Consumers Energy
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Particulate Matter
40 CFR Part 63 Subpart UUUUU
LEE Demonstration

EUBOILER01 and EUBOILER02

CMS Enterprises
TES Filer City Station
700 Mee Street
Filer City, Michigan 49634
SRN: N1685

Test Dates: November 28 through 30, 2017

Report Date: January 19, 2018

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section – Air Emissions Testing Body
Laboratory Services

Work Order No. 4101582
Version No. 0

EXECUTIVE SUMMARY

Consumers Energy Company (Consumers Energy) Regulatory Compliance Testing Section (RCTS) conducted filterable particulate matter (PM) air emissions testing at the stack exhausts associated with emissions units EUBOILER01 and EUBOILER02 operating at the Tondu Energy Systems (TES) Filer City Station in Filer City, Michigan. The facility is a cogeneration power plant with a rated output of 60-megawatts net (MW_n) and 50,000 pounds of process steam per hour subject to 40 Code of Federal Regulations (CFR) Part 63, Subpart UUUUU – National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-fired Electric Utility Steam Generating Units, aka the Mercury and Air Toxics (MATS) rule. The 4^{th} quarter 2017 air emissions tests were performed to (1) satisfy 40 CFR 63.10006(c) quarterly testing requirements, (2) evaluate compliance with the applicable emission limit of 0.030 lb/mmBtu FPM, and (3) to evaluate if the sources qualify as Low Emitting EGUs (LEE) as specified 40 CFR 63.10005(h)(1)(i).

Three 120-minute PM tests were performed at each boiler exhaust on November 28, 29, and 30, 2017 following the procedures described in the Test Protocol submitted by Consumers Energy to Michigan Department of Environmental Quality (MDEQ) on May 1, 2017 and subsequently approved by Mr. Jeremy Howe, MDEQ Environmental Quality Analyst, in his letter dated May 11, 2017. There were no deviations from the approved stack test protocol or the United States Environmental Protection Agency (USEPA) reference methods. The average results of the tests are presented below:

- Unit 1 0.0027 lb/mmBtu
- Unit 2 0.0019 lb/mmBtu

The results of this test program indicate EUBOILER01 and EUBOILER02 are in compliance with the applicable MATS PM lb/mmBtu emission limit, and because the emissions were less than 50 percent of the limit, meet the LEE qualification criterion for the 5^{th} consecutive calendar quarter.

Detailed results are presented in Appendix Tables 1 and 2. Sample calculations and field data sheets are presented in Appendices A and B. Laboratory, process operating data, and supporting information are provided in Appendices C, D, and E.

1.0 INTRODUCTION

Consumers Energy Company (Consumers Energy) Regulatory Compliance Testing Section (RCTS) conducted filterable particulate matter (PM) air emissions testing at the stack exhausts associated with emissions units EUBOILER01 (Unit 1) and EUBOILER02 (Unit 2) operating at the Tondu Energy Systems (TES) Filer City Station in Filer City, Michigan. The facility is a cogeneration power plant with a rated output of 60-megawatts net (MW_n) and 50,000 pounds of process steam per hour subject to 40 Code of Federal Regulations (CFR) Part 63, Subpart UUUUU – National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-fired Electric Utility Steam Generating Units, aka the Mercury and Air Toxics (MATS) rule. The 4th quarter 2017 air emissions tests were performed to (1) satisfy 40 CFR 63.10006(c) quarterly testing requirements, (2) evaluate compliance with the applicable emission limit, and (3) to evaluate if the sources qualify as Low Emitting EGUs (LEE) as specified 40 CFR 63.10005(h)(1)(i). The applicable emission limits are summarized in Table 1-1.

Table 1-1
MATS PM Emission Limits

Parameter	Emission Limit	Units	Applicable Requirement
PM	0.030	lb/mmBtu	Table 2 to Subpart UUUUU of Part 63—Emission Limits for Existing EGU's

lb/mmBtu: pounds per million British thermal unit heat input

The PM LEE demonstration requires quarterly sampling over a period of three consecutive years. The results of each quarterly test must be less than or equal to 50 percent of the applicable standard listed in Table 2 of the MATS rule, equating to 0.015 lb/mmBtu for PM. MATS LEE testing for PM commenced in the 4th quarter of 2015. However, the 3rd quarter 2016 PM results for both units were between 50% and 100% of the associated MATS emission limit, so the initial attempt at LEE qualification was ended and a new series of LEE qualification tests was commenced in the 4th quarter of 2016. This test program evaluated LEE status for the 5th consecutive calendar quarter.

A test protocol was submitted to the Michigan Department of Environmental Quality (MDEQ) on May 1, 2017 and subsequently approved by Mr. Jeremy Howe, MDEQ Environmental Quality Analyst, in his letter dated May 11, 2017. The preceding reflects a standing approval for all quarterly MATS PM tests as long as no modifications from the original protocol are required.

1.1 CONTACT INFORMATION

Table 1-2 presents the test program organization, major lines of communication, and names and phone numbers of responsible individuals.

Table 1-2
Contact Information

Program Role	Contact	Address
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
Regulatory Agency Inspector	Ms. Caryn Owens Environmental Engineer 231-876-4414 owensc1@michigan.gov	Michigan Department of Environmental Quality Cadillac District 120 W. Chapin Street Cadillac, Michigan 49601
Regulatory Agency Representative	Mr. Jeremy Howe Environmental Quality Analyst 231-876-4416 howejl@michigan.gov	Michigan Department of Environmental Quality Cadillac District 120 W. Chapin Street Cadillac, Michigan 49601
Responsible Official	Mr. Henry Hoffman General Manager 231-723-6573, Ext 102 henry.hoffman@cmsenergy.com	CMS Generation Filer City Operating, LLC Filer City Station 700 Mee Street Filer City, Michigan 49634
Plant Representative	Mr. Austin S. Swiatlowski Plant Operator 231-723-6573, Ext 108 austin.swiatlowski@cmsenergy.com	CMS Generation Filer City Operating, LLC Filer City Station 700 Mee Street Filer City, Michigan 49634
Test Team Representative	Mr. Gregg A. Koteskey, QSTI Engineering Technical Analyst 616-738-3712 gregg.koteskey@cmsenergy.com	Consumers Energy Company L&D Training Center 17010 Croswell Street West Olive, Michigan 49460
Test Team Representative	Mr. Thomas R. Schmelter, QSTI Engineering Technical Analyst 616-738-3234 thomas.schmelter@cmsenergy.com	Consumers Energy Company L&D Training Center 17010 Croswell Street West Olive, Michigan 49460

2.0 SUMMARY OF RESULTS

2.1 OPERATING DATA

During the tests, the boilers were operated as close as possible to 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 average steam flow during the test was approximately 289 klbs/hr for Unit 1 and 295 klbs/hr for Unit 2 (90% of the full load rating of 320,000 lbs/hr for Unit 1 and 92% of the full load rating of 320,000 lbs/hr for Unit 2). Recorded operating data, including fuel blend firing rate and composite fuel factor data, is included in Appendix D.

