Particulate Matter Test For MATS Compliance

EUBOILER2

Consumers Energy Company
J.H. Campbell Plant
17000 Croswell Street
West Olive, Michigan 49460
SRN: B2835
FRS: 110000411108

Test Dates: August 23 and 24, 2016

October 11, 2016

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section – Air Emissions Testing Body
Laboratory Services Section
Work Order No. 27538841
Revision 0

DEQ

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
AIR QUALITY DIVISION

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RENEWABLE OPERATING PERMIT REPORT CERTIFICATION

Authorized by 1994 P.A. 451, as amended. Failure to provide this information may result in civil and/or criminal penalties.

Reports submitted pursuant to R 336.1213 (Rule 213), subrules (3)(c) and/or (4)(c), of Michigan's Renewable Operating Permit (ROP) program must be certified by a responsible official. Additional information regarding the reports and documentation listed below must be kept on file for at least 5 years, as specified in Rule 213(3)(b)(ii), and be made available to the Department of Environmental Quality, Air Quality Division upon request.

Source Name Consumers Energy, J.H. Campbell Plant County Ottawa

Source Address 17000 Croswell City West Olive

AQD Source ID (SRN) B2835 ROP No. MI-ROP-B2835-2013a ROP Section No. 1

Please check the appropriate box(es):

☐ **Annual Compliance Certification (Pursuant to Rule 213(4)(c))**

Reporting period (provide inclusive dates): From ______ To ______

☐ 1. During the entire reporting period, this source was in compliance with **ALL** terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference. The method(s) used to determine compliance is/are the method(s) specified in the ROP.

☐ 2. During the entire reporting period this source was in compliance with all terms and conditions contained in the ROP, each term and condition of which is identified and included by this reference, **EXCEPT** for the deviations identified on the enclosed deviation report(s). The method used to determine compliance for each term and condition is the method specified in the ROP, unless otherwise indicated and described on the enclosed deviation report(s).

☐ **Semi-Annual (or More Frequent) Report Certification (Pursuant to Rule 213(3)(c))**

Reporting period (provide inclusive dates): From ______ To ______

☐ 1. During the entire reporting period, **ALL** monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred.

☐ 2. During the entire reporting period, all monitoring and associated recordkeeping requirements in the ROP were met and no deviations from these requirements or any other terms or conditions occurred, **EXCEPT** for the deviations identified on the enclosed deviation report(s).

☒ **Other Report Certification**

Reporting period (provide inclusive dates): From 04/16/2016 To 10/21/2016

Additional monitoring reports or other applicable documents required by the ROP are attached as described:

Particulate Matter compliance stack test report for the MATS regulation for Unit 2, as required by 40 CFR Part 63.10031(f).

I certify that, based on information and belief formed after reasonable inquiry, the statements and information in this report and the supporting enclosures are true, accurate and complete

Norman J. Kapala	Executive Director of Coal Generation	616-738-3200
Name of Responsible Official (print or type)	Title	Phone Number
[signature]		10-21-2016
Signature of Responsible Official		Date

* Photocopy this form as needed.

EQP 5736 (Rev 11-04)

EXECUTIVE SUMMARY

Consumers Energy Company (Consumers Energy) Regulatory Compliance Testing Section (RCTS) completed particulate matter (PM) testing at the single dedicated exhaust duct of coal-fired boiler EUBOILER2 (Unit 2) in operation at the J.H. Campbell Generating Station located in West Olive, Michigan. The purpose of the test program was to demonstrate qualification as a Low Emitting Electric Generating Unit (LEE) for filterable particulate matter (FPM) per 40 CFR 63, Subpart UUUUU – National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-fired Electric Utility Steam Generating Units (aka Mercury Air Toxics Rule [MATS]). Secondarily, the test program provides a direct comparison between USEPA Method 5 PM results and MATS 5 PM results.

The FPM LEE demonstration requires quarterly sampling over a period of three calendar years. The results of each quarterly test must be less than or equal to 50 percent of the applicable FPM standard listed in Table 2 of the MATS Rule, equating to 0.015 lb/mmBtu. The test program was conducted on August 23 and 24, 2016 in accordance with applicable requirements and sampling, calibration, and quality assurance procedures specified in 40 CFR 60, Appendix A, reference methods (RM) 1, 2, 3A, 4, 5, 19 and MATS method 5. Three 125-minute RM5 tests were performed in sequence with three 125-minute MATS5 tests to measure filterable particulate matter while the boiler was operating under maximum normal operating load. The results are summarized in the following table.

Summary of Results

Run	PM Concentration (gr/dscf)		PM Emission Rate (lb/mmBtu)		
	Results		Results		MATS LEE FPM Limit
	RM5	MATS5	RM5	MATS5	
1	0.00207	0.00276	0.005	0.006	-
2	0.00149	0.00136	0.003	0.003	-
3	0.00167	0.00185	0.004	0.004	-
Average	**0.00174**	**0.00199**	**0.004**	**0.004**	**0.015**

Each individual run, as well as the average of the three runs, was below the MATS LEE emission rate limit of 0.015 pounds of particulate matter per million British thermal unit heat input. The results indicate no difference between the average lb/mmBtu particulate matter emissions measured by MATS 5 and Reference Method 5. Detailed results are presented in the Reference Method 5 PM Results Summary and MATS 5 PM Results Summary behind the tables tab of this report.

Example calculations and field data sheets are presented in Appendix A and B. Laboratory data is presented in Appendix C.

1.0 INTRODUCTION

Consumers Energy Company (Consumers Energy) Regulatory Compliance Testing Section (RCTS) completed particulate matter (PM) testing at the single dedicated exhaust duct of coal-fired boiler EUBOILER2 (Unit 2) in operation at the J.H. Campbell Generating Station located in West Olive, Michigan. The purpose of the test program was to demonstrate qualification as a Low Emitting Electric Generating Unit (LEE) for filterable particulate matter (FPM) per 40 CFR 63, Subpart UUUUU – National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-fired Electric Utility Steam Generating Units (aka Mercury Air Toxics Rule [MATS]). This test event also fulfills an EPA request to provide a direct comparison between USEPA Reference Method 5 (RM5) PM results and MATS 5 PM results at the source in order to utilize RM5 as the compliance test method for the MATS rule.

The FPM LEE demonstration requires quarterly sampling over a period of three calendar years. The results of each quarterly test must be less than or equal to 50 percent of the applicable FPM standard listed in Table 2 of the MATS Rule (see Table 1-1 below), equating to 0.015 lb/mmBtu. The particulate emission limitations from MATS are presented in Table 1-1 below.

Table 1-1
MATS Rule PM Emission Limit

EGU Subcategory	Pollutant Being Sampled	Emission Limit
Existing Unit, Coal-fired not low rank virgin coal	Filterable Particulate Matter	0.030 lb/mmBtu

The test program was conducted on August 23 and 24, 2016 in accordance with applicable requirements and sampling, calibration, and quality assurance procedures specified in 40 CFR 60, Appendix A, reference methods 1, 2, 3A, 4, 5, 19 and MATS Method 5. As requested by EPA in order to utilize RM5 (in lieu of MATS 5) for PM Compliance, three 125-minute RM5 tests were performed in sequence with three 125-minute MATS5 tests to measure filterable particulate matter while the boiler was operating under maximum normal operating load.

1.1 CONTACT INFORMATION

Figure 1-1 presents the test program organization, major lines of communication and names of responsible individuals. Table 1-2 presents contact information for these individuals.

