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**BOILER NUMBER ONE
1st SEMI-ANNUAL 2017
HYDROGEN CHLORIDE
EMISSIONS TEST REPORT**

17 OCTOBER 2017



L'ANSE WARDEN ELECTRIC COMPANY, LLC.

157 South Main Street
L'Anse, Michigan 49946

December 2017

W.O. No. 14464.007.007

1. INTRODUCTION

Weston Solutions, Inc. (WESTON) was retained by L'Anse Warden Electric Company, LLC (LWEC) to perform an emissions testing program on the Boiler No. 1 exhaust duct at the LWEC facility located in L'Anse, Baraga County, Michigan. Boiler No. 1 was previously a coal, oil, and gas-fired steam generating station and has been converted to burn biomass. The objective of this test program is to satisfy the requirements set forth by the Michigan Department of Environmental Quality (MDEQ) Air Quality Division (AQD) Consent Order (AQD No. 35-2016). The Consent Order contains provisions requiring four successive quarters of emission stack testing for hydrogen chloride (HCl) on EUBOILER No. 1, followed by two semi-annual HCl emission stack tests for HCl, followed by one further HCl emission stack test within the succeeding three years thereafter. This report documents the results of the first of two semi-annual HCl stack tests. Boiler No. 1 is identified as EUBOILER No. 1, and the facility currently operates under the State of Michigan Renewable Operating Permit (ROP) No. MI-ROP-B4260-2011 and Permit to Install (PTI) 53-17.

WESTON's Integrated Air Services (IAS) group conducted the first semi-annual required testing on 17 October 2017. There were no representatives of the MDEQ present during the testing.

1.1 PLANT INFORMATION

L'Anse Warden Electric Company, LLC
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L'Anse, Michigan 49946
Mr. JR Richardson
Phone: 906-885-7187

1.2 TESTING FIRM INFORMATION

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West Chester, PA 19380
Mr. Ken Hill
Phone: 610-701-3043

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1.3 SUMMARY OF TEST PARAMETERS

Table 1-1 provides the test parameters, associated test methods, and reporting units for this test program.

**Table 1-1
Summary of Test Parameters**

Test Parameter ¹	Test Method ²	Reporting Units
Volumetric Flow Rate (VFR)	EPA M1-4	dscfm
Hydrogen Chloride (HCl)	EPA M26A (modified)	ppmvd, lb/hr

¹ VFR measurements were performed in conjunction with each HCl test run.

² EPA Method 26A modified by collecting a non-isokinetic sample from a single traverse point similar to EPA Method 26.

Following this introduction, Section 2 provides a summary of the test results. Section 3 provides a description of the process and sampling locations. Section 4 provides a description of the sampling and analytical procedures. Section 5 outlines the fuel processing, fuel sampling and analytical procedures used during the test program. Section 6 provides quality assurance and quality control procedures (QA/QC). Detailed test results, raw test data, boiler operating data, laboratory reports, fuel sample results, quality control records, example calculations, and a list of project participants are provided in Appendices A through H, respectively.

2. SUMMARY OF TEST RESULTS

2.1 TEST RESULTS DISCUSSION

Table 2-1 provides a summary of the hydrogen chloride (HCl) test results. Any differences in the test results summary tables and detailed test results shown in the appendices are due to rounding the results for presentation purposes.

As discussed in the Test Protocol (Revision 1, November 2016), WESTON conducted testing to measure the stack gas moisture, temperature, and velocity measurements concurrent with the HCl sampling at the ESP outlet duct. The measurements were used to calculate stack gas volumetric flow rates and hydrogen chloride mass rates. Detailed results tables are presented in Appendix A.

As an additional quality assurance measure, LWEC conducted fuel sampling and analysis during the test program. The chlorine results for each fuel sample collected can be found in Appendix E.

There were no sampling or operational issues that impacted the field testing and the results presented are believed to be representative of the emissions encountered during the test periods.