2.2 APPLICABLE PERMIT INFORMATION

The TES Filer City Station is currently operating pursuant to the terms and conditions of State of Michigan Registration Number (SRN) N1685 air permit MI-ROP-N1685-2015b. The air permit incorporates state and federal regulations. The USEPA has assigned a Facility Registry Service (FRS) identification number of 110056958225. EUBOILER01 and EUBOILER02 are the MATS subject emission unit sources listed within the permit and collectively comprise the FGBOILERS 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.

2.3 RESULTS

The results of the air emissions testing indicate the 3-run average PM emission rates are in compliance with the applicable limit and both EUBOILER01 and EUBOILER02 qualify as LEE EGUs. Refer to Table 2-1 for a summary of the PM test results. Refer to Section 5.0 for further discussion.

Table 2-1
Summary of PM Test Results

Source	Units	Run			Average	Emission Limit	
		1	2	3		MATS	MATS LEE†
EUBOILER01	lb/mmBtu	0.0030	0.0021	0.0031	**0.0027**	**0.030**	**0.015**
EUBOILER02	lb/mmBtu	0.0015	0.0020	0.0021	**0.0019**	**0.030**	**0.015**

† Applicable emission limit to qualify for low emitting EGU (LEE) status

3.0 SOURCE DESCRIPTION

TES Filer City Station is a cogeneration plant consisting of two solid-fuel fired boilers, with coal being the primary fuel. The electricity output is sold pursuant to a long-term power purchase agreement with Consumers Energy Company. Process steam is sold to an adjacent industrial customer.

3.1 PROCESS

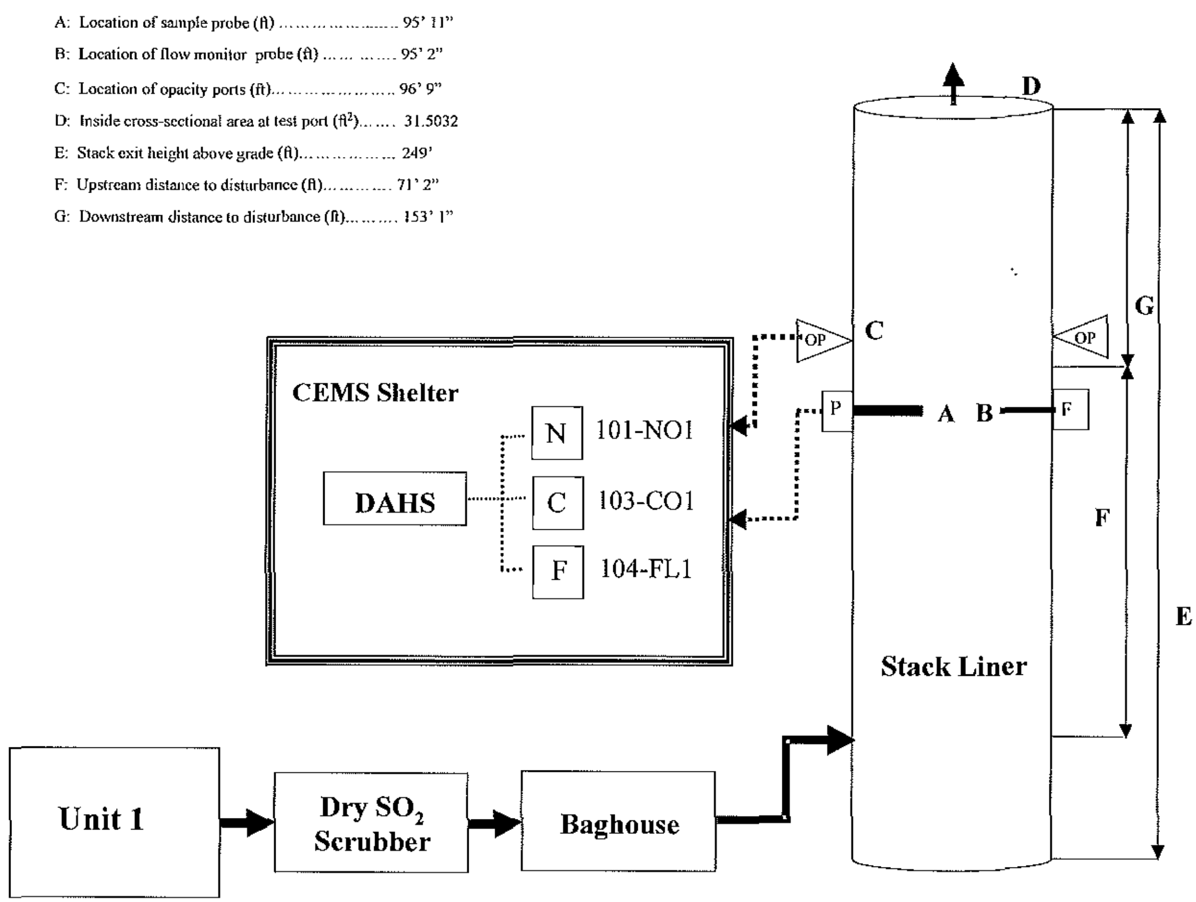
TES Filer City Station operates as a cogeneration electric power plant with a rated output of approximately 60-megawatts net (MW_n) and is also capable of generating 50,000 pounds of process steam per hour. The electricity and process steam are sold under contract to public and/or private companies. The facility commenced commercial operations beginning in 1990.

3.2 PROCESS FLOW

EUBOILER01 and EUBOILER02 are spreader stoker boilers used to generate steam. Each unit has a nominal heat input rating of approximately 384 mmBtu/hour and is currently allowed to combust bituminous coal, wood and wood waste, petroleum coke, industrial construction/demolition wood waste, tire derived fuel, and natural gas. The fuel is fired in the furnace where the combustion heats water within boiler tubes producing steam. At full load, each unit is capable of producing approximately 320,000 pounds per hour of steam. This steam is used to turn a common steam turbine that is connected to an electricity producing generator. The electricity is routed through the transmission and distribution system to customers.

The exhaust gas from each boiler is vented to a spray dryer absorber (SDA) flue gas desulfurization (FGD) system for sulfur dioxide (SO_2) and acid gas control and a baghouse to control particulate matter. The abated exhaust gases are discharged through separate circular flues housed within a single exhaust stack. The separate flues discharge approximately 250 feet above grade. Refer to Figure 3-1 for a Process Flow Diagram of Unit 1 which is representative of Unit 2.

Figure 3-1. Process Flow Diagram



3.3 RAW AND FINISHED MATERIALS PROCESSED

At the time of testing, Units 1 and 2 were capable of firing mixtures of coal (bituminous and subbituminous), wood and wood waste, construction/demolition (C/D) material, tire-derived-fuel (TDF) and natural gas. During the tests, coal, TDF, and wood were fired. Refer to Appendix D for facility operating data recorded during the test program.

In March of 2016, two low NO_x natural gas-fired burners were installed each boiler. Natural gas is utilized as a clean startup fuel, as well as at other times for flame stabilization and other purposes. Natural gas was not fired during the PM testing.

TES executed an Administrative Consent Order with the EPA which resulted in all petroleum coke having been removed from the site by March 31, 2016, and TES does not anticipate firing petroleum coke in the future.