Figure 1-1. Test Program Organization

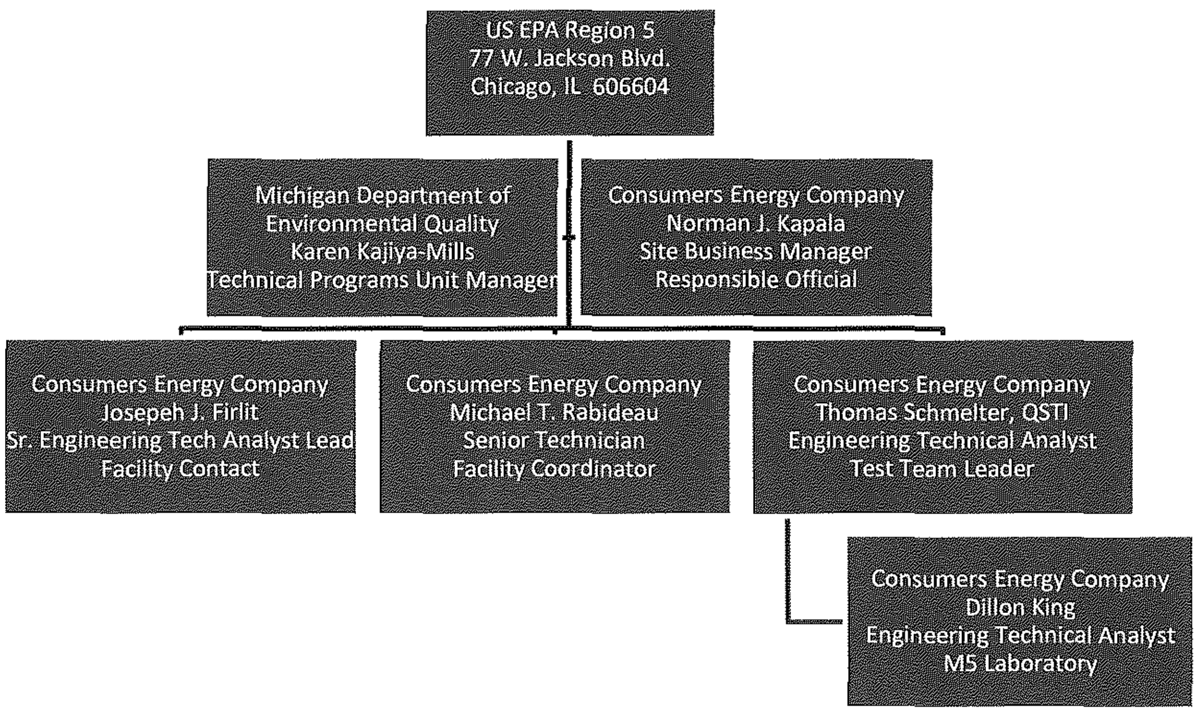


Table 1-2
Contact Information

Program Role	Contact	Address
EPA Consent Decree Contact	Director, Air Division	U.S. EPA Region 5 77 W. Jackson Blvd. (AE-17J) Chicago, IL 60604
Regulatory Agency Representative	Ms. Karen Kajiya-Mills Technical Programs Unit Manager 517-335-4874 kajiya-millsk@michigan.gov	Michigan Department of Environmental Quality Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
Responsible Official	Mr. Norman J. Kapala 616-738-3200 Executive Director of Coal Generation Norman.Kapala@cmsenergy.com	Consumers Energy Company J. H. Campbell Power Plant 17000 Croswell Street West Olive, Michigan 49460
Test Facility	Mr. Joseph J. Firlit 616-738-3260 Sr. Engineering Tech Analyst Lead Joseph.Firlit@cmsenergy.com	Consumers Energy Company J. H. Campbell Power Plant 17000 Croswell Street West Olive, Michigan 49460
Test Facility	Mr. Michael T. Rabideau 616-738-3273 Senior Technician Michael.Rabideau@cmsenergy.com	Consumers Energy Company J. H. Campbell Power Plant 17000 Croswell Street West Olive, Michigan 49460
Test Team Representative	Mr. Thomas Schmelter, QSTI 616-738-3234 Engineering Technical Analyst Thomas.Schmelter@cmsenergy.com	Consumers Energy Company L&D Training Center 17010 Croswell Street West Olive, Michigan 49460
Laboratory	Mr. Dillon King, QSTI 989-891-5585 Engineering Technical Analyst Dillon.King@cmsenergy.com	Consumers Energy Company Karn-Weadock ESD Trailer #4 2742 N. Weadock Highway Essexville, MI 48732

2.0 SUMMARY OF RESULTS

2.1 OPERATING DATA

Unit 2 has a nominally rated heat input capacity of 3,560 mmBtu/hr and can generate a gross electrical output of approximately 378 gross megawatts (MW), while firing a blend of eastern and western sub-bituminous coal; however Unit 2 is limited to 300 MW gross when firing only western sub-bituminous coal as was the case for this test event

During the performance test, the boiler was operated at maximum normal operating load conditions. 40 CFR 63.10007(2) states the maximum normal operating load is generally between 90 and 110 percent of design capacity but should be representative of site specific normal operations. The performance testing was performed while the boiler was operating within the range of 270 MW to 330 MW. A summary of the boiler gross megawatt (MW) electrical generation during each test is provided in Tables 2-1 and 2-2. Refer to Attachment D for detailed operating data, which was recorded using Eastern Standard Time.

Table 2-1
Summary of Boiler Operating Data – MATS Method 5

Date	Run	Sampling Time (EDT)	Boiler (MWg)
August 23, 2016	1	13:15 to 15:58	290
August 23, 2016	2	19:10 to 21:33	299
August 24, 2016	3	11:29 to 13:53	299
		Average	**296**

Table 2-2
Summary of Boiler Operating Data – Reference Method 5

Date	Run	Sampling Time (EDT)	Boiler (MWg)
August 23, 2016	1	10:11 to 12:39	285
August 23, 2016	2	16:20 to 18:39	298
August 24, 2016	3	8:29 to 10:47	298
		Average	**294**

2.2 APPLICABLE PERMIT INFORMATION

The J.H. Campbell generating station has State of Michigan Registration Number (SRN) B2835 and operates in accordance with air permit MI-ROP-B2835-2013a. The air permit incorporates federal regulations and reports under Federal Registry System (FRS) identification number 110000411108. EUBOILER2 is the emission unit source identification in the permit and included in the FGBOILER12 flexible group. Incorporated within the permit are the applicable requirements of 40 CFR 63, Subpart UUUUU – National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-fired Electric Utility Steam Generating Units.

In addition to the state issued air permit, Consumers Energy operates Unit 2 in accordance with the requirements in Consent Decree (CD), Civil Action No.: 14-13580, entered between Consumers Energy, the United States Environmental Protection Agency (EPA), and the United States Department of Justice (DOJ) on November 4, 2014. Section VI. of the Consent Decree presents the PM Emission Reduction and Control requirements applicable to the J.H. Campbell Unit 2 boiler and pollution control devices.

The regulatory enforceable particulate matter emissions limits for this source are summarized in Table 2-3.

Table 2-3
EUBOILER2 Regulatory PM Emission Limits

PM Emission Limit	Units	Applicable Requirement
0.030	lb/mmBtu	Table 2 to Subpart UUUUU of Part 63—Emission Limits for Existing EGU's
0.015	lb/mmBtu	Consent Decree Paragraph 145
0.15	lb/1,000 lbs exhaust gas, corrected to 50% excess air	MI-ROP-B2835-2013a Section C; EUBOILER2 Emission Unit Conditions

lb/mmBtu: pound of filterable particulate matter per million British thermal unit heat input

2.3 RESULTS

As shown in Table 2-4, each individual run, as well as the average of the three runs, was below the MATS LEE emission rate limit of 0.015 pounds of particulate matter per million British thermal unit heat input. Detailed results are presented in the Reference Method 5 PM Results Summary and MATS 5 PM Results Summary behind the tables tab of this report.