Table 2-1

Summary of 1st Semi-Annual 2017 HCl Test Results

Parameter	Date	Time	Unit of Measure	Result	PTI 168-07D Emissions Limit
HCl (EPA 26A)	10/17/17	1342-1442	lb/hr	1.24	2.17
	10/17/17	1456-1556	lb/hr	1.04	2.17
	10/17/17	1622-1722	lb/hr	1.21	2.17
Average				1.16	2.17

3. DESCRIPTION OF PROCESS AND SAMPLING LOCATIONS

3.1 PROCESS OVERVIEW

LWEC is a cogeneration facility, consisting of a single boiler generating process steam and electric power to the grid firing primarily biomass materials. The boiler typically produces steam at 180,000 lbs/hr and gross power generation from 14 to 17.7 MW/hr.

3.1.1 Basic Operating Parameters

The fuel feed to the boiler is regulated to meet process steam and electrical generation requirements. The fuel blend and excess air were modified to improve combustion characteristics. Adjustments to air, fuel blend or load were made as necessary to conform to emissions monitoring limits.

3.1.2 Boiler Operations

The hourly boiler operating limit is 324 million British thermal units (MMBtu). The maximum annual heat input is 2,656,800 MMBtu, based on 8,200 hours of operation per year.

The boiler load was determined by the demand for process steam and electricity. The boiler load was maintained at 90% of capacity during the test program.

3.1.3 Test Program Fuel Mix and Firing Rates

The fuel mix during testing consisted of wood, creosote treated railroad ties, and TDF. The firing rates for each of the fuels was within the range consistent for safe normal operations.

3.2 AIR POLLUTION CONTROL EQUIPMENT

Particulate emissions are controlled with a multi-cyclone followed by a single chamber, three-field electrostatic precipitator (ESP).

3.2.1 ESP Operating Parameters

The precipitator electrical controls and rapping sequence, intensity and frequency were set for optimum performance and were not modified after optimization unless emissions issues are observed.

3.3 REFERENCE METHOD TEST LOCATION

The HCl sampling and pitot traverse were conducted in the secondary set of sample ports (downstream sample ports) located on a section of rectangular ductwork that runs horizontally from the exit of the ESP prior to the exhaust stack. The pitot traverse was conducted at twelve traverse points in the downstream sample ports (three traverse points in four ports). The HCl sample train was located at a single point in the port that was located second from the top. The rectangular ductwork is six feet by six feet six inches (6' x 6 1/2') and has a straight run of fifty-seven feet (57'). All dimensions and port locations were verified prior to testing.

Figure 3-1 presents a diagram of the sample port and traverse point location.