3.4 Rated Capacity

EUBOILER01 and EUBOILER02 each have a nominally rated heat input capacity of 384 mmBtu/hr and a steam generation capacity of 320,000 lbs/hr; they can generate a combined net electrical output of approximately 60 MW_n and 50,000 pounds of process steam per hour. The boilers normally operate in a continuous manner near their rated capacity in order to meet the contractual electrical and steam requirements of TES Filer City Station customers.

3.5 Process Instrumentation

The process was continuously monitored by boiler operators, environmental technicians, and data acquisition systems during testing. The following operating parameters were recorded during the test program and are included in Appendix D:

- Carbon dioxide concentration (%)
- Fuel blend (coal, natural gas, TDF, and wood) firing rates (lb/hr) (scfm for natural gas)
- Steam load flow (1,000s lb/hr) and pressure (psia) [In lieu of electrical load, which is only determined on a combined basis.]
- Opacity (%)
- Total heat input (mmBtu/hr)
- Mixed fuel factor, F_c (scf/mmBtu)
- SO_2 reduction (%) [In lieu of scrubber flow rate; the SO_2 reduction is a much better measure of SDA performance and operating status.]

Due to the various instrumentation and monitoring systems, as well as the facility instrumentation time stamps reading 6 minutes earlier than reference method times, all times were correlated to reference method test times in local Eastern Standard Time (EST). Also note that during this test program, the facility CEMS were undergoing quarterly maintenance and calibration procedures. The operating parameters cited above which were affected by the CEMS maintenance have been identified in the production data presented in Appendix D, and have been excluded from the calculated run averages.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

TES tested for filterable particulate matter using the 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
Emission rate	19	Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates

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

Date (2017)	Run	Sample Type	Start Time (EST)	Stop Time (EST)	Test Duration (min)	EPA Test Method	Comment
Nov. 28	1	Unit 1 PM	13:12	15:20	120	1, 2, 3A, 4, 5	Port change between 14:12 and 14:20
	2	Unit 1 PM	15:54	17:59	120		Port change between 16:54 and 16:59
Nov. 29	3	Unit 1 PM	7:47	9:59	120		Port change between 8:47 and 8:52
Nov. 29	1	Unit 2 PM	10:33	14:05	120	1, 2, 3A, 4, 5	Test paused ~93 minutes prior to sampling from second test port due to facility transformer failure affecting SDA operation. Test was resumed after issue was resolved and SDA operations were stable. Port change between 11:33 and 13:05
	2	Unit 2 PM	14:34	16:39	120		Port change between 15:34 and 15:39
Nov. 30	3	Unit 2 PM	7:07	9:10	120		Port change between 8:07 and 8:10

Start and stop times are based on local eastern standard time.

4.1.1 Sample Location (USEPA Method 1)

The selection of the measurement site was evaluated using the procedure in USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources.* Each exhaust gas flue is 76 inches in diameter with two 6-inch internal diameter sample ports that extend 20 inches from the flue interior wall. The sample ports are situated:

- Approximately 90 feet or 14 duct diameters downstream of a duct bend disturbance where the combustion gases exit the baghouse and enter the exhaust stack, and
- Approximately 150 feet or 24 duct diameters upstream of the exhaust to atmosphere.

Because the sampling locations are at least eight stack or duct diameters downstream and two diameters upstream from any flow disturbance such as a bend, expansion, or contraction in the stack, or from a visible flame and meet the requirements of USEPA Method 1, flue gas measurements were collected from a total of 12 traverse points. The area of the exhaust duct was calculated and the cross-section divided into a number of equal areas based on distances to air flow disturbances. Flue gas was sampled for 10 minutes at six traverse points from the two sample ports for a total test duration of 120 minutes.

A dimensioned sketch of the sample location showing the sampling ports in relation to breeching and to upstream and downstream disturbances or obstructions in gas flow is presented as Figure 4-1. The Unit 1 duct cross section and sampling point detail is presented as Figure 4-2; Unit 2 is identical to Unit 1 with the exception the two test ports are located at the northeast and northwest compass positions.

Figure 4-1. Unit 1 and 2 Sample Location

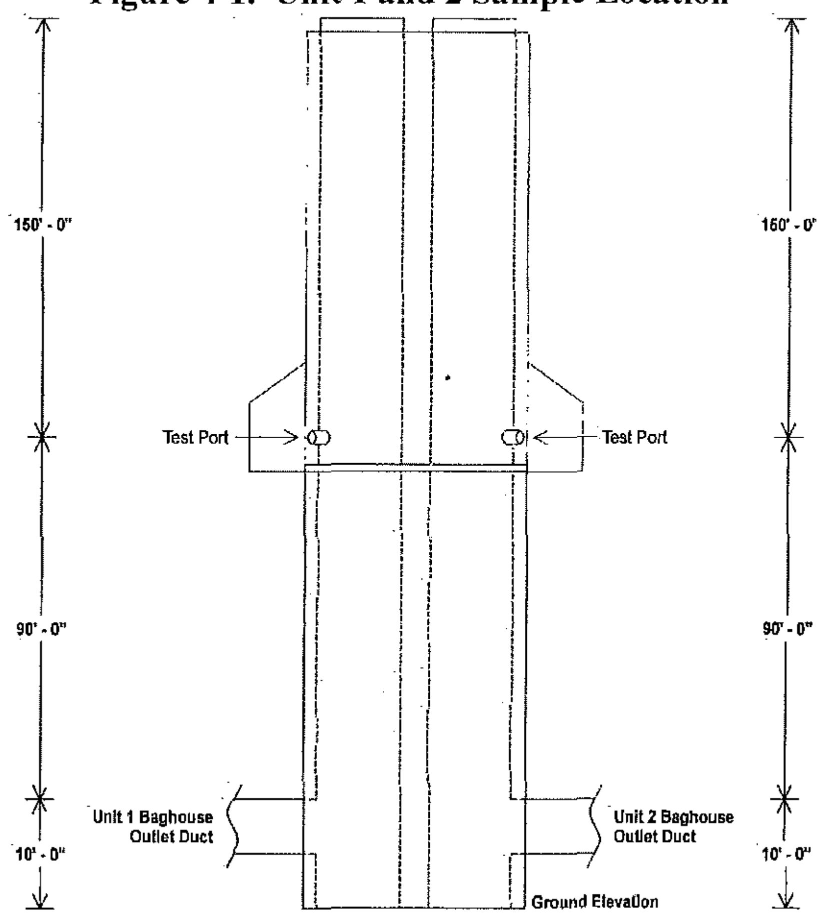
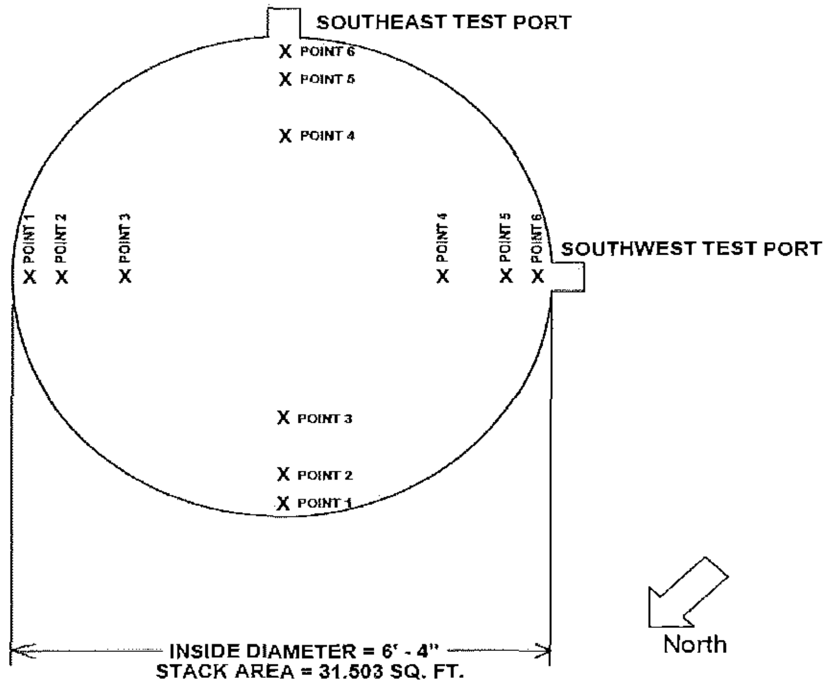


