BOILER NUMBER ONE RENEWABLE OPERATING PERMIT COMPLIANCE TEST PROGRAM EMISSIONS TEST REPORT

TEST DATE: 21 June 2023

L.W.E.C.

BRINGING GREEN TO MICHIGAN

L'ANSE WARDEN ELECTRIC COMPANY, LLC.
ROP No. MI-ROP-B4260-2021
SRN No. B2460
EUBOILER No.1
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L'Anse, Michigan 49946

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August 2023

W.O. No. 14464.008.006

TABLE OF CONTENTS

Section **Page**

1. INTRODUCTION AND TEST RESULTS SUMMARY 1

1.1 PLANT INFORMATION 2

1.2 TESTING FIRM INFORMATION 2

1.3 ANALYTICAL LABORATORIES 2

1.4 SUMMARY OF TEST PARAMETERS 2

2. TEST RESULTS DISCUSSION 4

3. DESCRIPTION OF PROCESS AND SAMPLING LOCATIONS 6

3.1 PROCESS OVERVIEW 6

3.1.1 Basic Operating Parameters 6
3.1.2 Test Program Boiler Load 6
3.1.3 Test Program Fuel Mix and Firing Rates 6

3.2 AIR POLLUTION CONTROL EQUIPMENT 6

3.2.1 ESP Operating Parameters 7
3.2.2 Dry Sorbent Injection System 7

3.3 REFERENCE METHOD TEST LOCATION 7

3.4 FLUE GAS PARAMETERS 9

4. SAMPLING AND ANALYTICAL PROCEDURES 10

4.1 PRE-TEST DETERMINATIONS 10

4.2 FORMAL TESTING 10

4.2.1 Gas Volumetric Flow Rate 10

4.3 PARTICULATE MATTER SAMPLING TRAIN 12

4.3.1 Particulate Matter Sample Recovery 14
4.3.2 Particulate Matter Sample Analysis 15

4.4 PARTICULATE MATTER $\leq$ 10 MICRON SAMPLING TRAIN 15

4.4.1 PM_{10} Sample Recovery 17
4.4.2 PM_{10} Sample Analysis 18

4.5 REFERENCE METHOD CONTINUOUS EMISSION MONITORING SYSTEM 20

4.5.1 NOx, SO_2 and O_2/CO_2 Monitoring Procedures 20
4.5.2 Reference Method CEMS Sampling Procedures 22
4.5.3 Gas Composition 22

TABLE OF CONTENTS (CONTINUED)

Section **Page**

5. QUALITY ASSURANCE/QUALITY CONTROL 23

5.1 QUALITY CONTROL PROCEDURES 23

5.2 GAS STREAM SAMPLING QA PROCEDURES 23

5.2.1 Stack Gas Velocity/Volumetric Flow Rate QA Procedures 23

5.2.2 Moisture and Sample Gas Volume QA Procedures...............................24

5.2.3 Isokinetic Sampling Train QA Procedures 25

5.2.4 Sample Identification and Custody...26

5.2.5 Data Reduction and Validation QC Checks..26

5.3 REFERENCE METHOD CEMS QA/QC CHECKS 27

APPENDIX A DETAILED TEST RESULTS

APPENDIX B RAW TEST DATA

APPENDIX C BOILER OPERATING DATA

APPENDIX D LABORATORY REPORTS

APPENDIX E QUALITY CONTROL RECORDS

APPENDIX F EXAMPLE CALCULATIONS

APPENDIX G PROJECT PARTICIPANTS

APPENDIX H PROJECT CORRESPONDENCE

LIST OF FIGURES

Title **Page**

Figure 3-1 Sample Port and Traverse Point Locations 8

Figure 4-1 EPA 5 – PM Sampling Train 13

Figure 4-2 EPA 201A/202 – PM_{10} Sampling Train 16

Figure 4-3 Reference Method Continuous Emission Monitoring System 21

LIST OF TABLES

Table 1-1 Summary of Compliance Test Results 1

Table 1-2 Summary of Test Parameters 2

Table 2-1 Boiler No.1 Test Run Summary of Compliance Results..5

Table 4-1 Detailed Summary of Sampling and Analytical Methods.....................................11

1. INTRODUCTION AND TEST RESULTS SUMMARY

Weston Solutions, Inc. (WESTON®) was retained by L'Anse Warden Electric Company, LLC (LWEC) to perform a emissions compliance 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 facility currently operates under the State of Michigan Renewable Operating Permit (ROP) MI-ROP-B4260-2021 and the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Air Quality Division (AQD) Permit to Install (PTI) MI-PTI-B4260-2021. Boiler No. 1 is identified as EUBOILER#1 in the ROP.

The objective of the test program was to determine concentrations and emission rates of particulate matter (PM), particulate matter ≤ 10 microns (PM_{10}), nitrogen oxides (NOx), and sulfur dioxide (SO_2) during a single fuel firing condition. Table 1-1 provides a summary of the compliance test results.

Table 1-1
Summary of Compliance Test Results
21 June 2023

Source(1) (Emissions Unit)	Parameter	Reporting Units	Emissions Results	Compliance Status(2)	PTI/ROP Emission Limits
Boiler No. 1 (EUBOILER#1)	PM	lb/hr lb/MMBtu	0.64 0.002	Pass Pass	19.2 lb/hr 0.06 lb/MMBtu
	PM_{10}	lb/hr	3.2	Pass	15.4 lb/hr
	NOx	lb/hr	60.4	Pass	145 lb/hr
	SO_2	lb/hr	69.5	Pass	290 lb/hr

(1) During the June 2023 test program, LWEC was unable to obtain sufficient inventory of engineered fuel pellets and all testing was conducted while firing a typical fuel mix of wood, CDF, and TDF.
(2) Compliance status contingent upon EGLE review and approval.