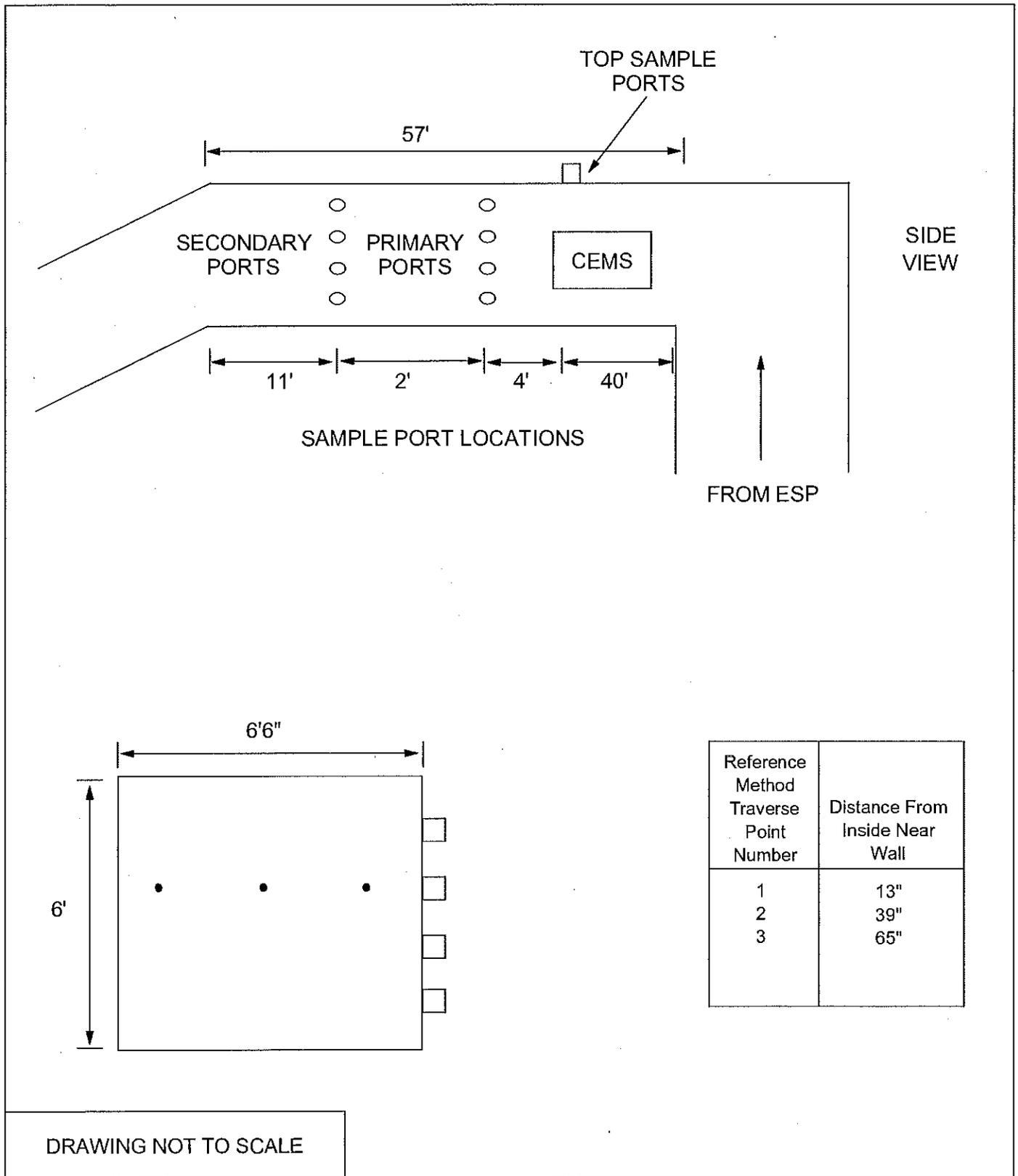
3.3.1 Flue Gas Parameters

The measured flue gas parameters at this location are as follows:

Temperature: approximately 400 - 450 °F, load dependent

Moisture: approximately 15% v/v, fuel moisture dependent

Volumetric Flow Rate: Up to about 150,000 ACFM, load dependent



**FIGURE 3-1
CEMS AND REFERENCE METHOD TEST LOCATION**

4. SAMPLING AND ANALYTICAL PROCEDURES

This section details the stack sampling and analytical procedures that were utilized during the test program. Table 4-1 summarizes the sampling and analytical methods.

4.1 PRE-TEST DETERMINATIONS

Preliminary test data was obtained at the sampling location. Geometry measurements were measured and recorded, and traverse point distances verified. A preliminary velocity traverse was performed utilizing a calibrated "S" type pitot tube and a Dwyer inclined manometer to determine velocity profiles. Flue gas temperatures were observed with a calibrated direct readout pyrometer equipped with a chromel-alumel thermocouple. Water vapor content was measured by performing an EPA Method 4 moisture test, or was based on previous test data (preliminary only).

A check for the presence or absence of cyclonic flow was conducted at the test location. The average cyclonic flow check angle was $< 20^\circ$, thus verifying the suitability of the test site for obtaining representative samples.

Pre-test calibration of probe nozzles, pitot tubes, metering systems, and temperature measurement devices were performed as specified in Section 5 of EPA Method 5 test procedures.