Figure 4-2. Unit 1 Duct Cross Section and Sampling Point Detail



Probe Depths From
Inside Stack Wall

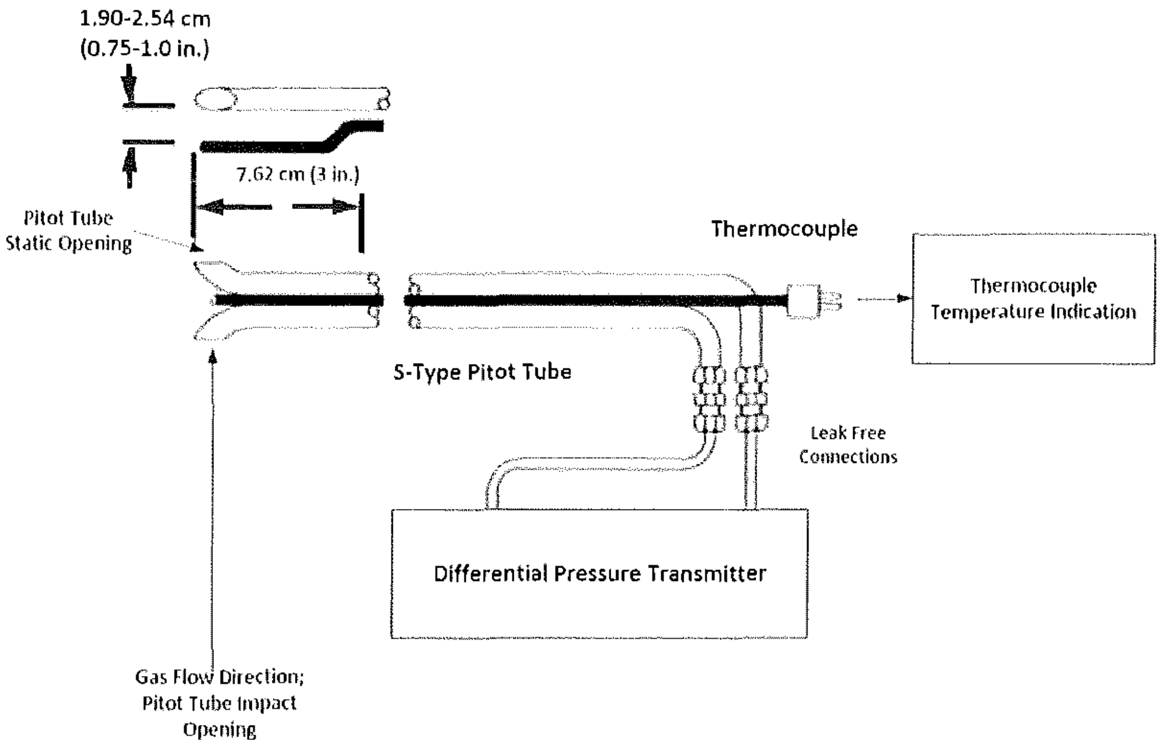
Flow Port Length = 20"

Point 1 = 72.656"
Point 2 = 64.904"
Point 3 = 53.504"
Point 4 = 22.496"
Point 5 = 11.096"
Point 6 = 3.344"

4.1.2 Velocity and Temperature (USEPA Method 2)

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 4-3 for a drawing of the Method 2 sample apparatus showing the Pitot tube and thermocouple configuration.

Figure 4-3. 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 locations. 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.

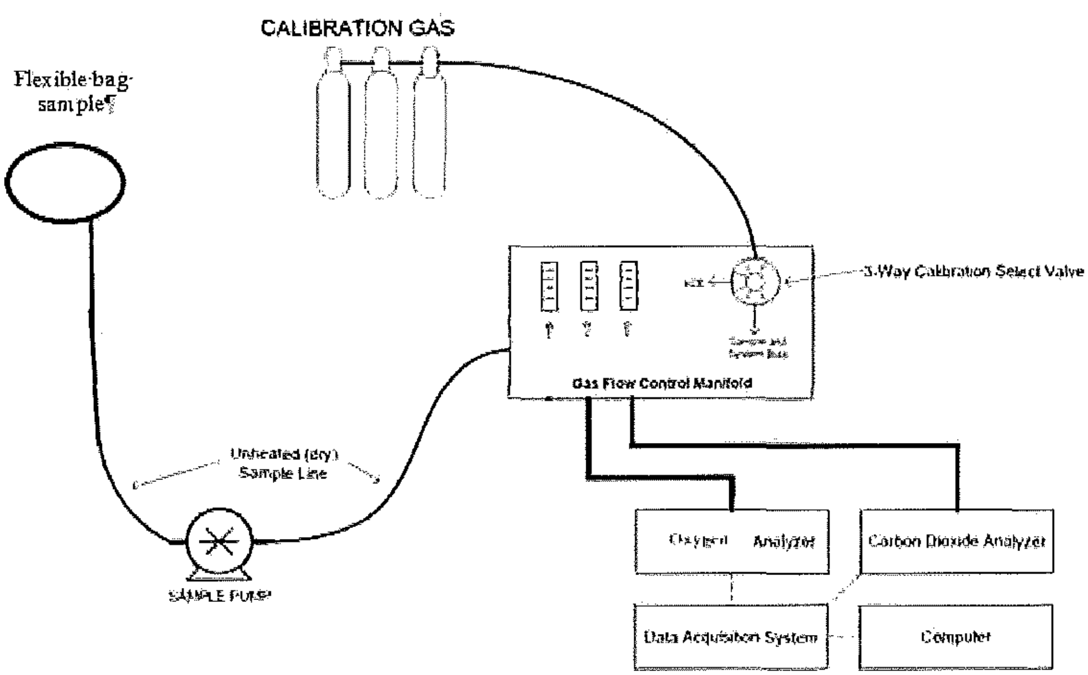
Appendix B of this report includes cyclonic flow test data as verification of the absence of cyclonic flow at each test location. Method 1, § 11.4.2 indicates *if the average* (null angle) *is greater than 20°, the overall flow condition in the stack is unacceptable, and alternative methodology... must be used.* The average null yaw angle measured in August 2012 was 3.25° for Unit 1 and 8.25° for Unit 2, thus meeting the less than 20° requirement. Because there have been no significant ductwork and/or stack configuration changes, this null angle information is considered to be valid and additional cyclonic flow verification was not performed prior to the PM test.