WESTON's Integrated Air Services (IAS) group completed all required testing on 21 June 2023. A representative of EGLE-AQD (Ms. Lindsey Wells) was present during a portion of the testing.

Contact information for LWEC and WESTON is presented in Sections 1.1 through 1.3.

1.1 PLANT INFORMATION

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157 South Main Street
L'Anse, Michigan 49946
Mr. Chad Cichosz, Plant Manager
Phone: 906-885-7187

1.2 TESTING FIRM INFORMATION

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Phone: 610-701-3043

1.3 ANALYTICAL LABORATORIES

Weston Solutions, Inc. Auburn Analytical Laboratory
1625 Pumphrey Avenue
Auburn, AL 36832
Ms. Staci Hickman, Laboratory Manager
Phone: 334-466-5683

1.4 SUMMARY OF TEST PARAMETERS

All testing was performed pursuant to WESTON's Emissions Test Protocol submitted in April 2023. Table 1-2 provides the test parameters, associated test methods, and reporting units for the compliance test program.

Table 1-2
Summary of Test Parameters

Analytical Parameters and EPA Reference Method	Reporting Units
Particulate Matter (PM)/EPA 5	gr/dscf, lb/MMBtu, lb/hr
Particulate Matter ≤ 10 microns (PM_{10})/EPA 201A-202	gr/dscf, lb/hr
Nitrogen Oxides (NO_x)/ EPA 7E	ppmvd, lb/hr
Sulfur Dioxide (SO_2)/EPA 6C	ppmvd, lb/hr

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 provides quality assurance and quality control procedures (QA/QC). Appendix A provides detailed test results. Raw test data, boiler operating data, laboratory reports, quality control records, example calculations, listing of project participants, and related project correspondence are provided in Appendices B through H, respectively.

2. TEST RESULTS DISCUSSION

Table 2-1 of this section provides a three-run summary of the compliance test results for each pollutant parameter. Any differences in the summary table and detailed test results shown in the appendices are due to rounding the results for presentation purposes.

All testing was performed while the boiler was fired with a typical fuel mix. Firing rates for each of the fuels were within the range consistent for safe normal operations.

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
Boiler No.1
Test Run Summary of Compliance Results

Pollutant	Test Run Number				PTI/ROP Emission Limits
	1	2	3	Average	
Particulate Matter (PM) (lb/hr)	0.65	0.42	0.85	0.64	19.2 lb/hr
Particulate Matter (PM) (lb/MMBtu)	0.002	0.001	0.003	0.002	0.06 lb/MMBtu
Particulate Matter $\leq$ 10 microns (PM_{10}) (lb/hr)	3.3	3.4	2.8	3.2	15.4 lb/hr
Nitrogen Oxides (NOx) (lb/hr)	61.7	59.9	59.5	60.4	145 lb/hr
Sulfur Dioxide (SO_2) (lb/hr)	76.9	62.7	68.8	69.5	290 lb/hr

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 lb/hr and maximum gross power generation from 14 to 17.7 megawatts per hour (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 may be modified to improve combustion characteristics. Adjustments to the air, fuel blend or load will be made as necessary to conform to emissions monitoring limits.

3.1.2 Test Program Boiler Load

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 maintained at ≥ 90% of capacity during the test program.

3.1.3 Test Program Fuel Mix and Firing Rates

The fuel mix during the testing consisted of wood, creosote treated wood derived fuel (CDF), and tire derived fuel (TDF). LWEC notes sufficient inventory of engineered fuel pellets was unavailable to include in the fuel mix during the test program. The firing rates for each of the fuels were within the range consistent for safe normal operations.

3.2 AIR POLLUTION CONTROL EQUIPMENT

Particulate bound pollutants are controlled by 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 are set for optimum performance and are not modified after this optimization exercise unless emissions issues are observed.

3.2.2 Dry Sorbent Injection System

To comply with the HCl emission limits set forth in the PTI/ROP while burning pellets, a dry sorbent injection system (DSI), provided by Nol-Tec Systems, was installed at the plant. This system is designed to inject reagent into the flue gas exhaust duct. The DSI system includes a super sack test system (bulk bag unloader and injection system) and control skid connected into LWEC's control room. The DSI system delivers reagent into the flue gas exhaust duct prior to the ESP and can deliver up to 1000 lb/hr of reagent to the duct.