4.2 FORMAL TESTING

4.2.1 Gas Volumetric Flow Rate

A series of three test runs were performed. The gas velocity was measured using EPA Methods 1 and 2. Velocity measurements were performed using an "S-type" pitot tube. The stack gas pressure differential was measured with inclined manometers. Flue gas temperatures were measured with calibrated digital temperature readouts equipped with chromel-alumel (type-K) thermocouples. Velocity measurements and stack gas temperatures were performed in conjunction with the HCl sampling train and traversed across the duct diameter. The velocity and volumetric flow rate were used for determining the HCl mass rate calculations. Likewise

**Table 4-1
Summary of Sampling and Analytical Methods**

Sample	No. of Test Runs	Sampling Duration	Sampling Method	Sample Size	Analytical Parameters	Analytical Method
Stack Gas	3	1-hr composite sample per run	Modified M26A	40-45 ft ³	HCl	Ion Chromatography (SW846-9057)
		Concurrent	M1-2	NA	Temperature	Temperature
		Integrated with M26A	M4	40-45 ft ³	Velocity	Pitot Tube
		Concurrent	M3A	30 Liter Bag	Moisture	Volumetric
					O ₂ /CO ₂	Continuous Emission Monitor

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moisture content was determined concurrently with each test. The moisture content of the gas stream was determined by the volume increase of the impinger water and weight increase of the silica gel in comparison to the volume of gas sampled.

The gas stream composition [oxygen (O₂) and carbon dioxide content (CO₂)] of the flue gas was measured according to EPA Method 3/3A procedures using a Reference Method Continuous Emission Monitoring (CEM) system. EPA protocol gas standards were used to calibrate the O₂/CO₂ analyzer.

A Tedlar bag sample technique was used to determine the gas stream composition. The Tedlar bag samples of O₂ and CO₂ were collected from the exhaust of the control console calibrated orifice at a constant rate of ~0.5 liters per minute. This provides an integrated, conditioned (dry) sample. The gas passing through the control console orifice is conditioned by the impinger train. The sample is also integrated with respect to time and location in the stack.

Analysis of the Tedlar bag samples were performed using EPA Reference Method 3A analytical procedures. The conditioned Tedlar bag samples was analyzed directly by calibrated analyzers such as a paramagnetic O₂ analyzer and a non-dispersive Infrared (NDIR) CO₂ analyzer. The O₂ and CO₂ analyzers were configured and calibrated in accordance with the gas analyzer requirements outlined in EPA Reference Method 3A. The dry molecular weight of the gas stream was calculated using the measured oxygen and carbon dioxide concentrations. The balance of the gas stream was assumed to be nitrogen.

4.3 EPA METHOD 26A – HYDROGEN CHLORIDE SAMPLING TRAIN

The sampling train utilized to perform the hydrogen chloride sampling was configured as an EPA Reference Method 26A full-size sampling train with the exception of no borosilicate nozzle attached to the sample probe (see Figure 4-1). This modification was implemented to allow non-isokinetic sampling from a single traverse point similar to EPA Method 26. A heated ($\geq 248^{\circ}\text{F}$) borosilicate probe was attached to a heated ($\geq 248^{\circ}\text{F}$) borosilicate filter holder containing a 9-cm quartz filter. The filter folder was connected to the first of four impingers by means of rigid glass connectors. The first moisture knockout impinger contained 50 ml of 0.1 normal sulfuric acid. The second and third impingers each contained 100 ml of 0.1 N sulfuric acid. The fourth

