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AIR QUALITY DIV.

Particulate Matter
40 CFR Part 63 Subpart UUUUU
LEE Demonstration
T.E.S. Filer City Station
Manistee, Michigan

EUBOILER01 and 02

T.E.S. Filer City Station
700 Mee Street
Manistee, Michigan 49634
SRN: N1685

Notification Submitted: May 8, 2017
Test Date: May 15-17, 2017

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section – Air Emissions Testing Body
Laboratory Services
Work Order No. 4101582
Revision No. 0

EXECUTIVE SUMMARY

Consumers Energy Company (Consumers Energy) Regulatory Compliance Testing Section (RCTS) conducted filterable particulate matter (FPM) 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 (MW) net and 50,000 pounds of process steam per hour. The FPM test followed requirements in the United States Environmental Protection Agency (U.S. EPA) Title 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 Air Toxics (MATS) Rule.

The 2nd quarter 2017 test program was conducted in May of 2017 to satisfy MATS quarterly test requirements in § 63.10006(c), to demonstrate compliance with the 0.030 lb/mmBtu FPM limit in MATS Table 2, § 2a, and to verify FPM emissions were less than 50 percent of the 3.0E-02 lb/mmBtu limit to qualify as a Low Emitting EGU (LEE) as specified in § 63.10005(h)(1)(i). The following summary of FPM emission rates indicates Unit 1 and Unit 2 comply with the MATS PM lb/mmBtu limit and meet LEE qualification criteria for the 3rd consecutive calendar quarter.

- Unit 1: 0.003 lb/mmBtu, based upon the average of three 2-hour test runs.
- Unit 2: 0.005 lb/mmBtu, based upon the average of three 2-hour test runs.

During the test program, there were no deviations from the approved stack test protocol or the associated US EPA Reference Methods. Additional detail regarding any testing variations, if applicable, or process/control device upset conditions during the testing program can be found within Section 5.1.

1.0 INTRODUCTION

1.1 SUMMARY OF TEST PROGRAM

Consumers Energy Company (CECo) Regulatory Compliance Testing Section (RCTS) performed the Filterable Particulate Matter (FPM) Low Emitting Electric Generating Unit (LEE) demonstration per Subpart UUUUU, 40 CFR Part 63 (commonly referred to as the Mercury and Air Toxics Standard [MATS] Rule) at the stack exhausts associated with emission units EUBOILER01 (Unit 1) and EUBOILER02 (Unit 2) in operation at the Tondu Energy Systems (TES) Filer City Station, located in Filer City, Michigan.

The purpose of the PM testing was to satisfy the quarterly performance testing requirements of 40 CFR 63, Subpart UUUUU. The testing evaluated compliance with the applicable emission limits summarized in Table 1-1 and is being used to support qualification as a Low Emitting Electric Generating Unit (LEE) for filterable particulate matter (FPM).

Table 1-1
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: pound per million British thermal unit heat input

The FPM 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 FPM commenced in the 4th quarter of 2015. However, the 3rd quarter 2016 FPM 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 indicates Unit 1 and 2 meet LEE qualification criteria for the 3rd 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. This test was conducted on May 15, 16, and 17, 2017.

1.2 Contact Information

Table 1-2 presents the EGU 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 Representative	Mr. Jeremy Howe Environmental Quality Analyst 231-876-4416 howejl@michigan.gov	Michigan Department of Environmental Quality 120 W. Chapin Street Cadillac, Michigan 49601
Regulatory Agency Representative	Ms. Caryn Owens Environmental Quality Analyst 231-876-4414 Owensc1@michigan.gov	Michigan Department of Environmental Quality 120 W. Chapin Street Cadillac, Michigan 49601
Responsible Official	Mr. Henry Hoffman 231-723-6573, Ext 102 General Manager henry.hoffman@cmsenergy.com	Tondu Energy Systems Filer City Station 700 Mee Street Filer City, Michigan 49634
Plant Representative	Mr. Todd Guenthardt 231-723-6573, Ext. 104 Maintenance and EHS Supervisor todd.guenthardt@cmsenergy.com	Tondu Energy Systems Filer City Station 700 Mee Street Filer City, Michigan 49634
Test Team Representative	Mr. Dillon King 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
Test Team Representative	Mr. Brian Miska 989-891-3415 Sr. Engineering Technical Analyst II brian.miska@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

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 for during the test was approximately 305 klbs/hr for Unit 1 and 301 klbs/hr for Unit 2, (95% of the full load rating of 320,000 lbs/hr for Unit 1 and 94% of the full load rating of 320,000 lbs/hr for Unit 2). Soot blowing occurred on at least one occasion during the testing of each unit. Recorded operating data, including fuel blend firing rate and composite fuel factor data, is included in Appendix E.