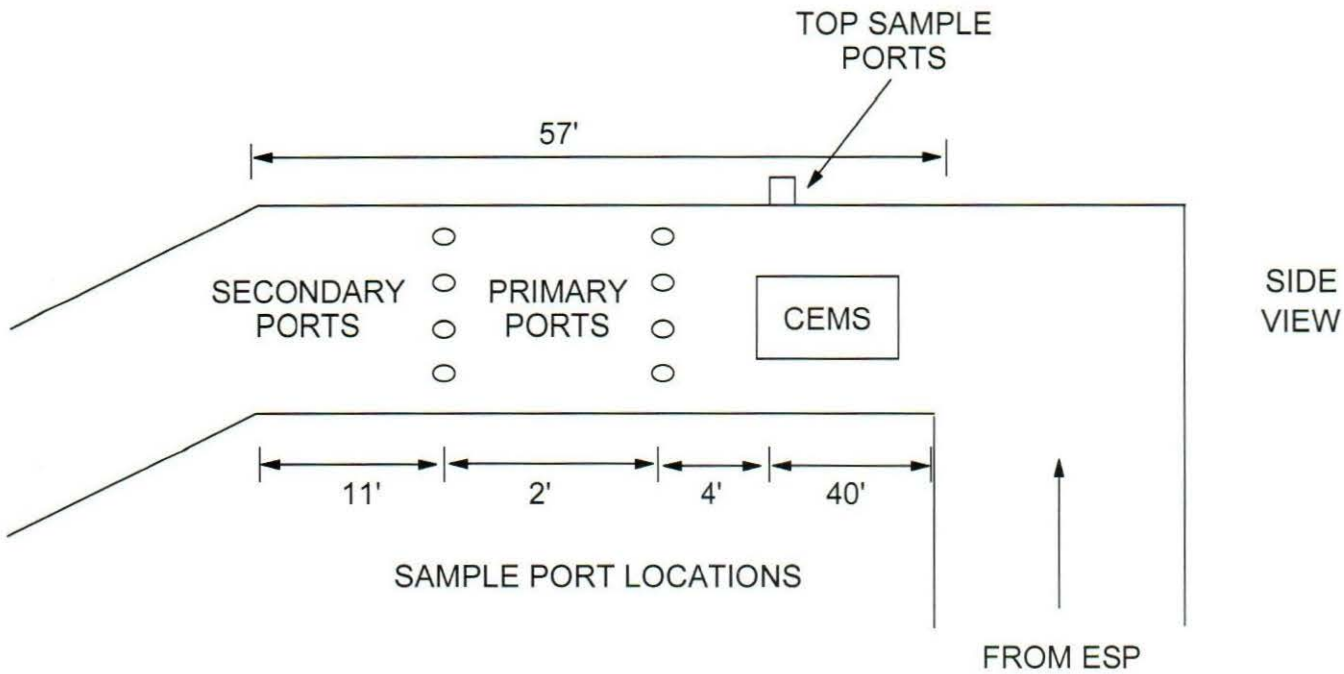
As per the PTI, the DSI system must always be running while burning any engineered fuel pellets and operating in a satisfactory manner.

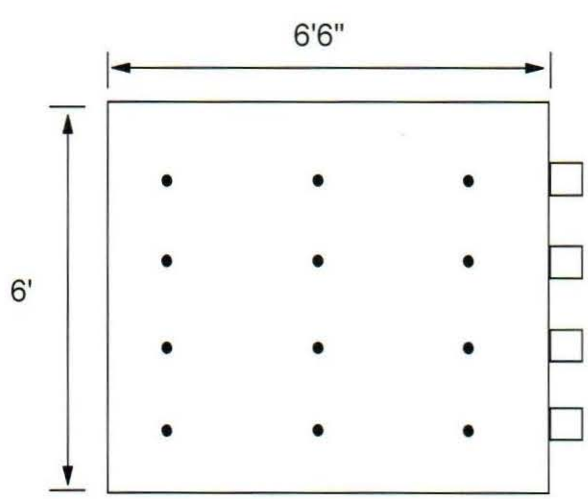
3.3 REFERENCE METHOD TEST LOCATION

The reference method sample ports (two sets) are located on a section of rectangular ductwork that runs horizontally from the exit of the ESP prior to the exhaust stack. The rectangular ductwork is 6 feet by 6.5 feet and has a straight run of 57 feet. All dimensions and port locations were verified prior to testing.

A second set of four sample ports are installed approximately 2 feet downstream from the primary sample ports and allows for additional sample trains to be operated simultaneously. Air flow disturbances in the secondary sample ports were minimized by port selection and placement of the upstream sampling equipment. Additionally, a third set of sample ports located on top of the ESP outlet ductwork was used for single point sampling (continuous emissions monitoring). All dimensions and port locations were verified prior to testing.

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





Reference Method Traverse Point Number	Distance From Inside Near Wall
1	13"
2	39"
3	65"

DRAWING NOT TO SCALE

FIGURE 3-1
SAMPLE PORT AND TRAVERSE POINT LOCATIONS

3.4 FLUE GAS PARAMETERS

The flue gas parameters observed at this location during the test program are as follows:

Temperature: approximately 370-450 °F, load dependent

Moisture: approximately 10%-15% v/v, fuel moisture dependent

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

4. SAMPLING AND ANALYTICAL PROCEDURES

The purpose of this section is to detail the stack sampling and analytical procedures utilized during the test program. Table 4-1 provides a detailed summary of 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. The water vapor content 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 results demonstrated the location was suitable for testing with no significant turbulent flow (<20° average flow angle) noted. Preliminary test data was used for nozzle sizing and sampling rate determinations for isokinetic sampling procedures.

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 was performed for each parameter at each test condition. The gas velocity was measured using EPA Methods 1 and 2. Velocity measurements were performed using an S-type pitot tube fastened alongside sample probes. 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.

Table 4-1
Detailed Summary of Sampling and Analytical Methods

Sample	No. of Test Runs	Sampling Duration	EPA Reference Method	Sample Size	Analytical Parameters	Preparation Method	Analytical Method
Stack Gas	3	60-minute composite sample per test run	5	39-40 ft^3	Particulate	Desiccation	Gravimetric (EPA Method 5)
		87 to 92-minute composite sample per test run	201A/202	28-31 ft^3	PM_{10}	Desiccation	Gravimetric (EPA Method 5)
		Continuous/Concurrent	3A	NA	CO_2/O_2	NA	CEMS
		Continuous/Concurrent	7E	NA	NOx	NA	CEMS
		Continuous/Concurrent	6C	NA	SO_2	NA	CEMS
		Concurrent	1-4	NA	Moisture	NA	Gravimetric
					Temperature	NA	Temperature
					Velocity	NA	Pitot Tube

Velocity measurements and stack gas temperatures were incorporated in the isokinetic sampling trains which traverse across the stack diameter. Likewise, moisture content was determined concurrently with each test. The moisture content of the gas stream was determined by the weight increase of the impinger water and weight increase of the silica gel in comparison to the volume of gas sampled. Velocity and volumetric flow rate were used for calculating the parameter mass emission rates. For the HCl test runs, an independent velocity and volumetric flow rate was conducted by EPA Method 2 procedures to calculate mass rates.