4.1.3 Molecular Weight (USEPA Method 3A)

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 dioxide 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.

An integrated flue gas sample was collected during each PM run from each of 12 traverse points into a stainless steel lined probe and inert sample line into a flexible sample bag. Molecular weight analysis was performed by connecting the flexible bag to a gas sample conditioner which conveyed the sample to paramagnetic and infrared gas analyzers that measure oxygen and carbon dioxide concentrations. Figure 4-4 depicts the Method 3A sampling system.

Figure 4-4. 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.

At the conclusion of one or more flexible bag analysis, 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 (USEPA Method 4)

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 conveyed 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 Particulate Matter (USEPA Method 5)

Filterable particulate matter samples were collected isokinetically following the procedures of USEPA Method 5, *Determination of Particulate Matter Emissions from Stationary Sources* with the necessary modifications specified in the MATS Rule for low emitting EGU (LEE) status determinations. Specifically, the Method 5 front half probe, filter, and filter exit temperatures were maintained at 320°F, ±25°F, throughout the duration of each test run and a minimum of 2 dry standard cubic meters (dscm) or 70.629 dry standard cubic feet (dscf) of sample volume was collected.

As flue gas is withdrawn isokinetically from the stack, filterable PM is collected on a heated quartz-fiber filter. Moisture or water vapor in the gas condenses in a series of impingers following the heated filter. Figure 4-5 depicts the Method 5 sample apparatus and Table 4-2 provides the Method 5 impinger configuration detail.

Figure 4-5. USEPA Method 5 Sample Apparatus

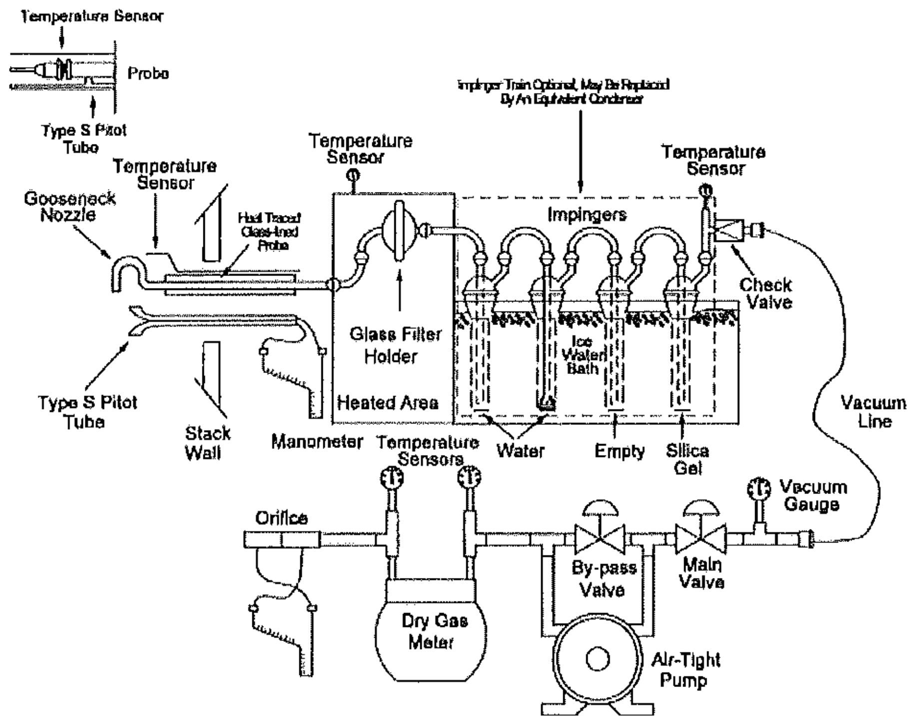


Table 4-2
Method 5 Impinger Configuration

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 was reviewed to calculate an ideal nozzle diameter allowing isokinetic sampling to be performed. The diameter of the selected nozzle was measured with a caliper 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 S-Type Pitot tube were leak-checked at or above a velocity head of 3.0 inches of water for a minimum of 15 seconds. The PM sample apparatus was leak-checked by capping the nozzle tip and applying a vacuum of approximately 15 inches of mercury while the dry-gas meter was monitored for approximately 1 minute to verify the sample train leakage rate was less than 0.02 cubic foot per minute (cfm). The sample probe was then inserted into the sampling port to begin sampling.

After placing ice around the impingers, the probe and filter temperatures were allowed to stabilize to a temperature of 320±25°F. Once the desired operating conditions were coordinated with the facility, testing was initiated. Stack and sampling apparatus parameters (e.g., flue velocity head, temperature) were then monitored throughout each run to maintain an isokinetic rate of 100±10 %. Refer to Appendix B for field data sheets.