2.2 TEST RESULTS AND DISCUSSION

The TES Filer City station has the State of Michigan Registration Number (**SRN**) N1685 and operates in accordance with air permit MI-ROP-N1685-2015a. EUBOILER01 and EUBOILER02 are the emission unit source identifications in the permit and included in 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.

As shown in Table 3-1 below, the results of each individual run, as well as the average of the three runs for each unit were below the 40 CFR Part 63 Subpart UUUUU limit of 0.030 lb/mmBtu for Units 1 and 2. Both units also demonstrated eligibility for Low Emitting EGU qualification as emission rates were below 0.015 lb/mmBtu (i.e., <50% of the FPM limit).

Table 3-1
Summary of Filterable PM Emission Test Results

Source	Run	PM Concentration (gr/dscf)	PM Emission Rate (lb/hr)	PM Concentration (lb/1,000 lbs Gas Flow*)	PM Emission Rate (lb/mmBtu)	
				Result	Result	LEE Qualification
Filterable Particulate Matter						
UNIT 1	1	0.00139	1.12	0.002	0.003	-
	2+	0.00150	1.24	0.003	0.003	-
	3+	0.00165	1.33	0.003	0.004	-
	Average	**0.00151**	**1.23**	**0.003**	**0.003**	**0.015**
UNIT 2	1	0.00173	1.47	0.003	0.004	-
	2	0.00160	1.33	0.003	0.004	-
	3+†	0.00280	2.40	0.005	0.006	-
	Average	**0.00204**	**1.73**	**0.004**	**0.005**	**0.015**

* Emissions in pounds of particulate per 1000 pounds gas flow corrected to 50 % excess air.

+ Soot blowing occurred during this test run.

† Scrubber was bypassed briefly during test run due to the SDA atomizer being swapped out.

3.0 SOURCE DESCRIPTION

3.1 PROCESS AND RATED CAPACITY

TES Filer City Station operates a cogeneration power plant with a rated output of 60-megawatts (MW) net and 50,000 pounds of process steam per hour. The electricity and process steam are sold under contract to public and/or private companies.

Each unit has a nominal heat input rating of approximately 384 mmBtu/hour. At full load, each unit is capable of producing approximately 320,000 pounds per hour of steam, and this steam is fed to a common steam turbine and electrical generator.

The exhaust gas from each boiler is vented to an individual baghouse for PM control and a spray dryer absorber (SDA) flue gas desulfurization (FGD) system for sulfur dioxide (SO_2) and acid gas control. 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.

3.2 RAW AND FINISHED MATERIALS

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. Units 1 and 2 are classified as "coal-fired unit not low rank virgin coal" in Item 1 of Table 2 Subpart UUUUU. During the tests, bituminous coal, TDF, and wood were fired.

In March of 2016, installation of natural gas-fired burners in Units 1 and 2 was completed. Natural gas is utilized as a clean startup fuel under MATS, as well as at other times for flame stabilization and other purposes. However, during this test event, Units 1 and 2 did not fire natural gas. Further, 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 near future.

3.3 OPERATING PARAMETERS

The following operating parameters were recorded during the test program and are included in Appendix D:

- Total heat input (mmBtu/hr)
- Steam flow (1,000s lb/hr) [In lieu of electrical load, which is only determined on a combined basis.]
- Fuel blend firing rate (lb/hr)
- CO_2 concentration (%, wet)
- Steam pressure (PSIA)
- Opacity (%)
- Composite fuel factor (CO_2-based)
- SO_2 reduction (%) [In lieu of scrubber liquor flow rate.]