The gas stream composition [oxygen (O_2) and carbon dioxide content (CO_2)] of the flue gas was measured according to EPA Method 3A procedures using a Reference Method Continuous Emission Monitoring System (CEMS) during all the test runs.

4.3 PARTICULATE MATTER SAMPLING TRAIN

The sampling train utilized to perform the particulate and metals sampling was an EPA Reference Method 5 (see Figure 4-1).

A calibrated glass nozzle was attached to a heated (248 ± 25 °F) borosilicate probe. The probe was connected to a heated (248 ± 25 °F) borosilicate filter holder containing a 9-centimeter (cm) glass fiber filter (preweighed to a constant 0.1 milligram (mg) weight). The filter holder was connected to the first of four impingers by means of rigid glass connectors. The first and second impingers each contained 100 mL deionized water, the third impinger was empty, and the fourth impinger contained 300 grams (g) of dry silica gel. The second impinger was a standard Greensburg-Smith type, while 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 was connected to the final impinger via an umbilical cord to complete the train.

During sampling, gas stream velocities were measured by inserting a calibrated S-type pitot tube into the gas stream adjacent to the sampling nozzle. The velocity pressure differential was observed immediately after positioning the nozzle at each traverse point, and the sampling rate was adjusted to maintain isokineticity ± 10%. Flue gas temperature was monitored at each point with a calibrated pyrometer and thermocouple.

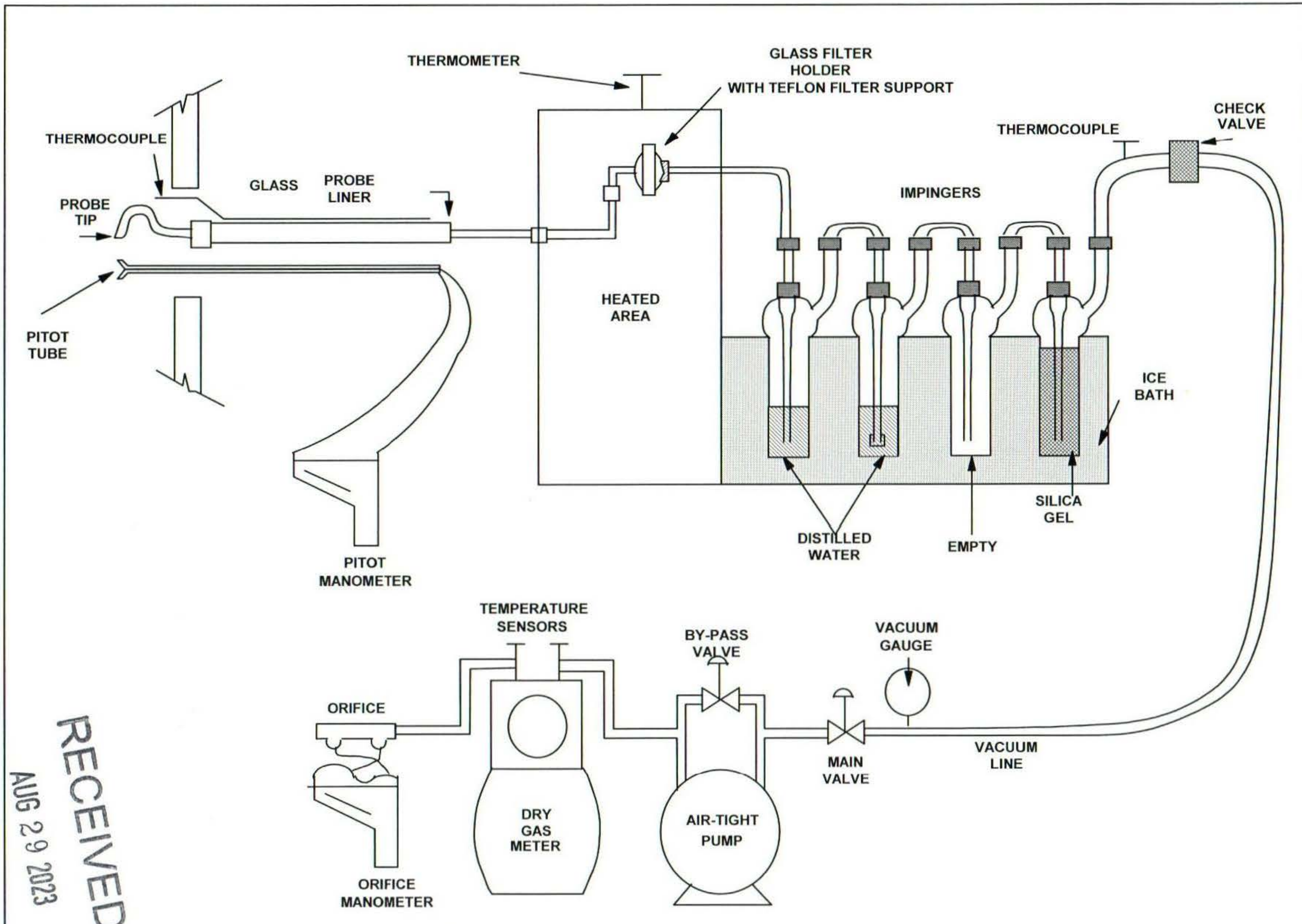


FIGURE 4-1
EPA METHOD 5
PARTICULATE SAMPLING TRAIN

Probe, filter box, and impinger exit gas temperatures were monitored with a calibrated direct readout pyrometer equipped with chromel-alumel thermocouples positioned in the heated filter chamber and in the sample gas stream after the last impinger.