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 Sample Recovery Scheme

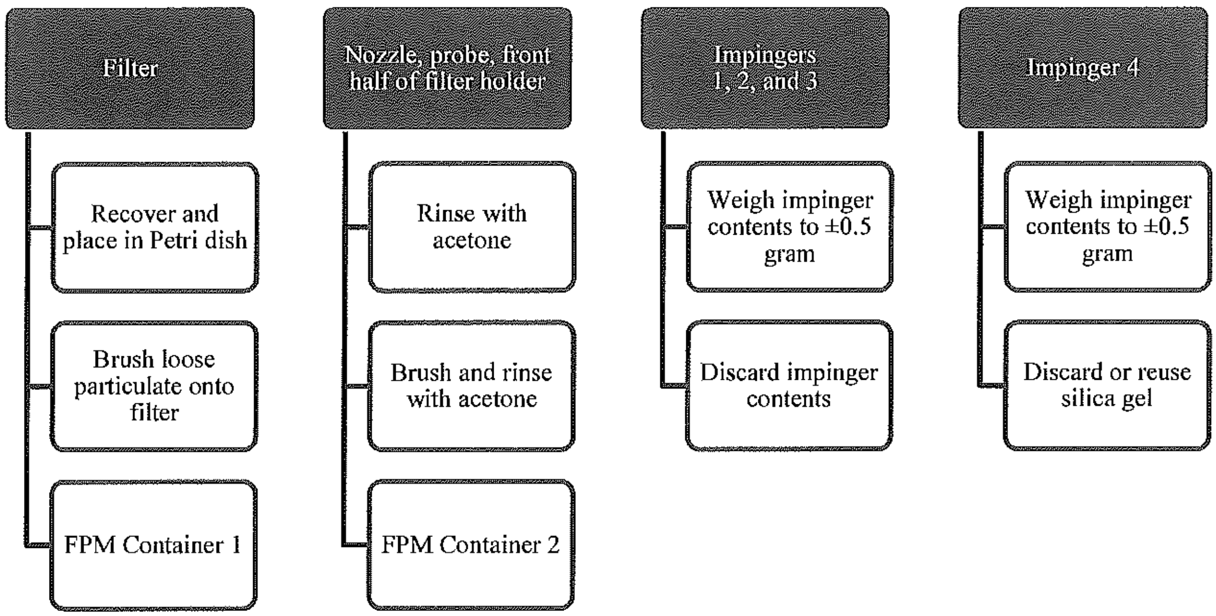
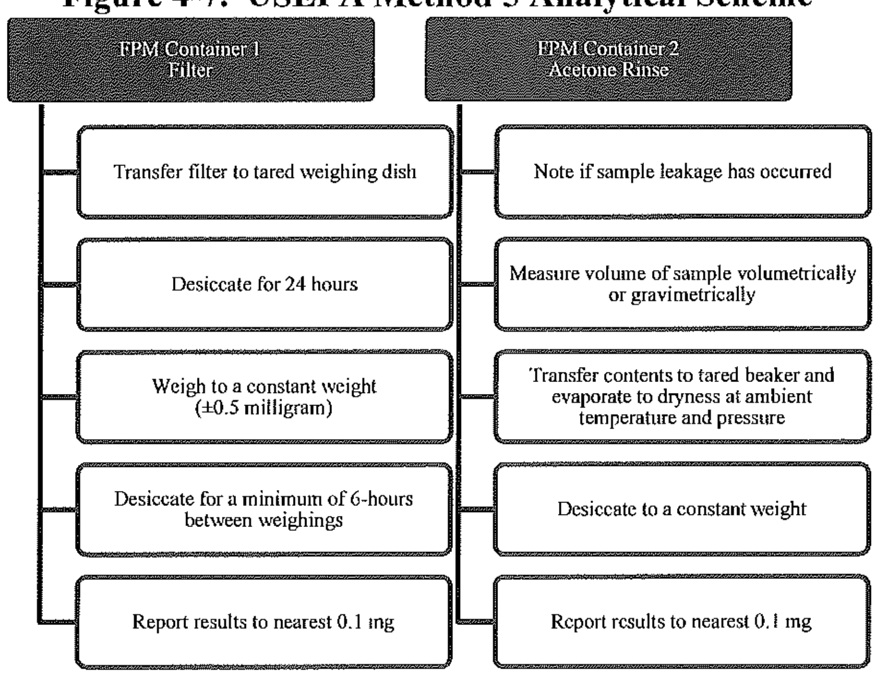


Figure 4-7. USEPA Method 5 Analytical Scheme



4.1.6 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 carbon dioxide concentrations and F factors (ratios of combustion gas volumes to heat inputs) were used to calculate emission rates using equation 19-6 from the method. Figure 4-8 presents the emissions calculation used:

Figure 4-8. USEPA Method 19 Equation 19-6

$$E = C_d F_c \frac{100}{(\%CO_{2d})}$$

Where:

E	=	Pollutant emission rate (lb/mmBtu)
C_d	=	Pollutant concentration, dry basis (lb/dscf)
F_c	=	Volumes of combustion components per unit of heat content (scf CO_2/mmBtu)
$\%CO_{2d}$	=	Concentration of carbon dioxide on a dry basis (%, dry)

Refer to Appendix A for example calculations and Appendix D for operating data that includes the calculated F_c factor based on the fuels combusted during each test run.

5.0 TEST RESULTS AND DISCUSSION

The test program results summarized in Section 2.3 indicate Units 1 and 2 are in compliance with the MATS Rule emission limits. Because the results are less than 50% of the applicable emission standard, both EUBOILER01 and EUBOILER02 achieved MATS LEE qualification criteria for the fifth consecutive calendar quarter. Refer to Tables 1 and 2 (following the report body and preceding the appendices) for detailed results.

When compiling test report support data, it was discovered that while soot blows had been performed on each day of PM testing for Units 1 and 2, the soot blows did not actually fall within any of the discrete PM test runs for Units 1 and 2. However, the test protocol approval letter requires that soot blows be conducted during at least one run for each unit. While Consumers Energy apologizes for this oversight, we do not believe that the lack of soot blows would bias the PM test results based upon the form of PM control technology. The predominant forms of PM control technology for solid fuel fired boilers are electrostatic precipitators (ESPs) and baghouses/fabric filters, and Units 1 and 2 are equipped with baghouses.

ESPs are designed as constant removal efficiency devices where increases in inlet loading would correlate fairly directly to increases in outlet loading. In contrast, baghouses are designed to maintain a consistent outlet grain loading regardless of variations in inlet loading; as such, they are far less sensitive to changes in inlet loading. When reviewing historic PM testing results for Units 1 and 2, there is little observable difference in the PM emission rates solely attributable to soot blowing. Thus, Consumers Energy believes that the PM results obtained in the absence of soot blowing are representative and do not underrepresent emissions.

5.1 VARIATIONS AND UPSET CONDITIONS

No sampling procedure variations from the USEPA test methods or approved Test Protocol were performed.

During Run 1 of the Unit 2 testing on November 29, 2017, at approximately 11:25 a transformer failure caused a power outage in the Unit 2 baghouse and affected the SDA atomizer operation, minutes before RCTS relocated the sampling apparatus to the second test port. RCTS identified the issue through observation of abnormally high stack gas temperature of approximately 250°F compared to an expected temperature of approximately 175°F. The high stack gas temperatures were measured prior to commencing the second half of the test in the second test port and were the result of reduced lime slurry injection rate by the SDA system. The test was paused until power was restored to the control devices and the boiler and control devices were allowed to stabilize before resuming the test at 13:05. The upset condition caused a delay of approximately 93 minutes. Because PM samples were not collected during the upset period the results of Unit 2 Run 1 were considered valid and not significantly affected.

For the other test runs performed, the process and control equipment were operating under routine conditions and no upsets were encountered.

5.2 Air Pollution Control Device Maintenance

No significant air pollution control device maintenance has occurred during the three months prior to the testing.

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. 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 performed. Refer to Appendix D for supporting documentation.

Table 5-1
Quality Control Procedures

QC Specification	Purpose	Procedure	Frequency	Acceptance Criteria
M1: Sampling Location	Evaluate if the sampling location is suitable for sampling	Measure distance from ports to downstream and upstream disturbance	Pre-test	≥2 diameters downstream; ≥0.5 diameter upstream.
M1: Duct diameter	Verify area of stack is accurately measured	Review as-built drawings and field measurement	Pre-test	Field measurement agreement with as-built drawings
M2: Pitot tube calibration and standardization	Verify construction and alignment of Pitot tube	Inspect Pitot tube against specification and assign a coefficient value	Pre-test and after each field use	Alignment and dimension requirements of M2