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Consumers Energy tested for filterable particulate matter using the U.S. EPA 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

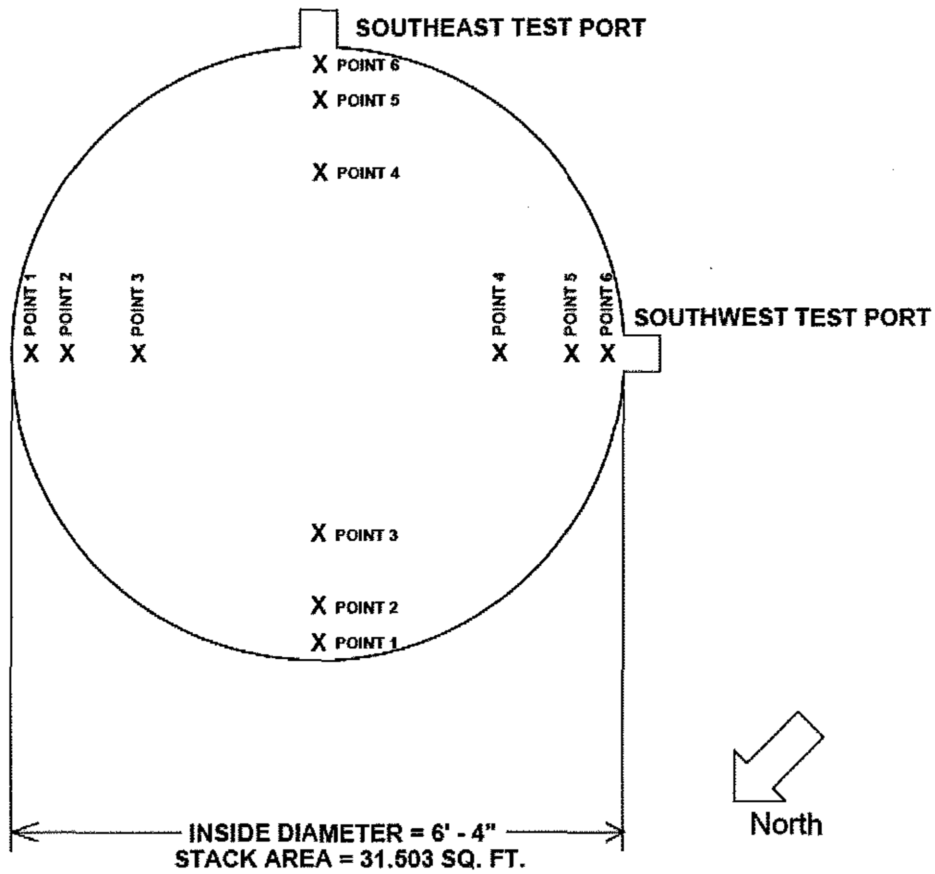
4.1 Sample Location and Traverse Points

The number and location of traverse points for determining exhaust gas velocity and volumetric air-flow was determined in accordance with U.S. EPA Method 1, *Sample and Velocity Traverses for Stationary Sources*. Each exhaust gas flue is 76 inches in diameter with two 6-inch internal diameter ports apiece that extend 20 inches from the flue interior wall. The ports are situated:

- Approximately 90 feet or 14 duct diameters downstream of a duct bend disturbance, and
- Approximately 150 feet or 24 duct diameters upstream of the exhaust to atmosphere.

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 of 12 sample points. The Unit 1 duct cross section and traverse point detail is presented as Figure 4-1; Unit 2 is identical to Unit 1 with the exception that the two test ports are located at the northeast and northwest compass positions. A schematic of the sample location is presented as Figure 4-2.