Isokinetic test data was recorded at each traverse point during all test periods. Leak checks were performed on the sampling apparatus according to reference method instructions, prior to and following each run, and/or component change.

4.3.1 Particulate Matter 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 glass fiber filter(s) was removed from its holder with tweezers and placed in its original container (petri dish), along with any loose particulate and filter fragments (Sample type 1).
2. The probe and nozzle were separated, and the particulate rinsed with acetone into a borosilicate container with a Teflon®-lined closure while brushing with a minimum of three times. Particulate adhering to the brush was rinsed with acetone into the same container. The front-half of the filter holder and connecting glassware was rinsed with acetone while brushing a minimum of three times. The acetone rinses were combined in a borosilicate container and sealed with a Teflon®-lined closure (Sample type 2).
3. The total weight of condensate collected in impingers 1, 2 and 3 was weighed to the nearest 0.1 mg and the value recorded. The liquid was discarded.
4. The silica gel was removed from the last impinger and immediately weighed to the nearest 0.1 g.
5. Blank samples of acetone and a glass fiber filter were retained for analysis.

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

4.3.2 Particulate Matter Sample Analysis

The particulate analysis proceeds as follows:

1. The filters (Sample type 1) and any loose fragments were desiccated for 24-hours and weighed to the nearest 0.1 mg to a constant (± 0.5 mg) weight.

2. The front-half acetone wash samples (Sample type 2), and an acetone blank were evaporated at ambient temperature and pressure in tared beakers, then desiccated and weighed to constant 0.5-mg weight.

The total weight of material measured in the acetone-rinse fraction plus the weight of material collected on the quartz filter represents the total particulate catch. Blank corrections were made where appropriate for all sample weights.

4.4 PARTICULATE MATTER ≤ 10 MICRON SAMPLING TRAIN

The PM_{10} sampling was performed using EPA Method 201A combined with EPA Method 202 (see Figure 4-2).

The sampling train consisted of the following components:

- A stainless-steel nozzle with an inside diameter sized to sample isokinetically connected to a PM_{10} cyclone separator.

- A heated borosilicate probe equipped with a calibrated thermocouple to measure flue gas temperature and a calibrated S-type pitot tube to measure flue gas velocity pressure.

- A heated (at stack temperature) borosilicate filter holder containing a tared quartz fiber filter followed by a water-cooled coil condenser.

- An impinger train consisting of four impingers. The first and second impingers were empty and the third impinger contained 100 mL of distilled water. The fourth impinger contained 300 grams of 6-16 mesh dry silica gel. The first impinger was a shortened stem and served as a moisture drop out. The second, third, and fourth impingers were a modified design. A glass filter holder containing a Teflon® filter was placed between the second and third impingers. The filter exit temperature was monitored and maintained at 65 °F to 85 °F.