Table 2-3
Summary of Results

Run	PM Concentration (gr/dscf)		PM Emission Rate (lb/mmBtu)		
	Results		Results		MATS5 LEE FPM Limit
	RM5	MATS5	RM5	MATS5	
1	0.00207	0.00276	0.005	0.006	-
2	0.00149	0.00136	0.003	0.003	-
3	0.00167	0.00185	0.004	0.004	-
Average	**0.00174**	**0.00199**	**0.004**	**0.004**	**0.015**

It should be noted that the RM 5 results are compared to the MATS emission limit to evaluate compliance, as approved by EPA. In addition, the results are less than 50% of the emission limit and this test may be used to qualify for Low Emitting EGU (LEE) status in the future. Example calculations and field data sheets are presented in Appendix A and B. Laboratory data is presented in Appendix C.

3.0 SOURCE DESCRIPTION

The approximate 378 megawatt (MW) gross output Unit 2 electric utility steam generating unit (EGU) is a coal-fired boiler that generates steam to turn a turbine connected to an electricity producing generator.

3.1 PROCESS

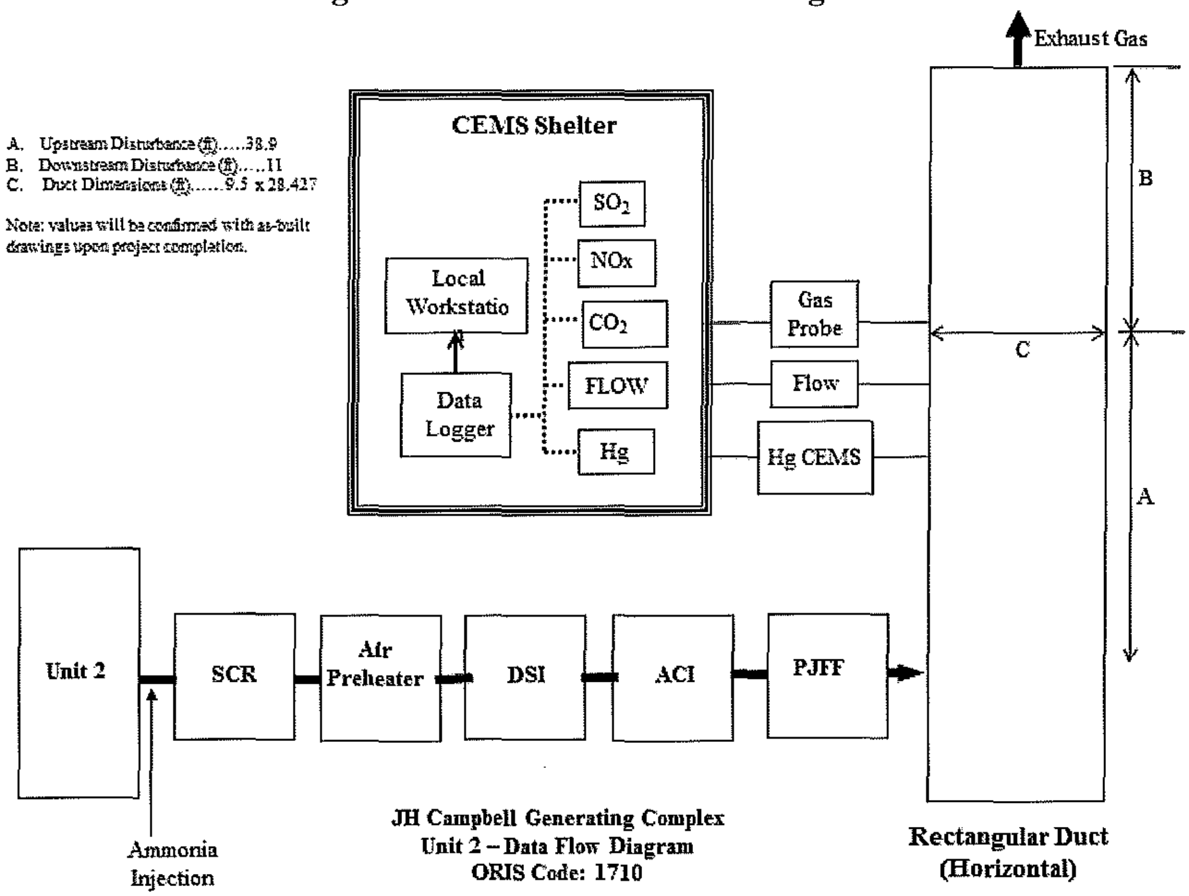
Unit 2 is a wall-fired boiler constructed in 1963 which combusts pulverized sub-bituminous coal as the primary fuel and oil as an ignition/flame stabilization fuel. The unit is also permitted to burn eastern coal blends. The source classification code (SCC) is 10100222. Coal is fired in the furnace where the combustion heats boiler tubes containing water producing steam. The steam is used to turn an engine turbine that is connected to an electricity producing generator. The electricity is routed through the transmission and distribution system to consumers.

3.2 PROCESS FLOW SHEET

The flue gas generated through coal combustion is controlled by multiple pollution control devices. The unit is currently equipped with low nitrogen oxides (NO_x) burners (LNB) and over fire air (OFA), and a selective catalytic reduction (SCR) system for NO_x control, an activated carbon injection (ACI) system for mercury (Hg) reduction, a dry sorbent (lime) injection (DSI) system for control of sulfur dioxides (SO_2) and other acid gasses, and a pulse jet fabric filter (PJFF) baghouse to control particulate matter emissions. Refer to Figure 3-1 for the Unit 2 Data Flow Diagram.

As the air enters the PJFF baghouse manifold it is evenly distributed into 10 compartments each containing 1,176 fabric filter bags. A total of 11,760 bags that are 29 feet 6 inches in length are used. Once the gas enters the compartments the velocity decreases and large particles fall out of suspension and are collected within the bottom ash hopper. As the flue gas passes through the fabric filters suspended particles are collected on the exterior surface of the bags. The particles are removed by pulsing clean air through the interior of the bags. The jet of air flexes and reverses the direction of airflow through the bag causing the particles to be released and collected in a hopper below. The clean air exiting the PJFF system enters induced draft fans and is exhausted through a header duct prior to being exhausted to atmosphere through a common approximate 400-feet high stack, shared with EUBOILER1.

Figure 3-1. Unit 2 Data Flow Diagram



Note: DSI injection lances can be utilized either upstream or downstream of the air heater inlet. For this test, injection was post air heater.

3.3 Materials Processed

The normal fuel utilized in Campbell Unit 2 boiler is 100% western coal; however, it has the ability to burn a blend of eastern and low-sulfur western coal. Western coal makes its way from Wyoming and Montana, while eastern coal arrives from a variety of states. The boiler is classified as a coal-fired unit not firing low rank virgin coal as described in Table 2 to Subpart UUUUU.

3.4 Rated Capacity

Unit 2 has a nominally rated heat input capacity of 3,560 mmBtu/hr and can generate a gross electrical output of approximately 378 megawatts gross; however it is limited to 300 MWg when firing 100% sub-bituminous coal. The boiler operates in a continuous manner in order to meet the electrical demands of Midcontinent Independent System Operator, Inc. (MISO) and Consumers Energy customers. EUBOILER2 is considered a baseload unit because it is designed to operate 24 hours a day, 365 days a year.

During the performance tests, the boiler was operated at maximum normal operating load conditions. 40 CFR 63.10007(2) states the maximum normal operating load will be generally between 90 and 110 percent of design capacity but should be representative of site specific normal operations. The performance testing was performed while the boiler was operating within the range of 270 MW to 330 MW. Refer to Tables 2-1 and 2-2 for the boiler gross megawatt electrical generation during testing.

3.5 PROCESS INSTRUMENTATION

The process was continuously monitored by boiler operators and environmental technicians. Due to the various instrumentation systems, the sampling times were correlated to instrumentation times. The control equipment process instrumentation is recorded on Eastern Daylight Time (EDT), whereas, the continuous emissions monitoring systems records data on Eastern Standard Time (EST). Primary process variables recorded by unit instrumentation are summarized in Table 3-1. Refer to Appendix D for detailed operating data.

