ME DEP, was present on the day of testing.

This report details the methodology that Air Tox used to determine system compliance with the required performance specifications. Section 2.0 contains the Scope of the Sampling Program description, while Section 3.0 describes the Process and Operations. Section 4.0 details the test methods used during the test program. Section 5.0 contains Air Tox's Quality Assurance procedures.

2.0 RESULTS AND DISCUSSION

All sampling and analyses performed during this test program were carried out in accordance with the requirements of the Maine DEP and the United States Environmental Protection Agency (US EPA). Testing was based on the requirements outlined in the 40 CFR 60, Appendix A. A detailed summary of the test methodology and results are presented below.

2.1 Testing Parameters & Methodologies

The following parameters were measured at the single outlet stack exhausting from the Boralex Stratton Energy power plant in accordance with the method listed.

Table 2-1
Sampling Parameters

EMISSION PARAMETER	REFERENCE METHOD
Volumetric Flowrate	EPA Methods 1& 2
Molecular Weight (O_2, CO_2)	EPA Methods 3A
Sulfur Dioxide (SO_2)	EPA Method 6C
Particulate Matter (PM)	EPA Method 5
Hydrogen Chloride (HCl)	EPA Method 26A
Multiple Metals (MM)	EPA Method 29

2.2 Emission Measurement Test Program

2.2.1 Multiple Metals Results

Three (3) two-hour PM/MM tests were performed on February 23rd, 2005 between 9:00 and 16:34. Metals analysis was performed for the following metals: arsenic (As), antimony (Sb), beryllium (Be), cadmium (Ca), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), selenium (Se), and vanadium (V). Data summaries and field data for all metals testing can be found in the Appendix of this report.

After the test program was completed Air Tox delivered the PM/MM samples to Maxxam Analytics Inc. of Burlington, Ontario.

Table 2-2
Multiple Metals Test Results
Boralex Stratton Energy
2/23/2005

Analyte	Units	Test No. 1	Test No. 2	Test No. 3	Average
Arsenic	ug/DSCM @ 12% CO_2	3.410	4.523	3.968	3.967
	lbs/hr	0.0022	0.0025	0.0026	0.0024
Antimony	ug/DSCM @ 12% CO_2	1.054	2.227	2.747	2.009
	lbs/hr	0.00067	0.0012	0.0018	0.0012
Beryllium	ug/DSCM @ 12% CO_2	0.031	0.042	0.061	0.045
	lbs/hr	0.000019	0.000023	0.000039	0.000027
Cadmium	ug/DSCM @ 12% CO_2	0.186	0.418	0.229	0.277
	lbs/hr	0.00012	0.00023	0.00015	0.00016
Chromium	ug/DSCM @ 12% CO_2	7.750	17.745	10.987	12.161
	lbs/hr	0.0049	0.0097	0.0071	0.0073
Copper	ug/DSCM @ 12% CO_2	2.914	5.219	2.899	3.677
	lbs/hr	0.0018	0.0029	0.0019	0.0022
Lead	ug/DSCM @ 12% CO_2	46.497	73.069	48.831	56.132
	lbs/hr	0.029	0.040	0.032	0.034
Mercury	ug/DSCM @ 12% CO_2	3.900	2.912	1.914	2.908
	lbs/hr	0.0025	0.0016	0.0012	0.0018
Nickel	ug/DSCM @ 12% CO_2	4.030	10.090	2.838	5.653
	lbs/hr	0.0026	0.0055	0.0018	0.0033
Selenium	ug/DSCM @ 12% CO_2	0.434	0.487	0.397	0.439
	lbs/hr	0.00028	0.00027	0.00026	0.00027
Vanadium	ug/DSCM @ 12% CO_2	0.372	0.592	0.427	0.464
	lbs/hr	0.00024	0.00032	0.00028	0.00028

2.2.2 Particulate Matter Results

Three (3) two-hour PM tests were performed on February 23rd, 2005 between 9:00 and 16:34. Particulate matter measurement was performed in conjunction with the metals testing described above. Data summaries and field data for all PM testing can be found in the Appendix of this report. Maxxam Analytics Inc. of Burlington, Ontario performed the analysis of particulate matter for this test program.