Table 5-1
Quality Control Procedures

QC Specification	Purpose	Procedure	Frequency	Acceptance Criteria
M3A: Calibration gas standards	Ensure accurate calibration standards	Traceability protocol of calibration gases	Pre-test	Calibration gas uncertainty ≤2.0%
M3A: Calibration Error	Evaluates operation of analyzers	Calibration gases introduced directly into analyzers	Pre-test	±2% of the calibration span
M3A: System Bias and Analyzer Drift	Evaluates ability of sampling system to deliver stack gas to analyzers	Cal gases introduced at inlet of sampling system and into analyzers	Pre-test and Post-test	±5% of the analyzer calibration span for bias and ±3% of analyzer calibration span for drift
M3A: Multi- point integrated sample	Ensure representative sample collection	Insert probe into stack and purge sample system	Pre-test	Collect samples at traverse points
M4: Field balance calibration	Verify moisture measurement accuracy	Use Class 6 weight to check balance accuracy	Daily before use	The field balance must measure the weight within ±0.5 gram of the certified mass
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
M5: sample rate	Ensure representative sample collection	Calculate isokinetic sample rate	During and post-test	100±10% isokinetic rate
M5: Apparatus Temperature	Ensures purge of acid gases in probe and on filter	Set probe & filter heat controllers to 320±25°F	Verify prior to and during each run	Apparatus temperature must be 320±25°F
M5: sample volume	Ensure sufficient sample volume is collected	Record pre- and post-test dry gas meter volume reading	Post test	≥1 dscm minimum for PM; ≥2 dscm minimum for LEE PM
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

Table 5-1
Quality Control Procedures

QC Specification	Purpose	Procedure	Frequency	Acceptance Criteria
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 %

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 and was assigned the baseline coefficient value of 0.84 (dimensionless). The S-Type Pitot tube and oil-filled incline manometer assembly were evaluated for leaks prior to testing as described in Section 4.1.2 to ensure measurements were performed with a leak free assembly. Refer to field data sheets for verification of Pitot tube leak checks and Appendix E for the Pitot tube inspection sheet.

5.3.2 Dry Gas Meter QA/QC Checks

The dry-gas meter calibration checks in comparison to the USEPA tolerance were acceptable. Refer to Appendix E for supporting calibration data.

5.3.3 Thermocouple QA/QC Checks

Thermocouple temperature calibrations were conducted following *Alternative Method 2 Thermocouple Calibration Procedure ALT-011*. ALT-011 describes the inherent accuracy and precision of the thermocouple within ±1.3°F in the range of -32°F and 2,500°F and states that a system that performs accurately at one temperature is expected to behave similarly at other temperatures. Therefore, the two-point calibration described in Method 2 may be replaced with a single point calibration procedure that verifies the thermocouple and reference thermometers agree to within ±2.0°F, while taking into account the presence of disconnected wire junctions, other loose connections or a potential mis-calibrated temperature display. Thermocouple calibration data is presented with the Dry Gas Meter Calibration Data in Appendix E of this report, and thermocouples met the required calibration criteria.

5.3.4 Nozzle QA/QC Checks

Prior to testing, calipers were 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 and at the conclusion of testing. Refer to Appendix E for the nozzle calibration sheet.

5.3.5 Oxygen and Carbon Dioxide Analyzer QA/QC Checks

The Method 3A sampling apparatus described in Section 4.1.3 was audited for measurement accuracy and data reliability. The analyzers passed the applicable calibration criteria. Refer to Appendix E for additional calibration data.

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, the application of blank corrections, duplicate and/or triplicate measurement, and analysis of calibration standards. Refer to Appendix C for the laboratory data sheets.

5.4.1 QA/QC Blanks

Reagent and media blanks were analyzed for the parameters of interest. The results of the blanks are presented in the Table 5-2. Refer to Appendix C for the laboratory data sheets. For Unit 2, Run 2, the net particulate filter weight gain post-test was slightly negative (-0.2 milligrams). This loss of filter weight is likely due the combination of extremely low particulate mass collected on the filter, and the loss of filter mass due to fibers transferring from the filter to the sample filter holder and filter frit. These transferred fibers were then recovered in FPM Container #2 during the acetone rinse of these components, and subsequently included in the total calculated FPM gain of 6.24 mg for this run.

Table 5-2
QA/QC Blanks

Sample Identification	Result	Comment
Method 5 Acetone Field Blank	0.2 mg	Blank sample volume was 200 milliliters. Acetone blank corrections between 0.04 and 0.07 mg were applied.
Method 5 Laboratory Filter Blank	0 mg	Reporting limit is 0.1 milligrams.

5.4.2 Audit Samples

A performance audit (PA) sample (if available) for each test method employed is required, unless waived by the administrator for regulatory compliance purposes as described in 40 CFR 63.7(c)(2)(iii). A PA sample consists of blind audit sample(s), as supplied by an accredited audit sample provider (AASP), which are analyzed with the performance test samples in order to provide a measure of test data bias. An audit sample for USEPA Method 5 particulate matter is currently not available from AASP sources.

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Table 1 - EUBOILER01 Particulate Matter Emissions Results

Facility and Source Information	Units	Run 1	Run 2	Run 3	Average
Customer:		TES Filer City			
Source:		Unit 1			
Work Order:		4101582			
Date:		11/28/2017	11/28/2017	11/29/2017	
Unit Steam Load	klbs/hr	290	291	287	289
Stack Diameter	inches	76.0	76.0	76.0	
Cross-sectional Area of Stack, A	ft^2	31.50	31.50	31.50	
Source Pollutant Test Data	**Units**	**Run 1**	**Run 2**	**Run 3**	**Average**
Barometric Pressure, P_{bar}	inches of Hg	29.70	29.70	29.59	29.66
Dry Gas Meter Calibration Factor, Y	dimensionless	0.999	0.999	0.999	0.999
Pitot Tube Coefficient, C_p	dimensionless	0.84	0.84	0.84	0.84
Stack Static Pressure, P_g	inches of H_2O	-0.70	-0.70	-0.70	-0.70
Nozzle Diameter, D_n	inches	0.217	0.217	0.217	0.217
Run Start Time	hr:mm	13:12	15:54	7:47	
Run Stop Time	hr:mm	15:20	17:59	9:52	
Duration of Sample, θ	minutes	120	120	120	120
Dry Gas Meter Leak Rate, L_p	cfm	0.000	0.000	0.000	0.000
Dry Gas Meter Start Volume	ft^3	903.97	2.01	100.73	335.57
Dry Gas Meter Final Volume	ft^3	1001.30	100.14	203.16	434.86
Average Pressure Difference across the Orifice Meter, ΔH	inches of H_2O	2.18	2.18	2.50	2.28
Average Dry Gas Meter Temperature, T_m	°F	77.7	85.6	66.8	76.7
Average Square Root Velocity Head, √Δp	√inches H_2O	1.1613	1.1537	1.2512	1.1887
Stack Gas Temperature, $T_{s(abavg)}$	°F	171.9	171.7	171.5	171.7
Source Moisture Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Volume of Water Vapor Condensed in Silica Gel, $V_{wsg(std)}$	scf	1.3	1.3	1.0	1.2
Total Volume of Water Vapor Condensed, $V_{w(std)}$	scf	14.977	14.598	14.659	14.745
Volume of Gas Sample as Measured by the Dry Gas Meter, V_m	dcf	97.326	98.124	102.426	99.292
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscf	95.243	94.631	102.008	97.294
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscm	2.697	2.680	2.889	2.76
Moisture Content of Stack Gas, B_{ws}	% H_2O	13.59	13.36	12.56	13.17
Gas Analysis Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Carbon Dioxide, $\%CO_2$	%, dry	12.1	11.3	11.3	11.6
Oxygen, $\%O_2$	%, dry	7.5	8.4	8.4	8.1
Nitrogen, %N	%, dry	80.5	80.3	80.3	80.4
Dry Molecular Weight, M_d	lb/lb-mole	30.23	30.14	30.14	30.17
Wet Molecular Weight, M_s	lb/lb-mole	28.56	28.52	28.62	28.57
Percent Excess Air, %EA	%	54.01	64.97	65.02	61.33
Fuel F-Factor, F_o:	dimensionless	1.116	1.109	1.109	1.111
Fuel F-Factor, F_c:	scf/mmBtu	1,801	1,801	1,800	1,801
Gas Volumetric Flow Rate Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Average Stack Gas Velocity, v_s	ft/s	72.0	71.6	77.7	73.8
Stack Gas Volumetric Flow Rate, Q	acfm	136,161	135,347	146,793	139,434
Stack Gas Standard Volumetric Flow Rate, Q_s	scfm	112,737	112,108	121,169	115,338
Stack Gas Dry Standard Volumetric Flow Rate, Q_{sd}	dscfm	97,418	97,126	105,945	100,163
Percent of Isokinetic Sampling, I	%	100.0	99.7	98.5	99.4
Gas Concentrations and Emission Rates		**Run 1**	**Run 2**	**Run 3**	**Average**
Mass of Filterable PM Collected, m_n	mg	8.76	5.75	8.93	7.81
Filterable PM Concentration, c_s	gr/dscf	0.00142	0.00094	0.00135	0.00123
Filterable PM Concentration at Stack Conditions, $c_{s@stack\ conditions}$	mg/wacm	2.323	1.540	2.230	2.031
Filterable PM Concentration, C_s [Actual Conditions, Wet Basis]	lb/1,000 lbs	0.00237	0.00157	0.00228	0.00208
Filterable PM Concentration, C_{s50} [Actual Conditions, Wet Basis]	lb/1,000 lbs @ 50% EA	0.00242	0.00171	0.00247	0.00220
Filterable PM Mass Emission Rate, E	lb/hr	1.18	0.78	1.22	1.06
Filterable PM, lb/mmBtu, E	lb/mmBtu	0.0030	0.0021	0.0031	0.0027
Filterable PM, tpy [Assumes 8,760 Hrs/Yr Operation]	tpy	5.18	3.41	5.36	4.65