Table 3-1
Summary of Process Instrumentation Data

Parameter	Run 1	Run 2	Run 3	Average
Reference Method 5				
6-minute Opacity (%)	1	1	1	1
Boiler load (MW)	285	298	298	294
Heat input rate (mmBtu/hr)	2,804.8	2,932.1	2,916.6	2,884.5
MATS Method 5				
6-minute Opacity (%)	1	1	1	1
Boiler load (MW)	290	299	299	296
Heat input rate (mmBtu/hr)	2,862.8	2,969.2	2,927.7	2,919.9

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Consumers Energy tested for filterable particulate matter using the United States Environmental Protection Agency (USEPA) test methods presented in Table 4-1. Descriptions of the sampling and analytical procedures are presented in the following sections.

Table 4-1
Test Methods

Parameter	USEPA	
	Method	Title
Sampling location	1	Sample and Velocity Traverses for Stationary Sources
Traverse points	2	Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
Molecular weight (O_2 and CO_2)	3A	Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Moisture	4	Determination of Moisture Content in Stack Gases
Filterable particulate matter	5	Determination of Particulate Matter Emissions from Stationary Sources
Filterable particulate matter	MATS 5[a]	Determination of Particulate Matter Emissions from Stationary Sources (with a front half filter temperature of 320±25°F)
Emission rate	19	Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates

[a] Table 5 to Subpart UUUUU of Part 63-Performance Testing Requirements notes the Method 5 front half temperature shall be 320±25°F

4.1 Description of Sampling Train and Field Procedures

The test matrix presented in Table 4-2 summarizes the sampling and analytical methods performed for the specified parameters during this test program.

Table 4-2
Test Matrix

Sampling Location	No. of Runs	Sample/Type Pollutant	Sampling Method	Sampling Organization	Sample Run Time (min)	Analytical Method	Analytical Laboratory
EUBOILER2 Outlet duct	3	Sample location and traverse points	M1	Consumers Energy	-	Field measurement and area calculations	Consumers Energy
		Velocity and volumetric flowrate	M2	Consumers Energy	125	Velocity head and temperature measurements	Consumers Energy
		Molecular weight (O_2 and CO_2)	M3A	Consumers Energy	125	Paramagnetic and infrared analyzers	Consumers Energy
		Moisture	M4	Consumers Energy	125	Gravimetric	Consumers Energy
	3	Filterable particulate matter	M5	Consumers Energy	125	Gravimetric	Consumers Energy
	3	Filterable particulate matter	MATS 5	Consumers Energy	125	Gravimetric	Consumers Energy
	3	Emission rate	M19	Consumers Energy	-	Stoichiometric calculation	Consumers Energy

4.1.1 Sample Location and Traverse Points

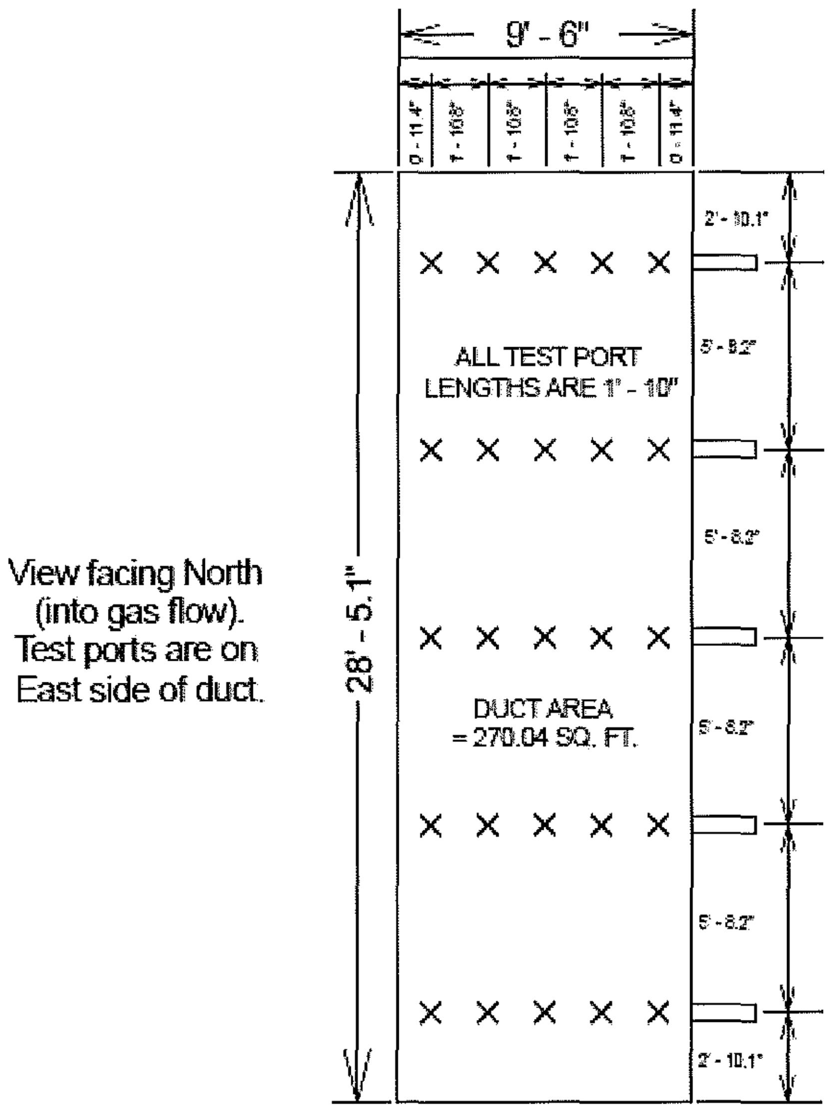
The number and location of traverse points for determining exhaust gas velocity and volumetric air-flow was determined in accordance with USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources.* Five test ports are located in the horizontal plane on one side of the 9.5 feet by 28 feet 5.1-inch rectangular duct. The duct has an equivalent duct diameter of 14 feet 2.4 inches. The ports are situated:

- Approximately 38.9 feet or 2.7 duct diameters downstream of a duct diameter change flow disturbance, and

- Approximately 11 feet or 0.8 duct diameters upstream of flow disturbance caused by a change in duct diameter as it enters the exhaust stack.

The sample ports are 6-inches in diameter and extend 22 inches beyond the stack wall. The area of the exhaust duct was calculated and the cross-section divided into a number of equal rectangular areas based on distances to air flow disturbances. Flue gas was sampled for four minutes at five traverse points from the five sample ports for a total of 25 sample points and 125 minutes. A Drawing of the Unit 2 exhaust test port locations and traverse points is presented as Figures 4-1.