Table 2-3
Particulate Matter Test Results
Boralex Stratton Energy
2/23/2005

Analyte	Units	Test No. 1	Test No. 2	Test No. 3	Average
Particulate Matter	gr/dscf	0.002	0.003	0.003	0.003
	lbs/hr	2.10	2.74	3.99	2.68

2.2.3 Hydrogen Chloride Results

Three (3) one-hour non-isokinetic HCl tests were performed on February 23rd, 2005 between 9:37 and 14:43. Data summaries and field data for all PM testing can be found in the Appendix of this report. Environmental Health Laboratory of Cromwell, Connecticut performed the analysis of HCl for this test program.

Table 2-4
Hydrogen Chloride Test Results
Boralex Stratton Energy
2/23/2005

Analyte	Units	Test No. 1	Test No. 2	Test No. 3	Average
Hydrogen Chloride	ppm @12% CO_2	5.79	11.28	9.62	8.89
	lbs/hr	5.48	9.38	9.35	8.07

2.2.4 Sulfur Dioxide Results

Three (3) one-hour SO_2 tests were performed on February 23rd, 2005 between 9:25 and 13:20. Data summaries and field data for all SO_2 testing can be found in the Appendix of this report.

Table 2-5
Sulfur Dioxide Test Results
Boralex Stratton Energy
2/23/2005

Analyte	Units	Test No. 1	Test No. 2	Test No. 3	Average
Hydrogen Chloride	ppm @12% CO_2	26.19	31.11	47.54	34.95
	lbs/hr	44.17	45.36	68.85	52.79

3.0 PROCESS AND OPERATIONS

Boralex, Inc. owns an electric generating facility located in Stratton, Maine. The Stratton Energy 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. Up to 50% of the annual fuel usage may be from Construction & demolition Wood (CDW). 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, sawmill residues and CDW 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, then reduced in size by an in-line wood hog, if required. The sized fuel is then conveyed to a covered fuel storage building. Fuel is reclaimed from the storage building, then conveyed to the boiler 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 three-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 electrostatic precipitator. Cleaned flue gas is then discharged to the atmosphere through the stack.

4.0 SAMPLING AND ANALYTICAL METHODOLOGY

Emission measurements were performed at the exhaust stack to determine the concentration of SO_2, O_2, CO_2, multiple metals, particulate matter, and hydrogen chloride according to EPA Reference Methods 6C, 3A, 29, 5, and 26 respectively. Measurements of O_2 and CO_2 was taken concurrently with the MM/PM and HCL testing.

4.1 Instrument Reference Method Sampling

4.1.1 Reference Method Sampling System

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 was then 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 SAMPLING SYSTEM

Parameter	Analyzer	Measurement Principle
O_2	Servomex 1400	Paramagnetic
CO_2	CAI Model ZRH	NDIR
SO_2	TECO Model 43C	NDIR

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 are contained in the Appendix of the certification test report.

4.1.2 Analyzer Calibrations

A multiple point (zero, mid, and span) calibration was performed directly on each analyzer (bypassing the sample transport and conditioning system) at the beginning of the test program to determine calibration error and demonstrate analyzer linearity. A zero and upscale bias check and calibration drift check was performed prior to and after each test run. An injection point at the base of the sample extraction probe was used for the introduction of gases to the entire sample transport and conditioning system for pre and post run calibration checks. Calibration drift was determined using the pre-run and post-run monitor responses, and was used to correct each average test run concentration of each of the two measured parameters. Procedures and calculations contained in EPA Reference Method 6C, Sections 7 & 8 were used to determine the average stack concentration of the measured constituents for each test run.