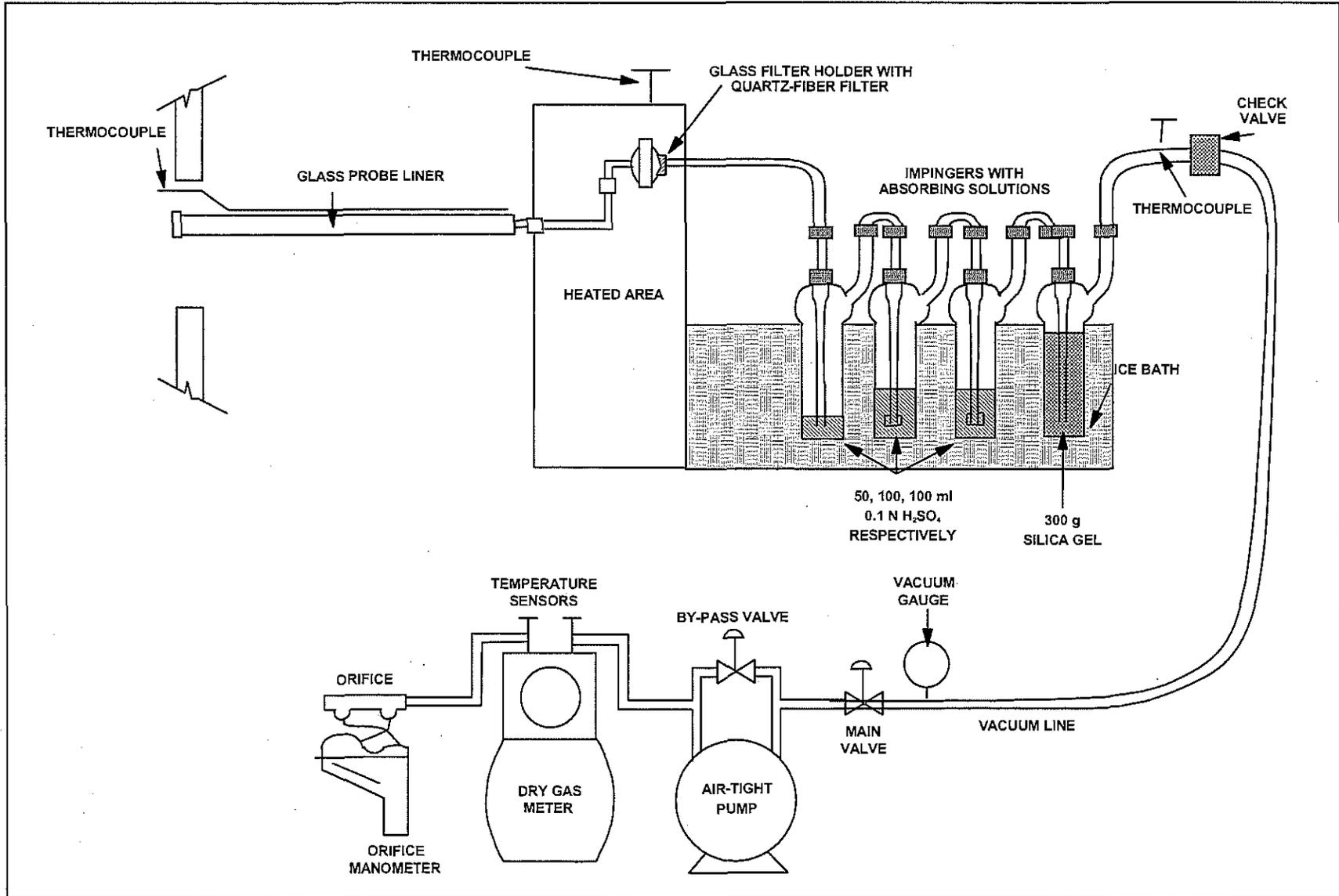


FIGURE 4-1
EPA METHOD 26A (MODIFIED)
HYDROGEN CHLORIDE SAMPLING TRAIN

impinger contained 300 grams of dry silica gel. The second and third impingers were a standard Greenburg-Smith type and all other impingers were of a modified design. All impingers were maintained in an ice bath. A control console with a leakless vacuum pump, a calibrated dry gas meter, a calibrated orifice, and inclined manometers were connected to the final impinger via an umbilical cord to complete the train. Probe, filter box, and impinger exit gas temperatures were monitored with a calibrated direct read-out pyrometer equipped with a chromel-alumel thermocouples.

The HCl sample was collected in conjunction with independent stack gas velocities and stack gas composition (O_2/CO_2 content) in order to calculate the stack gas volumetric flow rate and HCl mass rates.

4.3.1 Hydrogen Chloride Sample Recovery

At the conclusion of each test, the sampling train was dismantled, the openings sealed, and the components transported to the field laboratory.