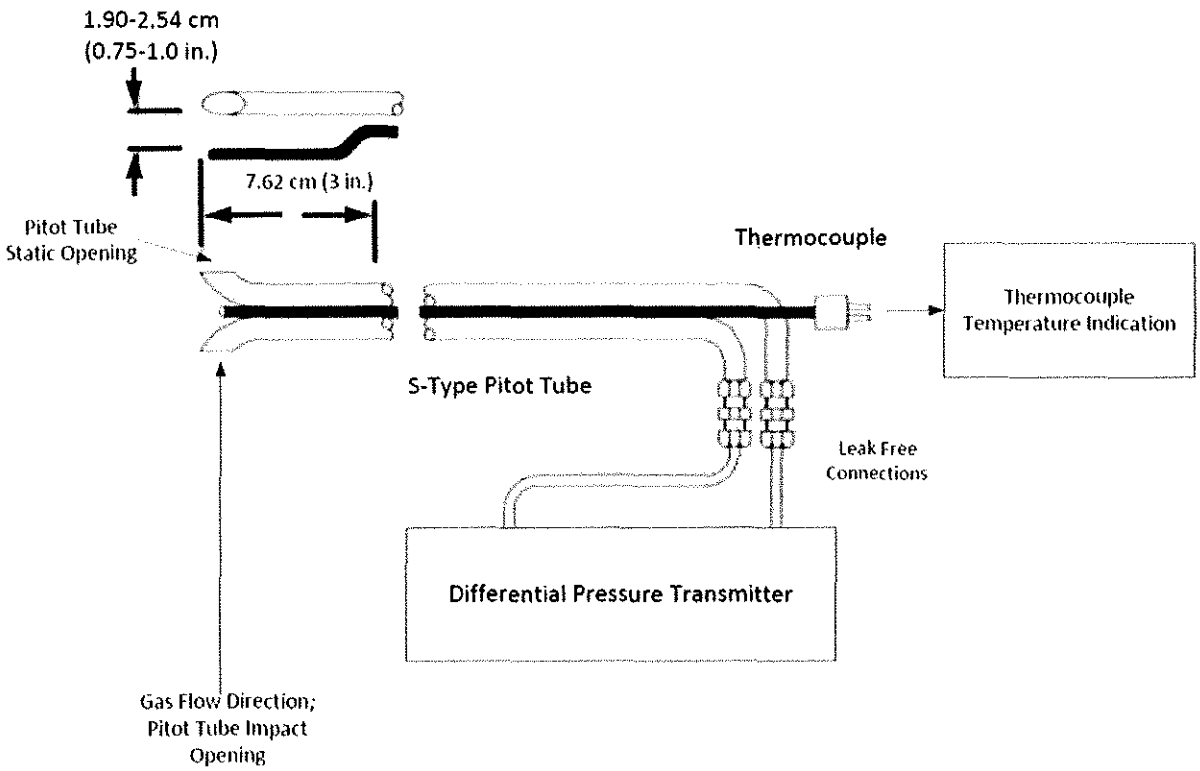
Figure 4-1. Unit 2 Duct Cross Section and Test Port/Traverse Point Detail



4.1.2 Velocity and Temperature

The exhaust gas velocity and temperature were measured using USEPA Method 2, *Determination of Stack Gas Temperature and Velocity (Type S Pitot Tube).* The pressure differential (ΔP) across the positive and negative openings of the Pitot tube inserted in the exhaust duct at each traverse point were measured using an "S Type" (Stauscheibe or reverse type) Pitot tube connected to an appropriately sized oil filled inclined manometer. Exhaust gas temperatures were measured using a chromel/alumel "Type K" thermocouple and a temperature indicator. Refer to Figure 4-2 for the Method 2 Pitot tube and thermocouple configuration.

Figure 4-2. Method 2 Sample Apparatus



Flue gas velocity and velocity vector measurements (cyclonic flow evaluation) were measured following the procedures in USEPA Method 2 at the sampling location. Cyclonic flow is defined as a flow condition with an average null angle greater than 20 degrees. The direction of flow can be determined by aligning the Pitot tube to obtain zero (null) velocity head reading—the direction would be parallel to the Pitot tube face openings or perpendicular to the null position. By measuring the angle of the Pitot tube face openings in relation to the stack walls when a null angle is obtained, the direction of flow is measured. If the absolute average of the flow direction angles is greater than 20 degrees, the flue gas is considered to be cyclonic at that sampling location and an alternative location should be found. The cyclonic flow measurements are summarized in Table 4-3.

Table 4-3
Cyclonic Flow Measurements

Sample Port	Traverse Point Null Angle (°)					
	5 (far wall)	4	3	2	1 (near wall)	Average
A (Bottom)	5	3	3	5	1	3.4
B	5	4	5	5	5	4.8
C	2	2	5	7	5	4.2
D	3	5	3	5	5	4.2
E (Top)	0	2	0	0	0	0.4
Average	3.0	3.2	3.2	4.4	3.2	**3.4**

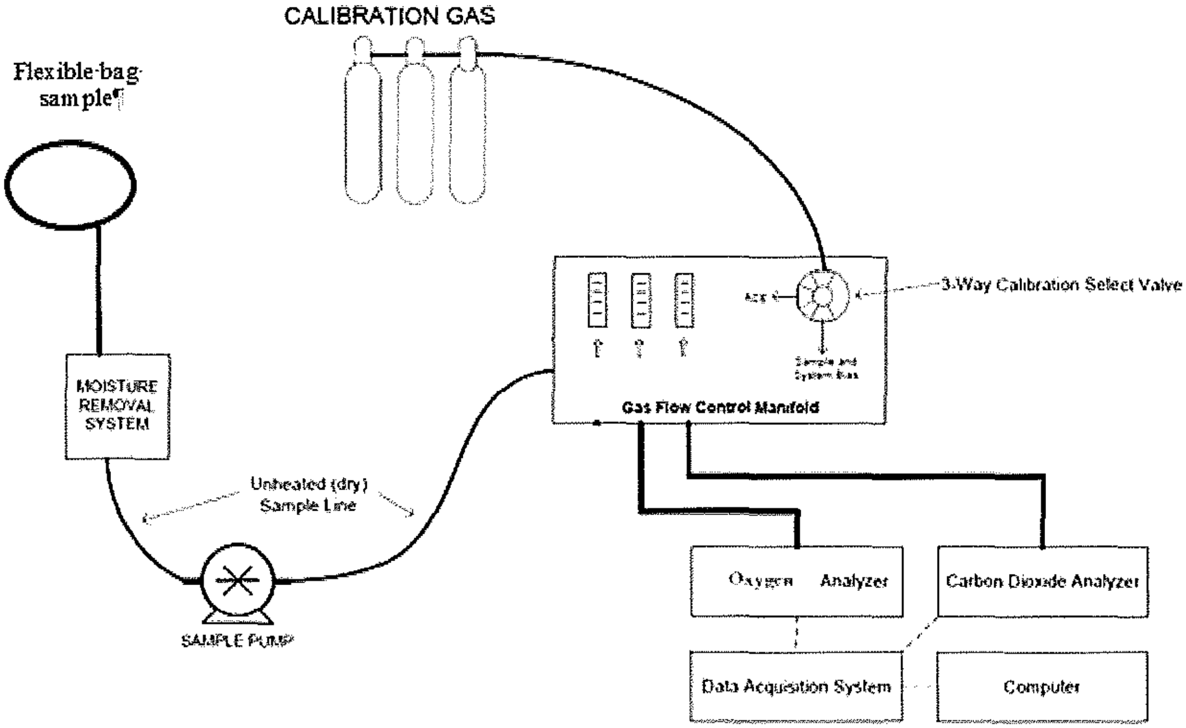
The average Pitot tube null angle measured was 3.4 degrees indicating an acceptable sampling location. Refer to Appendix B for Data Sheets documenting the cyclonic flow evaluation.

4.1.3 Molecular Weight

The exhaust gas composition and molecular weight was measured using the sampling and analytical procedures of USEPA Method 3A, *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure).* The flue gas oxygen and carbon monoxide concentrations were used to calculate molecular weight, flue gas velocity, and emissions in lb/mmBtu, and lb/1,000 lbs corrected to 50% excess air.

Flue gas was extracted from the stack through a heated stainless steel lined probe and Teflon® sample line into a flexible sample bag. The sample was withdrawn from the flexible bag and conveyed through a gas conditioning system to remove water content before entering paramagnetic and infrared gas analyzers that measure oxygen and carbon monoxide concentrations. Figure 4-3 depicts the Method 3A sampling system.

Figure 4-3. Method 3A Sampling System



Prior to sampling flue gas, the analyzers were calibrated by performing a calibration error test where zero-, mid-, and high-level calibration gases are introduced to the back of the analyzers. The calibration error check was performed to evaluate if the analyzers response was within ±2.0% of the calibration gas span. A system-bias and drift test was performed where the zero- and mid- or high- calibration gases are introduced at the inlet to the gas conditioner to measure the ability of the system to respond to within ±5.0 percent of span.

In lieu of performing a stratification test, the flexible bag samples were collected throughout the particulate matter tests at each of the 25 traverse points.