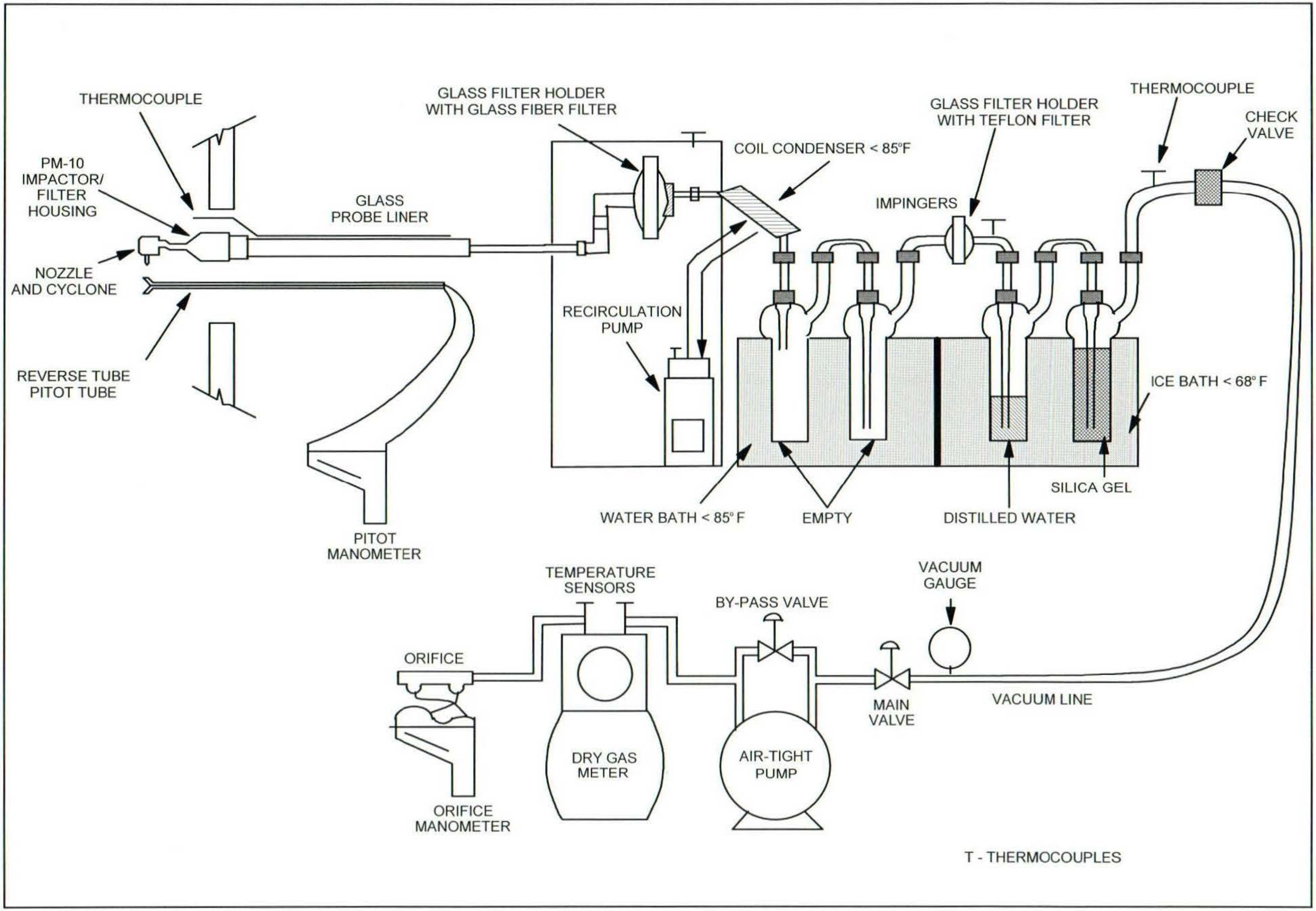


FIGURE 4-2
EPA METHOD 201A/202
PARTICULATE (PM10) / CONDENSABLES SAMPLING TRAIN

IASDATA\LWEC\14464.008.006\FIGURE 4-3 EPA 201A-202

- A vacuum hose with adapter to connect the outlet of the impinger train to a control module.
- A control module containing a 3-cfm carbon vane vacuum pump, a calibrated dry gas meter (sample gas volume measurement device), a calibrated orifice (sample gas flow rate monitor), and inclined manometers (orifice and gas stream pressure indicators).
- A switchable calibrated digital pyrometer to monitor flue and sample gas temperatures.

Leak checks of the entire sampling train were performed prior to sampling. At test completion, a final leak check was performed at the sample probe inlet. Per EPA 201A procedures, no leak check of the PM_{10} cyclone was performed at test completion. This will minimize particle bypass through the cyclone during the leak check.

4.4.1 PM_{10} Sample Recovery

At the conclusion of each PM_{10} test, the sampling train was dismantled. The openings were sealed, and the components transported to the field laboratory.

Following test completion and prior to the start of sample recovery, the condenser and impinger portion of the EPA 202 train was purged with ultra-high purity nitrogen for one hour at a rate of $\geq$ 14 liters per minute to expel dissolved sulfur dioxide. Prior to the purge, the short stem impinger in the moisture dropout was replaced with a long stem impinger and if necessary, a known volume of DI water was added so that the water level was at least 1 cm above the impinger tip.

A consistent procedure was employed for sample recovery:

1. The pre-weighed quartz fiber filter was removed from the borosilicate filter housing with tweezers and placed in original containers (petri dish) along with any loose particulate and filter fragments (sample type 1).
2. The particulate adhering to the internal surfaces of the nozzle and cyclone inlet was rinsed with acetone into a borosilicate container while brushing a minimum of three times with acetone until no visible particulate remains. Particulate adhering to the brush was rinsed with acetone into the same container. The container was sealed with a Teflon®-lined closure (sample type 2 – front half acetone No. 1).
3. The particulate adhering to the internal surfaces of the cyclone to filter holder connecting tube (cyclone exit) and filter holder was rinsed with acetone into a

borosilicate container while brushing a minimum of three times until no visible particulate remains. Particulate adhering to the brush was rinsed with acetone into the same container. The container was sealed with a Teflon®-lined closure (sample type 3 – front half acetone No. 2).

4. Following completion of the nitrogen purge, the total liquid content of impingers one, two and three were measured volumetrically and the sample placed in a borosilicate container (sample type 4).

5. The condenser, first and second impingers, front half of the Teflon® filter holder, and connectors were rinsed two times with degassed (with nitrogen) distilled water. The rinsate was added to sample type 4.

6. Following the water rinses, the condenser, first and second impingers, front half of the Teflon® filter holder, and connectors were rinsed once with acetone and then two times with hexane. The rinses were placed in a borosilicate container (sample type 5).

7. The silica gel was removed from the last impinger and immediately weighed to the nearest one-tenth g. Weight gain was recorded.

8. Acetone, PM_{10} filter, Teflon® filter, distilled water and hexane blank samples were placed into a borosilicate/Teflon® container or petri dish and sealed for gravimetric analysis.

In addition, and as required by EPA 202, a blank train was set up, recovered, and analyzed with the source samples.

Each container was labeled to clearly identify its contents. The height of the fluid level was marked on the container of each liquid sample to determine whether leakage occurred during transport.

4.4.2 PM_{10} Sample Analysis

1. The filters and any loose fragments were desiccated for 24 hours and weighed to the nearest 0.1 mg to a constant weight of no more than 0.5 mg between two consecutive weighings with no less than six hours of desiccation time between weighings. As an alternative, the filters were heated to 105 °C and desiccated prior to the first weighing. This option is an alternative procedure per EPA Method 5.