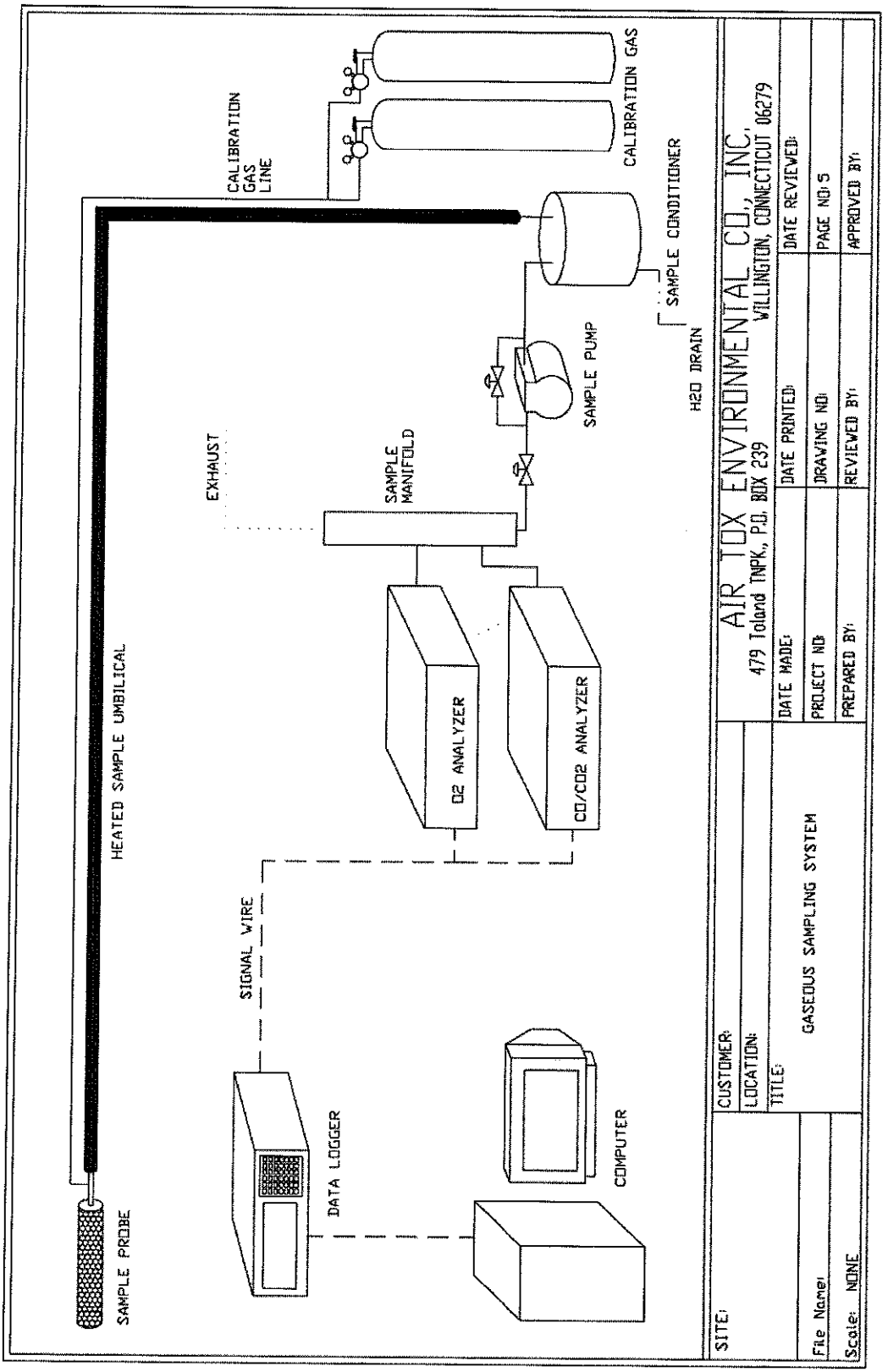

Figure 4.1 – Gaseous Sampling System

4.2 Manual Emission Measurements

Concurrent with the instrumental measurements detailed above, measurements were performed utilizing manual test methods to determine stack gas molecular weight, moisture content, and volumetric flowrate. This data was used to calculate the lbs/hr emission rates, where applicable.