At the conclusion of each test run, an additional system bias check was performed to evaluate the drift from the pre- and post-test system bias checks. The system-bias checks evaluated if the analyzers drift is within the allowable criterion of ±3.0% of span from pre- to post-test system bias checks. The measured oxygen and carbon dioxide concentrations were corrected for analyzer drift. Refer to Appendix E for analyzer calibration supporting documentation.

4.1.4 Moisture Content

The exhaust gas moisture content was determined using USEPA Method 4, *Determination of Moisture in Stack Gases* in conjunction with the Method 5 sample apparatus. The sampled gas was pumped through a series of impingers immersed in an ice bath to condense water in the flue gas. The amount of water condensed and collected in the impingers was measured gravimetrically and used to calculate the exhaust gas moisture content.

4.1.5 Emission Rates (USEPA Method 19)

USEPA Method 19, *Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates*, was used to calculate PM emission rates in units of lb/mmBtu. Measured oxygen concentrations and F factors (ratios of combustion gas volumes to heat inputs) were used to calculate emission rates using equation 19-1 from the method. Figure 4-4 presents the emissions calculation used:

Figure 4-4. USEPA Method 19 Equation 19-1

$$E = C_d F_d \frac{20.9}{(20.9 - \%O_{2d})}$$

Where:

E	=	Pollutant emission rate (lb/mmBtu)
C_d	=	Pollutant concentration, dry basis (lb/dscf)
F_d	=	Volumes of combustion components per unit of heat content 9,820 dscf/mmBtu for subbituminous coal from 40 CFR 75, Appendix F, Table 1
$\%O_{2d}$	=	Concentration of oxygen on a dry basis (%, dry)

Refer to Appendix A for example calculations.

4.1.6 Particulate Matter

Filterable particulate matter samples were collected isokinetically by withdrawing a sample of the flue gas through a filter following the procedures of (1) USEPA Method 5, *Determination of Particulate Matter Emissions from Stationary Sources,* and (2) MATS 5.

USEPA Method 5 measures filterable particulate matter (aka PM, FPM) collected on a filter heated to 248±25°F, while MATS 5 measures PM at a filter temperature of 320±25°F.

In a letter received from USEPA on April 12, 2016 in response to a February 10, 2016 request by Consumers Energy, USEPA has approved the use of USEPA Method 5 as an alternative to MATS 5 in order to avoid having to conduct compliance tests using multiple test methods. The approval was granted with the following limitation:

> In order to have data directly comparing M5 to MATS M5 at your facility, we request that you perform three additional test runs using MATS M5 during the next scheduled PM compliance test on Units 1 and 2 at Campbell. These three additional MATS M5 runs are to be conducted simultaneously with three of the required M5 runs. Please submit the data from these three simultaneous MATS M5 test runs, along with a copy of the required certification report, including the testing performed using M5, to Ms. Kim Garnett of my staff.

Pursuant to USEPA's conditional approval, two particulate matter sampling trains were employed for this test program, consisting of a Method 5 sampling train and a MATS Method 5 sampling train. However, due to the sampling location configuration, RM5 and MATS 5 runs were performed in sequence, as approved by EPA, rather than being simultaneous, meaning one run was with a USEPA Method 5 sample train, with the next run utilizing the MATS 5 sampling train, and so forth, for a total of 6 runs, 3 with MATS5 and 3 with RM5.

The MATS 5 and the Method 5 sampling apparatus are setup and operated similarly. The flue gas was passed through a nozzle, heated probe, quartz-fiber filter, and into a series of impingers with the configuration presented in Table 4-4. The filter collects filterable particulate matter while the impingers collect water vapor. Figure 4-5 depicts the USEPA Method 5/MATS 5 sampling train.

Table 4-4
Method 5/MATS 5 Impinger Configuration

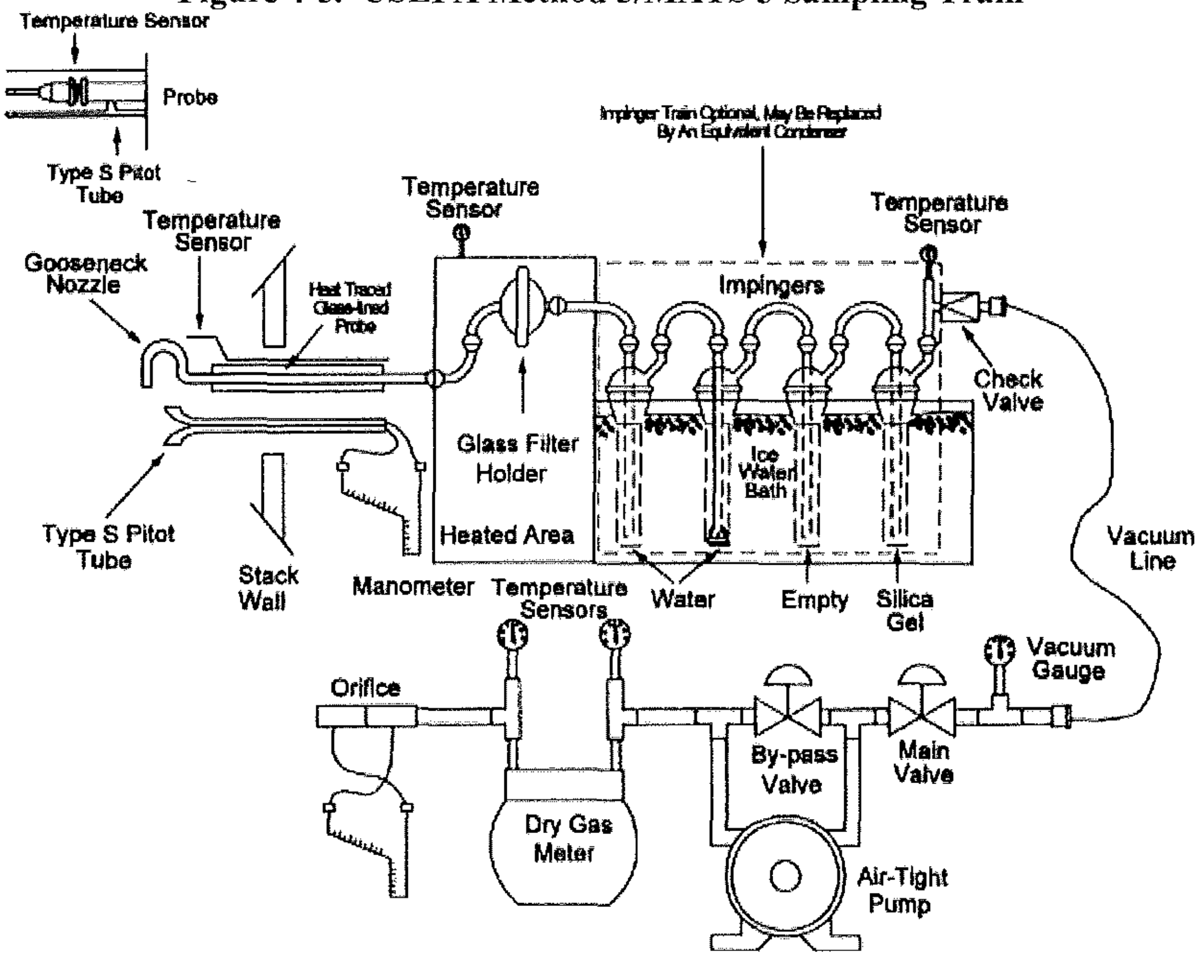
Impinger Order (Upstream to Downstream)	Impinger Type	Impinger Contents	Amount (gram)
1	Modified	Water	100
2	Greenburg-Smith	Water	100
3	Modified	Empty	0
4	Modified	Silica gel desiccant	~200-300

Prior to testing, representative velocity head and temperature data from a recently performed high load relative accuracy test audit (RATA) was reviewed to calculate an ideal nozzle diameter that would allow isokinetic sampling to be performed. The diameter of the selected nozzle was measured with a micrometer across three cross-sectional chords and used to calculate the cross-sectional area. Prior to testing the nozzle was rinsed and brushed with deionized water and acetone, and connected to the sample probe.