2. The front-half acetone wash samples (nozzle/cyclone rinse and cyclone exit/filter holder rinse) were evaporated at ambient temperature and pressure in tared beakers and then desiccated to constant weight to the nearest 0.1 mg. Since the acetone No. 1 sample collects particulate greater than PM_{10}, analysis of this sample is optional.

3. The contents of sample type 4 were mixed with approximately 30 mL of hexane in a separatory funnel. After mixing, the organic phase was removed and retained in a tared beaker. Two separate additions of 30 mL of hexane were added to the separatory funnel and removed (following mixing and separation) to the tared beaker. The organic extract from Sample Type 4 was combined with the organic train rinse in sample type 4. The organic fraction was evaporated at room temperature (not to exceed 85 °F) to approximately 10 mL. The resulting liquid was transferred to a preweighed tin, evaporated to dryness at room temperature (not to exceed 85 °F), desiccated for 24 hours and weighed to a constant ± 0.5 mg to the nearest 0.1 mg.

4. The resulting water (inorganic fraction) was placed in a tared beaker and taken to near dryness (~ 50 mL) on a hot plate and then evaporated to not less than 10 mL in an oven at 105 °C. The sample was then allowed to evaporate to dryness at room temperature. After obtaining dryness, the residue was redissolved in 100 mL distilled water. The sample was titrated to a pH of 7.0 using NH_4OH (of known normality). The volume of titrant was recorded. The solution evaporated to approximately 10 mL. The resulting liquid was transferred to a pre-weighed tin, evaporated to dryness at room temperature (not to exceed 85 °F), desiccated for 24 hours and weighed to a constant ± 0.5 mg to the nearest 0.1 mg.

5. The water soluble condensable particulate matter from the Teflon® filter was extracted from the filter using ultra-filtered water in an extraction tube and sonication bath. The aqueous extract was combined with the contents of Sample Type 4. The organic soluble condensable particulate matter from the Teflon® filter was extracted from the filter using methylene chloride in an extraction tube and sonication bath. The organic extract was combined with the contents of Sample Type 5.

6. The field blank train and blank samples of acetone, distilled water and hexane were analyzed as described above.

The total of the organic and inorganic fractions represents the condensable particulate catch. The PM_{10} includes the filterable PM_{10} particulate catch (front-half acetone sample No. 2 and filter) plus the organic and inorganic condensable.

4.5 REFERENCE METHOD CONTINUOUS EMISSION MONITORING SYSTEM

A continuous emission monitoring trailer equipped with instrumental analyzers was used to measure concentrations of oxygen O_2/CO_2, SO_2, and NOx (see Figure 4-4). A description of each instrumental analyzer is provided below:

Pollutant	EPA Reference Method	Operating Principle
O_2	3A	Paramagnetic
CO_2	3A	Single beam, single wavelength infrared
SO_2	6C	Ultraviolet
NOx	7E	Chemiluminescent

Stack gas was withdrawn from the stack through a heated stainless-steel probe and heated filter via a heated sample line maintaining a temperature > 250 °F. The probe was inserted into a dedicated sample port at a single point in the gas stream. The outlet of the heated sample line was connected to a sample conditioning system for moisture removal. The clean, dried sample was then transported to the analyzers via a Teflon® sample line. A separate Teflon® line was used for introduction of O_2/CO_2, SO_2, and NOx bias gases to the probe outlet.

4.5.1 NOx, SO_2 and O_2/CO_2 Monitoring Procedures

The analyzers were calibrated daily by direct introduction of EPA Protocol calibration gases to the analyzers. These gases are prepared with a balance of nitrogen and nitrogen is also used as the zero gas. After the analyzer calibration, a system bias check was conducted by introducing the zero gas and one selected O_2/CO_2, SO_2, and NOx calibration gas to the sample probe outlet.

The bias check was repeated at the end of each test run to determine sampling system bias and instrument drift for each analyzer.

The interference checks on WESTON's instrumental analyzers were previously performed (December 2014) in accordance with EPA Method 7E and were not repeated for this test program.