4.2.1 Stack Gas 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 in accordance with EPA Reference Method 3A. This data allows the stack gas molecular weight to be calculated.

4.2.2 Stack Gas Moisture Content Measurements

Stack gas moisture content was determined according to EPA Reference Method 4. The necessary three (3) two-hour moisture runs were performed in conjunction with the Method 29 (Multiple Metals) testing.

4.2.3 Volumetric Flow Measurements

Exhaust stack volumetric flowrate were determined in accordance with EPA Reference Methods 1 and 2.

4.2.4 Multiple Metals and Particulate Matter Testing

The exhaust stack concentration of heavy metals was determined utilizing Reference Method 5/29. Three (3) two-hour isokinetic test runs were performed to determine the emissions of particulate matter and the following metals: antimony, arsenic, beryllium, cadmium, chromium III, chromium VI, copper, lead, mercury, nickel, selenium and vanadium. The train consisted of a calibrated quartz nozzle, a heated quartz-lined probe, a heated quartz-fiber (pre-cleaned) filter encased in a glass holder with a porous Teflon® frit, and seven impingers. Impingers one (modified Greenburg-Smith) and two (Greenburg-Smith) were each charged with 100 ml of a nitric acid/hydrogen peroxide solution (5% HNO_3/10% H_2O_2). The third impinger was empty, while the fourth and fifth impingers (modified) were each charged with 100 ml potassium permanganate/sulfuric acid solution (4% $KMnO_4$/10% H_2SO_4). The sixth impinger contained 200 grams of indicating silica gel to remove any remaining moisture. A schematic of the multiple metals sampling train is presented in Figure 4-2.

Prior to testing, all sample train components was 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 was sealed with Parafilm® to prevent contamination. Upon completion of each 2-hour sample run, the train components were moved to a clean and dust free area to minimize the chances of contamination during sample recovery.

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

Container No. 1	Filter is 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. 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 3. 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 4 & 5. 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 4 & 5 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 was 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.