The impact and static pressure openings of the Pitot tube were leak-checked at or above a velocity head of 3.0 inches of water for a minimum of 15 seconds. The sampling trains were leak-checked by capping the nozzle tip and applying a vacuum of approximately 15 inches of mercury. The dry-gas meter was monitored for approximately 1 minute to verify the sample train leakage rate is less than 0.02 cubic foot per minute (cfm). The sample probe was then inserted into the sampling port to begin sampling.

Ice was placed around the impingers and the probe, and filter temperatures were allowed to stabilize to a temperature of 248±25°F or 320±25°F before sampling, as applicable. After the desired operating conditions were coordinated with the facility, testing was initiated. Stack and sampling apparatus parameters (e.g., flue velocity head, temperature) were monitored to calculate and sample at the isokinetic rate within 100±10 % for the duration of the test. Refer to Appendix B for field data sheets.

Figure 4-5. USEPA Method 5/MATS 5 Sampling Train



At the conclusion of a test run and the post-test leak check, the sampling apparatus were disassembled and the impingers and filter housing were transported to the recovery area.

The filter was recovered from the filter housing and placed in a Petri dish, sealed with Teflon tape, and labeled as "FPM Container 1." The nozzle and probe liner, and the front half of the filter housing were triple rinsed with acetone to collect particulate matter. The acetone rinses were collected in pre-cleaned sample containers, sealed with Teflon tape, and labeled as "FPM Container 2." The weight of liquid collected in each impinger, including the silica gel impinger, was measured using an electronic scale; these weights were used to calculate the moisture content of the sampled flue gas. The contents of the impingers were discarded. Refer to Figure 4-6 for the USEPA Method 5 sample recovery scheme.

The sample containers, including a filter and acetone blank were transported to the laboratory for analysis. The sample analysis followed USEPA Method 5 procedures as summarized in the analytical scheme presented in Figure 4-7. Refer to Appendix C for laboratory data sheets.

Figure 4-6. USEPA Method 5/MATS 5 Sample Recovery Scheme

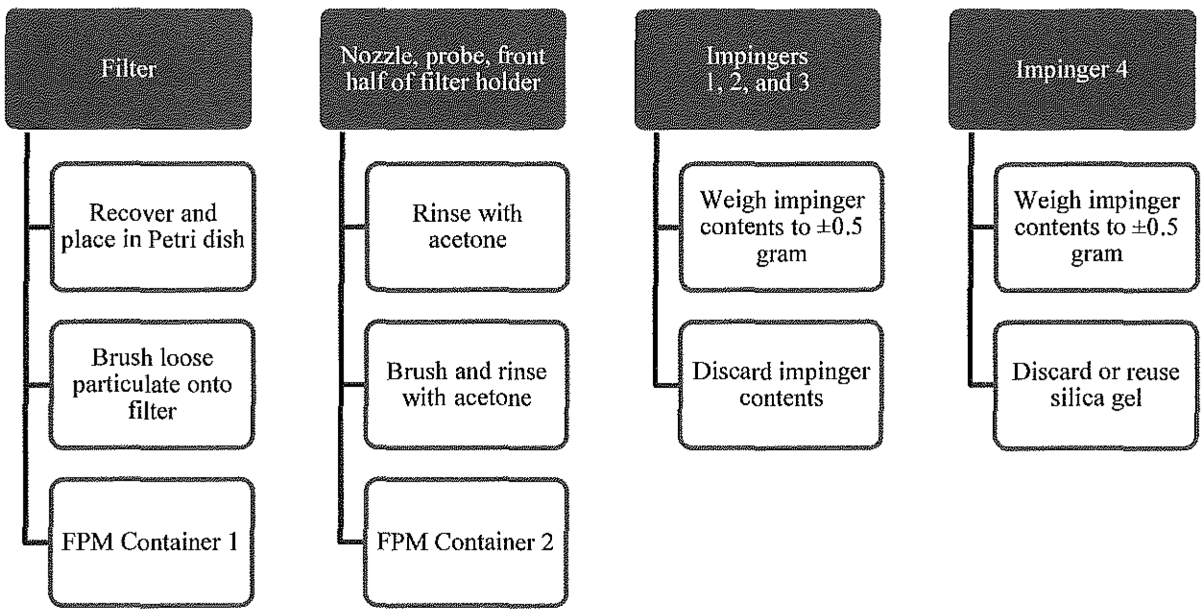
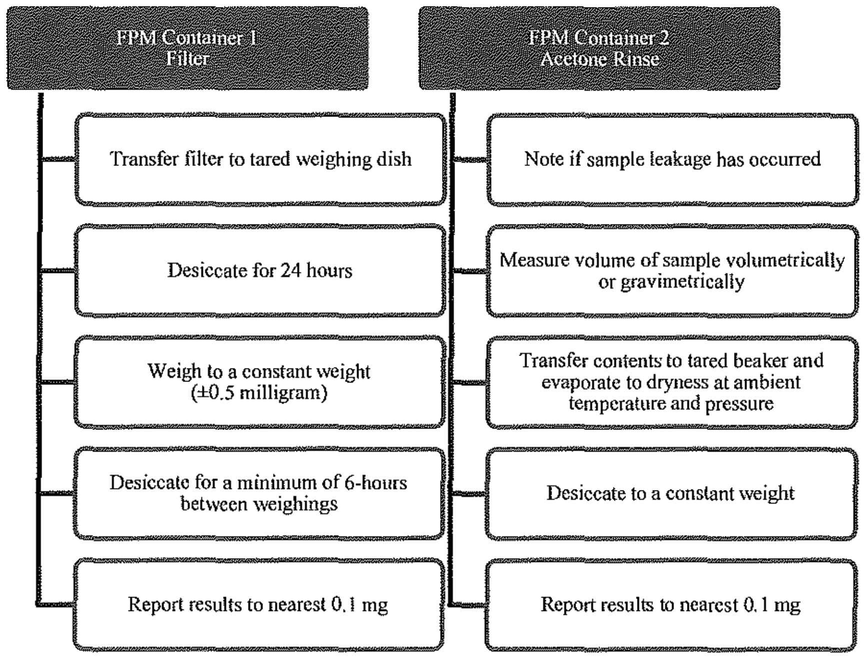


Figure 4-7. USEPA Method 5/MATS 5 Analytical Scheme



5.0 TEST RESULTS AND DISCUSSION

The purpose of the test program was to demonstrate qualification as a Low Emitting Electric Generating Unit (LEE) for filterable particulate matter (FPM) per 40 CFR 63, Subpart UUUUU – National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-fired Electric Utility Steam Generating Units (aka Mercury Air Toxics Rule [MATS]). This test event also fulfills an EPA request to provide a direct comparison between USEPA Reference Method 5 (RM5) PM results and MATS 5 PM results at the source in order to utilize RM5 as the compliance test method for the MATS rule. Three 125-minute tests were performed following USEPA procedures for each test method. The results of the testing in comparison to MATS emission limits are presented in Table 2-4.

Each individual run, as well as the average of the three runs, was below the MATS LEE emission rate limit of 0.015 pounds of particulate matter per million British thermal unit heat input.

Detailed results are presented in the Reference Method 5 PM Results Summary and MATS 5 PM Results Summary behind the tables tab of this report.

5.1 VARIATIONS AND UPSET CONDITIONS

No sampling procedure or boiler operating condition variations that could have affected the results were encountered during the test program. The process and control equipment were operating under routine conditions and no upsets were encountered.

5.2 AIR POLLUTION CONTROL DEVICE MAINTENANCE

No significant PJFF air pollution control device maintenance had occurred during the three months prior to the testing. Optimization of the air pollution control devices is a continuous process to ensure compliance with regulatory emission limits.