A consistent procedure was employed for sample recovery as follows:

1. The quartz fiber filter or thimble was removed from its filter holder with tweezers and discarded.
2. The total liquid content of impingers one, two and three (0.1 N H_2SO_4) were measured and the sample placed in a polyethylene container fitted with a Teflon-lined closure (Sample type 1). Also included in this sample was a distilled water rinse of the impingers and connectors. The sample was labeled for chloride analysis.
3. The silica gel impinger was immediately weighed to the nearest 0.5 g.
4. Samples of sulfuric acid and distilled water used for this program were retained for blank analysis.

Each sample bottle was labeled to clearly identify its contents. The height of the fluid level was marked on each bottle. The samples were then transported to the subcontract laboratory. Sample integrity was assured by maintaining chain-of-custody records.

4.3.2 Hydrogen Chloride Analysis

The samples from the H₂SO₄ impingers were analyzed for chloride (Cl⁻) by the procedures outlined in EPA SW-846 Method 9057 (ion chromatography) and reported as HCl. Maxxam Analytics of Mississauga, Ontario, Canada conducted the analysis. A blind audit sample developed by Sigma-Aldrich RTC Inc. (RTC), as per EPA's Stationary Source Audit Sample Program, was submitted and analyzed with the stack samples.

5. FUEL SAMPLING AND ANALYSIS

LWEC fuel is supplied by M.A. Energy Resources LLC (MAER). MAER operates a fuel aggregation facility where raw materials are processed then conveyed to the facility.

Fuel samples were collected during the test program during each test run in accordance with 40 CFR 63 Subpart 7521(c and d) by LWEC designated personnel from a point where each fuel drops onto the conveyor belt feeding the boiler. Three samples of each fuel type were submitted for analysis as listed in Table 5-1.

**Table 5-1
Fuel Sample Analytical Methods**

Fuel Type	Required Analysis	Analytical Methods	Minimum Detection Level
TDF, Wood, & Creosote Ties	Moisture Content	<i>ASTM D3173, "Standard Test Method for Moisture in the Analysis Sample of Coal and Coke"</i>	Not Applicable
	Chlorine Concentration	<i>EPA 5050/9056, "Determination of Inorganic Anions by Ion Chromatography"</i>	~50 ppm

6. QUALITY ASSURANCE/QUALITY CONTROL

6.1 QUALITY CONTROL PROCEDURES

As part of the HCl quarterly program, WESTON implemented a QA/QC program. QA and QC are defined as follows:

- Quality Control: The overall system of activities whose purpose is to provide a quality product or service: for example, the routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process.
- Quality Assurance: A system of activities whose purpose is to provide assurance that the overall quality control is being done effectively. Further,

The field team manager for stack sampling was responsible for implementation of field QA/QC procedures. Individual laboratory managers were responsible for implementation of analytical QA/QC procedures. The overall project manager oversaw all QA/QC procedures to ensure that sampling and analyses met the QA/QC requirements and that accurate data resulted from the test program.

6.2 GAS STREAM SAMPLING QA PROCEDURES

General QA checks were conducted during testing and apply to all methods including the following:

- Performance of leak checks.
- Use of standardized forms, labels and checklists.
- Maintenance of sample traceability.
- Collection of appropriate blanks.
- Use of calibrated instrumentation.
- Review of data sheets in the field to verify completeness.
- Use of validated spreadsheets for calculation of results.

The following section details specific QA procedures applied to the test methods.

6.2.1 Stack Gas Velocity/Volumetric Flow Rate QA Procedures

The QA procedures followed for velocity/volumetric flow rate determinations followed guidelines set forth by EPA Method 2. Incorporated into this method, were sample point determinations by EPA Method 1, and gas moisture content determination by EPA Method 4. QA procedures for Methods 1 and 2 are discussed below.

Volumetric flow rates were determined during the isokinetic flue gas tests. The following QC steps were followed during these tests:

- The S-type pitot tube was visually inspected before sampling.
- Both legs of the pitot tube were leak checked before sampling.
- Proper orientation of the S-type tube was maintained while making measurements. The yaw and pitch axes of the S-type pitot tube were maintained at 90° to the flow.
- The manometer oil was leveled and zeroed before each run.
- Pitot tube coefficients were determined based on physical measurement techniques as delineated in Method 2.