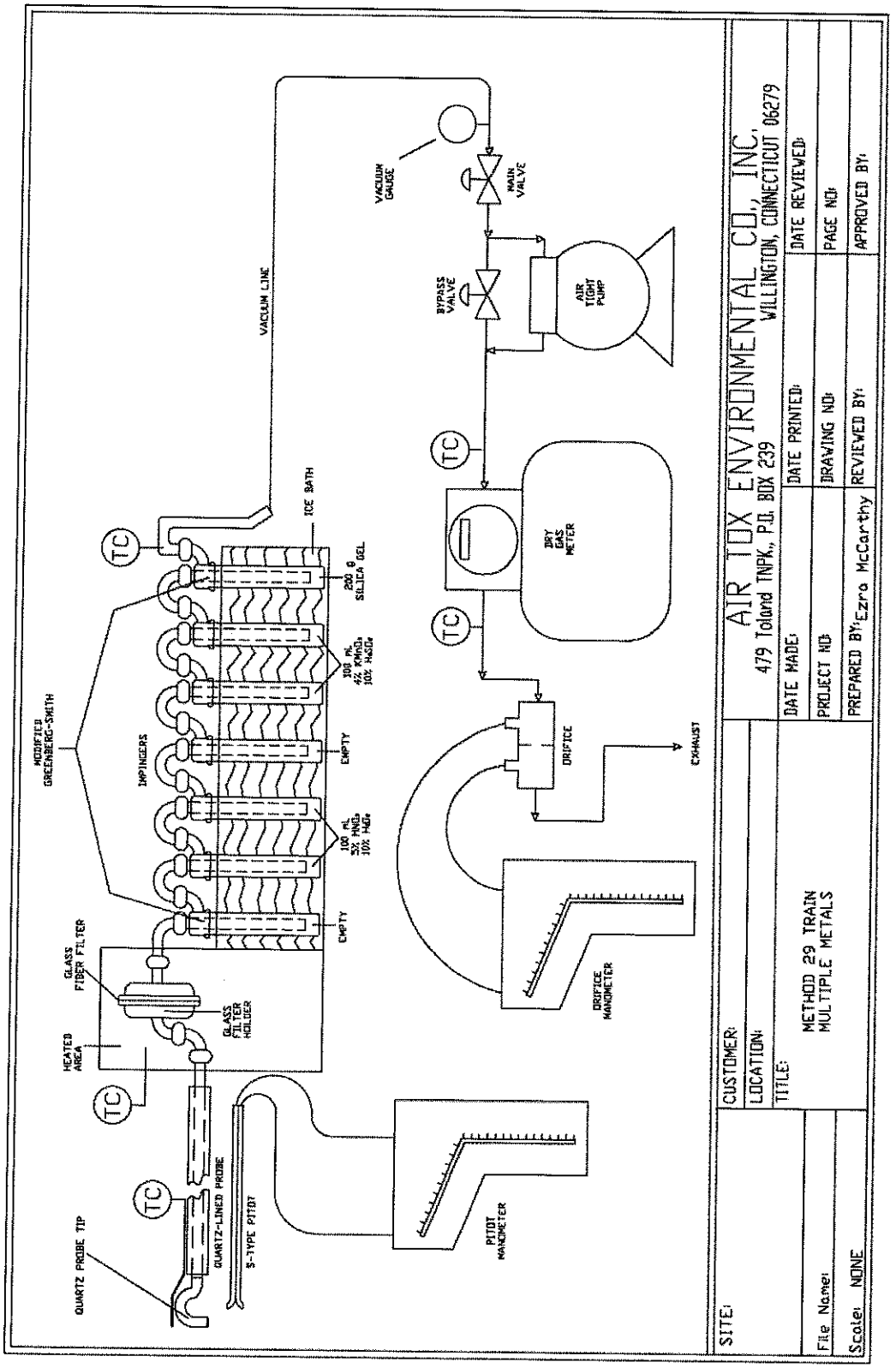

Figure 4.2 – EPA Method 29 Multiple Metals Sampling Train

4.2.5 HCl Testing

The stack concentration of hydrogen chloride was determined utilizing a modified Reference Method 26. Three (3) one-hour non-isokinetic test runs were performed for this test program. Hydrogen chloride emissions were expressed as the arithmetic mean of the three (3) one-hour test runs. A schematic of the HCl sampling train is presented in Figure 4-3.

A glass-lined probe was attached to a heated Teflon filter to prevent condensation. The remainder of the sample train consisted of four impingers in an ice bath, flexible tubing, vacuum gauge, needle valves, leakless vacuum pump, bypass valve, and a dry gas meter. Impingers one and two each contained 100 ml 0.1N H_2SO_4 (sulfuric acid), the third impinger contained 100 ml 0.1N NaOH (sodium hydroxide) to act as a scrubber, and the fourth impinger contained silica gel. Following the pre-test purge, samples were collected at the flow rate of approximately 0.75 cubic feet per minute (±10%).