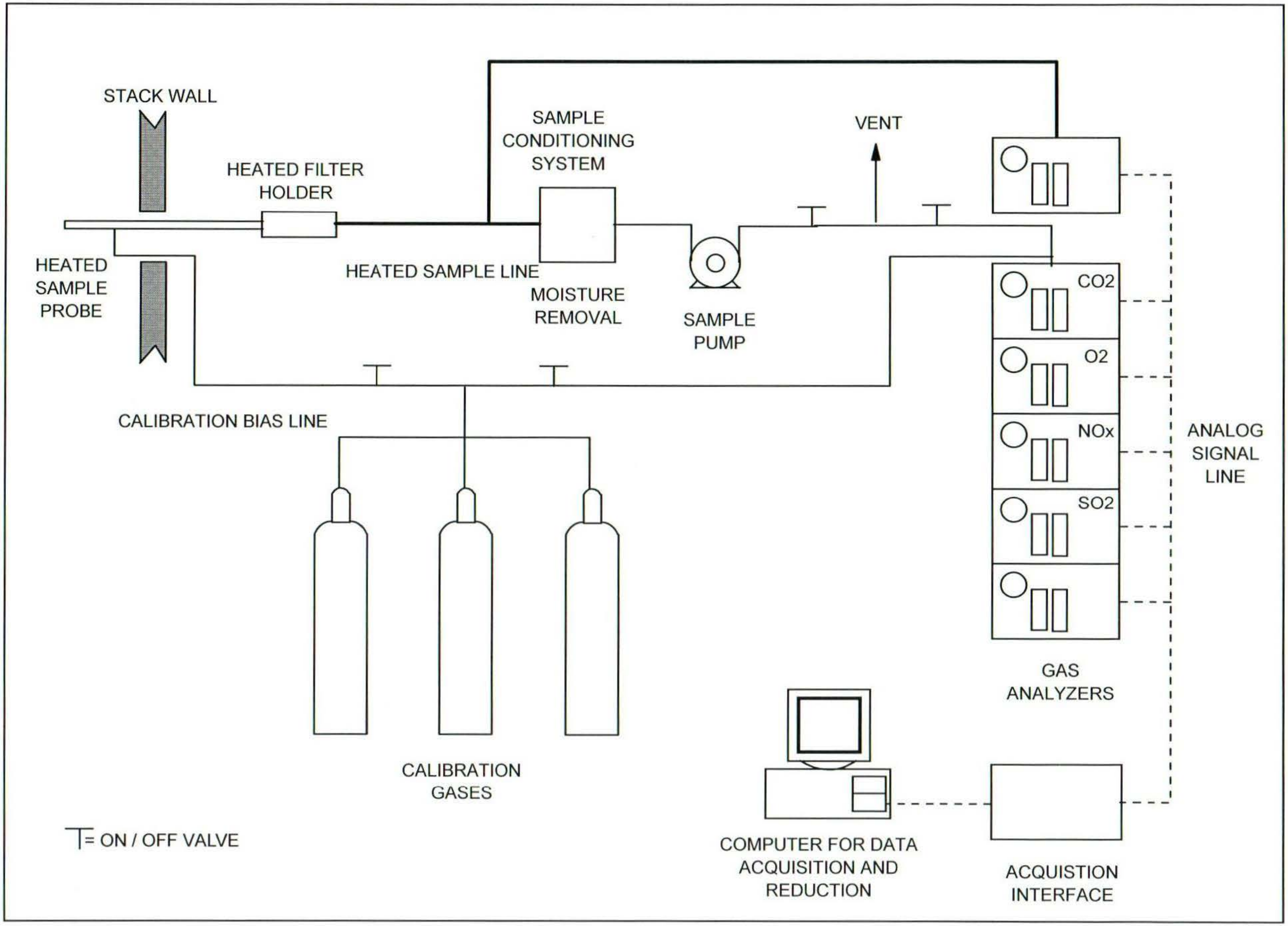


FIGURE 3-3
WESTON SAMPLING SYSTEM

IASDATA\LWEC\FIGURE 3-4 WESTON SAMPLING SYSTEM

Additionally, an O_2 stratification check was performed prior to the test effort in accordance with EPA Method 7E – Section 8.1.2. Based on the stratification test results, no more than ± 5.0% difference of the average for each traverse point, the WESTON system sampled from a single point during all formal test runs.

Gas stream moisture content and stack volumetric flow rate data from the corresponding isokinetic testing were used to calculate NOx and SO_2 mass emission rates.

The output from the analyzers was directed to a data acquisition system and recorded by a computer equipped with data reduction software designed by WESTON. The software calculated the average one-minute measured concentrations used to compute the average concentration for the test run.

4.5.2 Reference Method CEMS Sampling Procedures

The reference method analyzers are calibrated daily by direct introduction of EPA Protocol calibration gases to the analyzers. These gases are prepared with a balance of nitrogen. Nitrogen is also used as the zero gas for calibrations. After the analyzer was calibrated, a system bias check is conducted by introducing the zero gas and one selected VOC, and O_2/CO_2 calibration gas to the sample probe outlet. An initial vacuum (leak) test was conducted on the sample and conditioning system prior to testing.

4.5.3 Gas Composition

The composition of the exhaust gas (CO_2 and O_2) was measured by EPA Method 3A. A paramagnetic-type analyzer (Servomex Model 4900) was used to measure oxygen. A non-dispersive infrared analyzer (Servomex Model 4900) was used to measure carbon dioxide. Both analyzers were calibrated using EPA Protocol gas standards.

5. QUALITY ASSURANCE/QUALITY CONTROL

5.1 QUALITY CONTROL PROCEDURES

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

- Quality Control: The overall system of activities with the purpose of providing 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 with the purpose of providing assurance that overall quality control is being conducted effectively.

The field team manager was responsible for the implementation of all 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.

5.2 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 isokinetic methods.

5.2.1 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.

5.2.2 Moisture and Sample Gas Volume QA Procedures

Gas stream moisture was determined as part of the isokinetic 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 regarding 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% 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).

5.2.3 Isokinetic Sampling Train QA Procedures

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

- All glassware was prepared per reference method procedures.
- The sample rates were within ± 10% of the true isokinetic (100%) rate.
- All sampling nozzles were manufactured and calibrated according to EPA standards.
- 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 nozzle through the last impinger were constructed of glass (except for the filter support pad which is Teflon®).
- All recovery equipment (i.e., brushes, graduated cylinders, etc.) were non-metallic.

5.2.4 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.

5.2.5 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.

5.3 REFERENCE METHOD CEMS QA/QC CHECKS

- Continuous emissions monitoring system (probe to sample conditioner) were checked for leaks prior to the testing.
- Pre- and post-test calibration bias tests were performed as required by the reference methods.
- Prior to formal testing, a three-point O_2 stratification check was performed pursuant to Section 8.1.2 of EPA Method 7E. The three points (16.7, 50 and 83.3% of the stack diameter) were each sampled for a minimum of two times the system response. Based on the stratification test results (each point compared to the mean difference was no more than ± 5.0%), all sampling was performed at a single traverse point near the stack midpoint.
- A permanent data record of analyzer response was made using computer software designed by WESTON.
- All calibration gases used met EPA Protocol standards.