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Table 2 - EUBOILER02 Particulate Matter Emissions Results

Facility and Source Information	Units	Run 1	Run 2	Run 3	Average
Customer:		TES Filer City			
Source:		Unit 2			
Work Order:		4101582			
Date:		11/29/2017	11/29/2017	11/30/2017	
Unit Steam Load	klbs/hr	293	295	296	295
Stack Diameter	inches	76.0	76.0	76.0	
Cross-sectional Area of Stack, A	ft^2	31.50	31.50	31.50	
Source Pollutant Test Data	**Units**	**Run 1**	**Run 2**	**Run 3**	**Average**
Barometric Pressure, P_{bar}	inches of Hg	29.62	29.60	29.15	29.46
Dry Gas Meter Calibration Factor, Y	dimensionless	0.999	0.999	0.999	0.999
Pitot Tube Coefficient, C_p	dimensionless	0.84	0.84	0.84	0.84
Stack Static Pressure, P_g	inches of H_2O	0.80	0.80	0.90	0.83
Nozzle Diameter, D_n	inches	0.217	0.217	0.217	0.217
Run Start Time	hr:mm	10:33	14:34	7:07	
Run Stop Time	hr:mm	14:05	16:39	9:10	
Duration of Sample, θ	minutes	120	120	120	120
Dry Gas Meter Leak Rate, L_p	cfm	0.000	0.000	0.000	0.000
Dry Gas Meter Start Volume	ft^3	203.92	307.86	412.55	308.11
Dry Gas Meter Final Volume	ft^3	307.17	411.78	518.02	412.32
Average Pressure Difference across the Orifice Meter, ΔH	inches of H_2O	2.49	2.49	2.58	2.52
Average Dry Gas Meter Temperature, T_m	°F	73.1	73.6	65.6	70.8
Average Square Root Velocity Head, √Δp	√inches H_2O	1.2444	1.2406	1.2744	1.2531
Stack Gas Temperature, $T_{s(abavg)}$	°F	175.2	172.5	172.8	173.5
Source Moisture Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Volume of Water Vapor Condensed in Silica Gel, $V_{wsg(std)}$	scf	1.2	1.5	1.1	1.3
Total Volume of Water Vapor Condensed, $V_{w(std)}$	scf	14.770	15.517	15.317	15.201
Volume of Gas Sample as Measured by the Dry Gas Meter, V_m	dcf	103.253	103.920	105.470	104.214
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscf	101.719	102.211	103.745	102.558
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscm	2.881	2.895	2.938	2.90
Moisture Content of Stack Gas, B_{ws}	% H_2O	12.68	13.18	12.86	12.91
Gas Analysis Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Carbon Dioxide, $\%CO_2$	%, dry	11.7	11.9	11.3	11.6
Oxygen, $\%O_2$	%, dry	8.1	7.9	8.4	8.1
Nitrogen, %N	%, dry	80.3	80.3	80.3	80.3
Dry Molecular Weight, M_d	lb/lb-mole	30.19	30.21	30.14	30.18
Wet Molecular Weight, M_s	lb/lb-mole	28.64	28.60	28.58	28.61
Percent Excess Air, %EA	%	61.34	58.95	65.12	61.80
Fuel F-Factor, F_o:	dimensionless	1.101	1.099	1.109	1.103
Fuel F-Factor, F_c:	scf/mmBtu	1,800	1,801	1,800	1,800
Gas Volumetric Flow Rate Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Average Stack Gas Velocity, v_s	ft/s	77.2	76.9	79.7	77.9
Stack Gas Volumetric Flow Rate, Q	acfm	146,006	145,404	150,597	147,335
Stack Gas Standard Volumetric Flow Rate, Q_s	scfm	120,393	120,321	122,693	121,136
Stack Gas Dry Standard Volumetric Flow Rate, Q_{sd}	dscfm	105,129	104,462	106,910	105,500
Percent of Isokinetic Sampling, I	%	99.0	100.1	99.3	99.4
Gas Concentrations and Emission Rates		**Run 1**	**Run 2**	**Run 3**	**Average**
Mass of Filterable PM Collected, m_n	mg	4.63	6.24	6.33	5.74
Filterable PM Concentration, c_s	gr/dscf	0.00070	0.00094	0.00094	0.00086
Filterable PM Concentration at Stack Conditions, $c_{s@stack\ conditions}$	mg/wacm	1.157	1.549	1.530	1.412
Filterable PM Concentration, C_s [Actual Conditions, Wet Basis]	lb/1,000 lbs	0.00118	0.00158	0.00159	0.00145
Filterable PM Concentration, C_{s50} [Actual Conditions, Wet Basis]	lb/1,000 lbs @ 50% EA	0.00126	0.00166	0.00172	0.00155
Filterable PM Mass Emission Rate, E	lb/hr	0.63	0.84	0.86	0.78
Filterable PM, lb/mmBtu, E	lb/mmBtu	0.0015	0.0020	0.0021	0.0019
Filterable PM, tpy [Assumes 8,760 Hrs/Yr Operation]	tpy	2.77	3.69	3.77	3.41