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

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

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

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

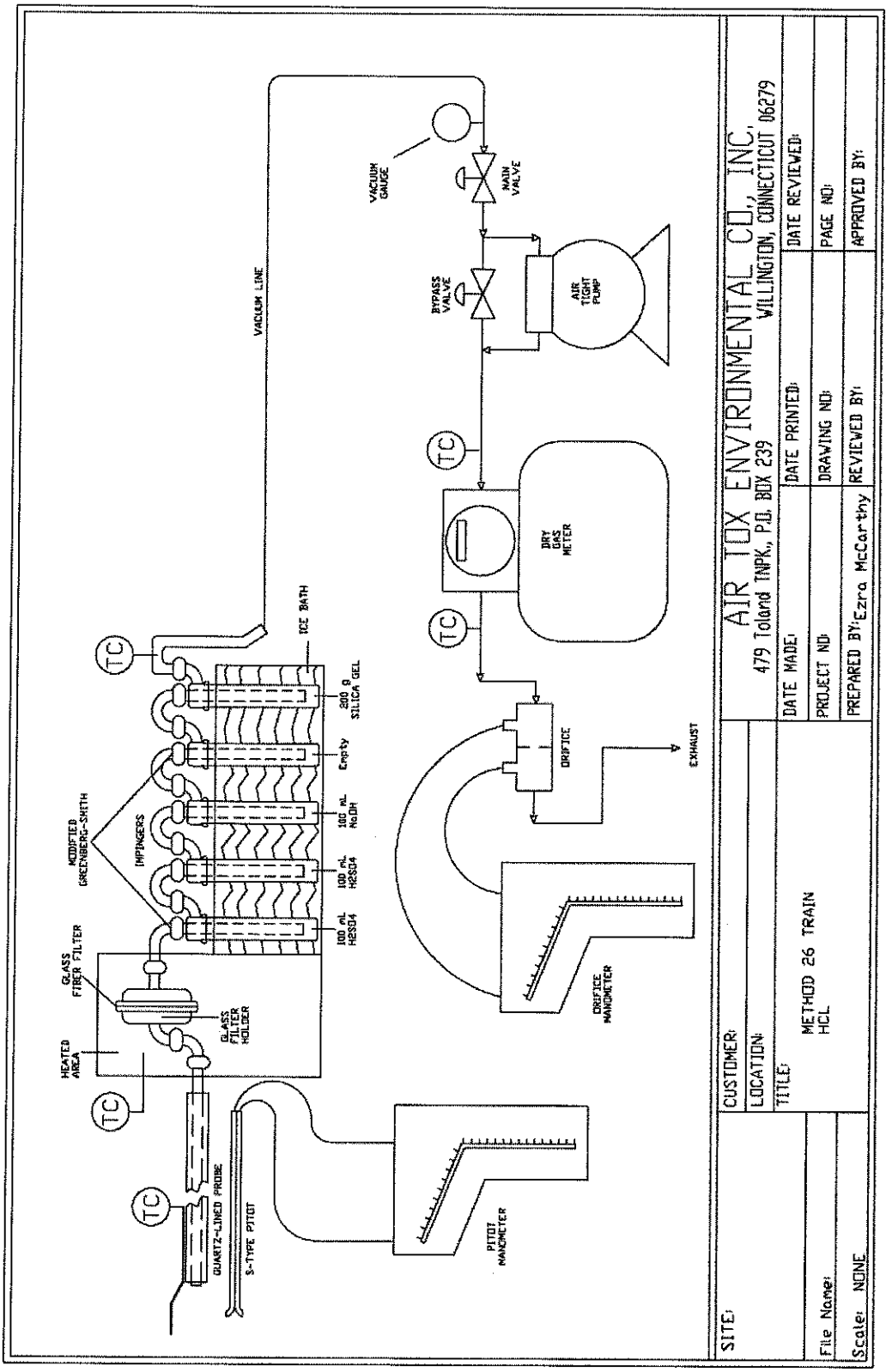

Figure 4.3 – EPA Method 26 HCl Sampling Train

5.0 QUALITY ASSURANCE

The project manager was 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 was 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 will be prepared in accordance with EPA Protocol 1, and will be certified to be within ±2% of the cylinder "tag" value concentration. Analyzer linearity, bias, calibration drift, and calibration drift corrections will be 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).