5.3 FIELD QUALITY ASSURANCE / QUALITY CONTROL PROCEDURES

The USEPA reference methods performed state reliable results are obtained by persons equipped with a thorough knowledge of the techniques associated with each method. To that end, factors with the potential to cause measurement errors are minimized by implementing quality control

(QC) and assurance (QA) programs into the applicable components of field testing. QA/QC components are included in this test program. Table 5-1 summarizes the primary field quality assurance and quality control activities that were performed. Refer to Appendix E for supporting documentation.

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria	QA/QC Met
M1: Sampling Location	Evaluate if the sampling location is suitable for sampling	Measure distance from ports to downstream and upstream flow disturbances	Pre-test	≥2 diameters downstream; ≥0.5 diameter upstream.	Yes
M1: Duct diameter/ dimensions	Verify area of stack is accurately measured	Review as-built drawings and field measurement	Pre-test	Field measurement agreement with as-built drawings	Yes
M1: Cyclonic flow evaluation	Evaluate the sampling location for cyclonic flow	Measure null angles	Pre-test	≤20°	Yes
M2: Pitot tube inspection	Verify Pitot and thermocouple assembly is free of aerodynamic interferences	Inspection	Pre-test and post-test	Refer to Section 6.1 and 10.0 of USEPA Method 2	Yes
M2: Pitot tube leak check	Verify leak free sampling system	Apply minimum pressure of 3.0 inches of H_2O to Pitot tube	Pre-test and Post-test	±0.01 in H_2O for 15 seconds at minimum 3.0 in H_2O velocity head	Yes
M3A: Calibration gas standards	Ensure accurate calibration standards	Traceability protocol of calibration gases	Pre-test	Calibration gas uncertainty ≤2.0%	Yes
M3A: Calibration Error	Evaluates operation of analyzers	Calibration gases introduces directly into analyzers	Pre-test	±2.0% of the calibration span	Yes
M3A: System Bias and Analyzer Drift	Evaluates ability of sampling system to delivery stack gas to analyzers	Calibration gases introduced at sample probe tip, heated sample line, and into analyzers	Pre-test and Post-test	±5.0% of the analyzer calibration span for bias and ±3.0% of analyzer calibration span for drift	Yes
M5: nozzle diameter measurements	Verify nozzle diameter used to calculate sample rate	Measure inner diameter across three cross-sectional chords	Pre-test	3 measurements agree within ±0.004 inch	Yes
M5: sample rate	Ensure representative sample collection	Calculate isokinetic sample rate	During and post-test	100±10% isokinetic rate	Yes
M5: sample volume	Ensure sufficient sample volume is collected	Record pre- and post-test dry gas meter volume reading	Post test	≥1.70 dscm	Yes
M5: post-test leak check	Evaluate if the sample was affected by system leak	Cap sample train; monitor dry gas meter	Post-test	≤0.020 cfm	Yes
M5: post-test meter audits	Evaluates accurate measurement equipment for sample volume	DGM pre- and post-test; compare calibration factors (Y and Y_{qa})	Pre-test Post-test	±5 %	Yes

5.3.1 Volumetric Flowrate QA/QC Checks

The S-Type Pitot tube used to measure flue gas velocity head pressures was inspected prior to and after emissions testing. The Pitot tube met the specifications of Section 6.1 of USEPA Method 1. Refer to Appendix E for the Pitot tube inspection and certification sheet.

The S-Type Pitot tube and oil-filled incline manometer assembly were evaluated for leaks prior to testing. Testing was performed with leak free assembly. Refer to field data sheets for verification of Pitot tube leak checks.

5.3.2 Dry Gas Meter QA/QC Checks

Table 5-2 summarizes the dry-gas meter calibration checks in comparison to the acceptable USEPA tolerance. Refer to Appendix E for complete DGM calibrations.

Table 5-2
Dry-gas Meter Calibration QA/QC Audit

Dry-Gas Meter	Pre-test DGM Calibration Factor (Y) (dimensionless)	Post-Test DGM Calibration Check Value (Y_{qa}) (dimensionless)	Difference Between Pre- and Post-test DGM Calibrations (%)	Acceptable Tolerance (%)	Comment
2039	1.003	1.01	-0.55	≤5	Valid

5.3.3 Thermocouple QA/QC Checks

Temperature measurements using thermocouples and digital pyrometers were compared to a reference temperature (i.e., ice water bath, boiling water) to evaluate accuracy of the equipment. The thermocouples and pyrometers measured temperature within ±1.5% of the reference temperatures and were within USEPA acceptance criteria. Thermocouple calibration sheets are presented at the bottom of Table 1 after the Tables tab of this report.

5.3.4 Nozzle QA/QC Checks

Prior to testing a micrometer was used to separately measure three different inner diameters of the nozzle. The average of the measurements was used to calculate the sampling velocity and isokinetic sampling rate. The nozzle was inspected for nicks, dents, or corrosion before connecting to the sample probe. Refer to Appendix E for the nozzle calibration sheet.

5.3.5 Oxygen and Carbon Dioxide Analyzer QA/QC Checks

The instrument analyzer sampling apparatus described in Section 4.1 were audited for measurement accuracy and data reliability. The analyzers passed the applicable calibration criteria. The following tables summarize gas cylinders used during this test program and QA/QC audits. Refer to Appendix E for additional calibration data.

Table 5-3
Calibration Gas Cylinder Information

Parameter	Gas Vendor	Cylinder Serial Number	Cylinder Value (%)	Expiration Date
N_2	Airgas	EB0013140	99.9995	2/18/2023
O_2	Airgas	CC159768	9.03	3/8/2024
CO_2			9.985	
O_2	Airgas	CC220123	20.11	1/5/2023
CO_2			19.04	

Table 5-4
Method 3A O_2 Sampling Train QA/QC Audits

Parameter	Run 1	Run 2	Run 3	Acceptable Tolerance	Comment
Calibration error (%)	<0.5	<0.5	<0.4	±2% of calibration span	Valid
Low-level (zero) gas system bias (%)	0.5	0.5	0	≤5% of calibration span	Valid
Upscale gas system bias (%)	0	0	0.2	≤5% of calibration span	Valid
Low-level (zero) gas analyzer drift (%)	0.7	0.7	0	≤3% of calibration span	Valid
Upscale gas analyzer drift (%)	0.1	0.1	0.0	≤3% of calibration span	Valid

Table 5-5
Method 3A CO_2 Sampling Train QA/QC Audits

Parameter	Run 1	Run 2	Run 3	Acceptable Tolerance	Comment
Calibration error (%)	<0.2	<0.2	<0.3	±2% of calibration span	Valid
Low-level (zero) gas system bias (%)	0.2	0.2	0.3	≤5% of calibration span	Valid
Upscale gas system bias (%)	0	0	0	≤5% of calibration span	Valid
Low-level (zero) gas analyzer drift (%)	0.3	0.3	0.1	≤3% of calibration span	Valid
Upscale gas analyzer drift (%)	0.6	0.6	0	≤3% of calibration span	Valid

5.3.6 QA/QC Blanks

Reagent, field train recovery, and field train proof blanks were analyzed for the parameters of interest. The results of the blanks are presented in the Table 5-6.

Table 5-6
QA/QC Blanks

Sample Identification	Result (mg)	Comment
Method 5 Acetone Field Blank	0.9	Sample volume was 200 milliliters. Acetone blank corrections were applied.
Method 5 Laboratory Filter Blank	0.1	Reporting limit is 0.1 milligrams.

5.4 Laboratory Quality Assurance / Quality Control Procedures

Laboratory quality assurance and quality control procedures were performed in accordance with USEPA Method 5 guidelines. Specific QA/QC procedures include evaluation of reagent and filter blanks and the application of blank corrections, if applicable. Refer to Appendix C for the laboratory data sheets.

6.0 CERTIFICATION

I hereby certify the statements and information in this test report and supporting enclosures are true, accurate, and complete, and the test program was performed in accordance with test methods specified in this report.

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