6.2.2 Moisture and Sample Gas Volume QA Procedures

Gas stream moisture was determined as part of the HCl test trains. The following QA procedures were followed in determining the volume of moisture collected:

- Preliminary impinger train tare weights were weighed or measured volumetrically to the nearest 0.1 g or 1.0 ml.
- The balance was leveled and placed in a clean, motionless, environment for weighing.
- The indicating silica gel was fresh for each run and periodically inspected and replaced during runs if needed.
- The silica gel impinger gas temperature was maintained below 68°F.

The QA procedures that were followed in regards to accurate sample gas volume determination were:

- The dry gas meter was fully calibrated annually using an EPA approved intermediate standard device.

- Pre-test, port-change, and post-test leak-checks were completed (must be less than 0.02 cfm or 4 percent of the average sample rate).
- The gas meter was read to the thousandth of a cubic foot for all initial and final readings.
- Readings of the dry gas meter, meter orifice pressure (Delta H) and meter temperatures were taken at every sampling point.
- Accurate barometric pressures were recorded at least once per day.
- Pre- and Post-test dry gas meter checks were completed to verify the accuracy of the meter calibration constant (Y).

6.2.3 HCl Sampling Train QA Procedures

The Quality Assurance procedures outlined in this section were designed to ensure collection of representative, high quality test parameter (HCl) concentrations and mass emissions data. The sampling QA procedures followed to ensure representative measurements were:

- All glassware was prepared per reference method procedures.
- Recovery procedures were completed in a clean environment.
- Sample containers for liquids and filters were constructed of borosilicate or polyethylene with Teflon®-lined lids.
- At least one reagent blank of each type of solution or filter was retained and analyzed.
- All test train components from the probe tip through the last impinger were constructed of glass (with the exception of the filter support pad which is Teflon®).
- All recovery equipment (i.e., brushes, graduated cylinders, etc.) were non-metallic.

6.2.4 Sample Identification and Custody

Sample custody procedures for this program were based on EPA recommended procedures. Since samples were analyzed at remote laboratories, the custody procedures emphasized careful documentation of sample collection and field analytical data and the use of chain-of-custody records for samples being transferred. These procedures are discussed below.

The Field Team Manager was responsible for ensuring that all stack samples taken were accounted for and that all proper custody and documentation procedures were followed for the

field sampling and field analytical efforts. The Field Team Manager was assisted in this effort by key sampling personnel involved in sample recovery.

Following sample collection, all stack samples were given a unique sample identification code. Stack sample labels were completed and affixed to the sample container. The sample volumes were determined and recorded and the liquid levels on each bottle were marked. Sample bottle lids were sealed on the outside with Teflon® tape to prevent leakage. Additionally, the samples were stored in a secure area until they are shipped.

As the samples were packed for travel, chain-of-custody forms were completed for each shipment. The chain-of-custody forms specifying the treatment of each sample were also enclosed in the sample shipment container.

6.2.5 Data Reduction and Validation QC Checks

All data and/or calculations for flow rates, moisture contents, and isokinetic rates, were made using a computer software program validated by an independent check. In addition, all calculations were spot checked for accuracy and completeness by the Field Team Leader.

In general, all measurement data was validated based on the following criteria:

- Process conditions during sampling or testing.
- Acceptable sample collection procedures.
- Consistency with expected or other results.
- Adherence to prescribed QC procedures.

Any suspect data was flagged and identified with respect to the nature of the problem and potential effect on the data quality.

A pre and post-test bias calibration check was performed on the O₂/CO₂ analyzer using a zero gas and mid gas as required by the reference methods.

All calibration gases used met EPA Protocol standards.

6.3 LABORATORY AUDIT SAMPLES

A laboratory audit sample for HCl was obtained from Sigma-Aldrich RTC Inc. (RTC) which is an accredited Stationary Source Audit Sample (SSAS) provider. The audit sample was analyzed in conjunction with the stack samples. The audit result is reported in the Maxxam analytical report along with the source emission results. Additionally, the reported audit result is compared to the assigned value in the RTC submittal included in Appendix D. The RTC laboratory report indicates passing results for the audit sample.