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

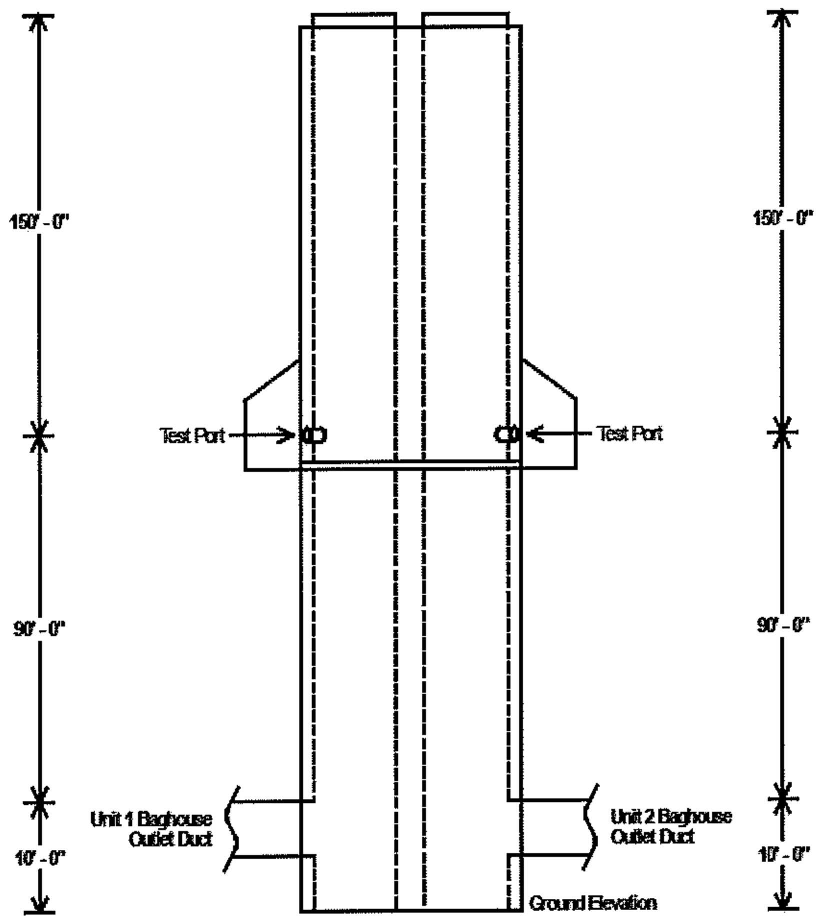


Probe Depths From Inside Stack Wall

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"

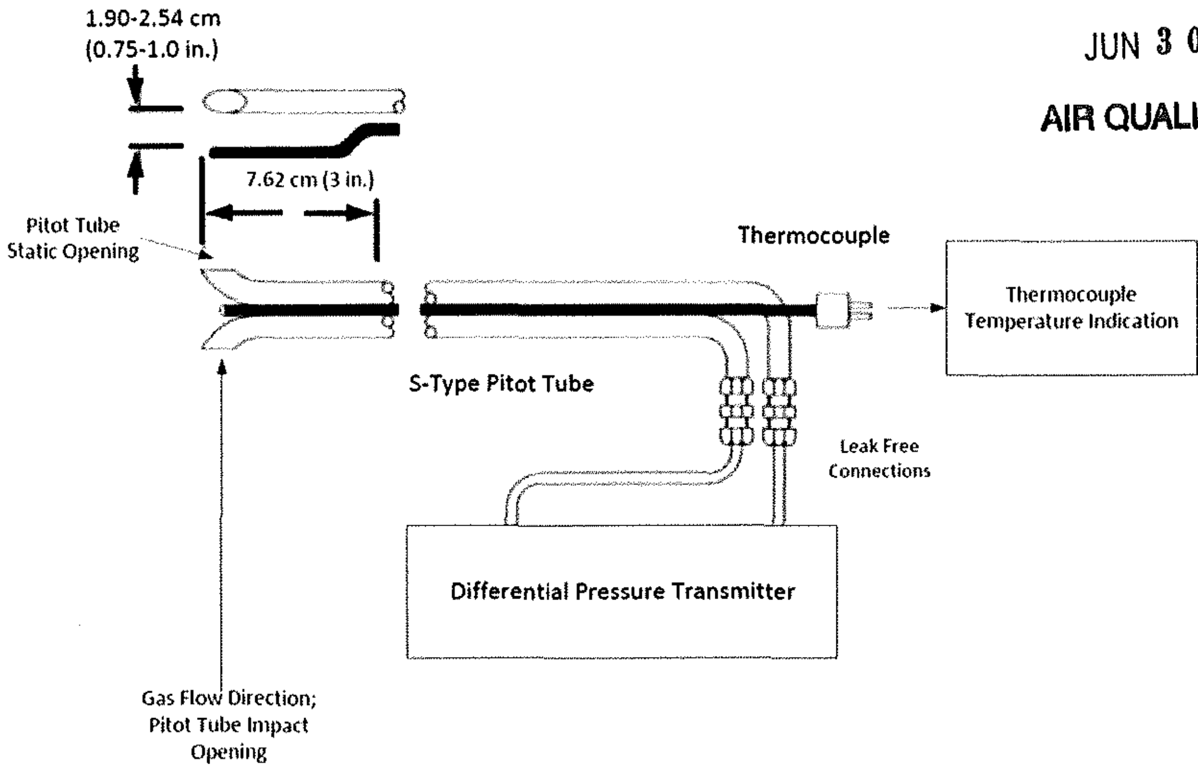
Figure 4-2. Unit 1 and 2 Test Port Elevation



4.2 Velocity and Temperature

The exhaust gas velocity and temperature were measured using U.S. EPA 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 the Method 2 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 U.S. EPA 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. 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 observed to be 3.25° for Unit 1 and 8.25°

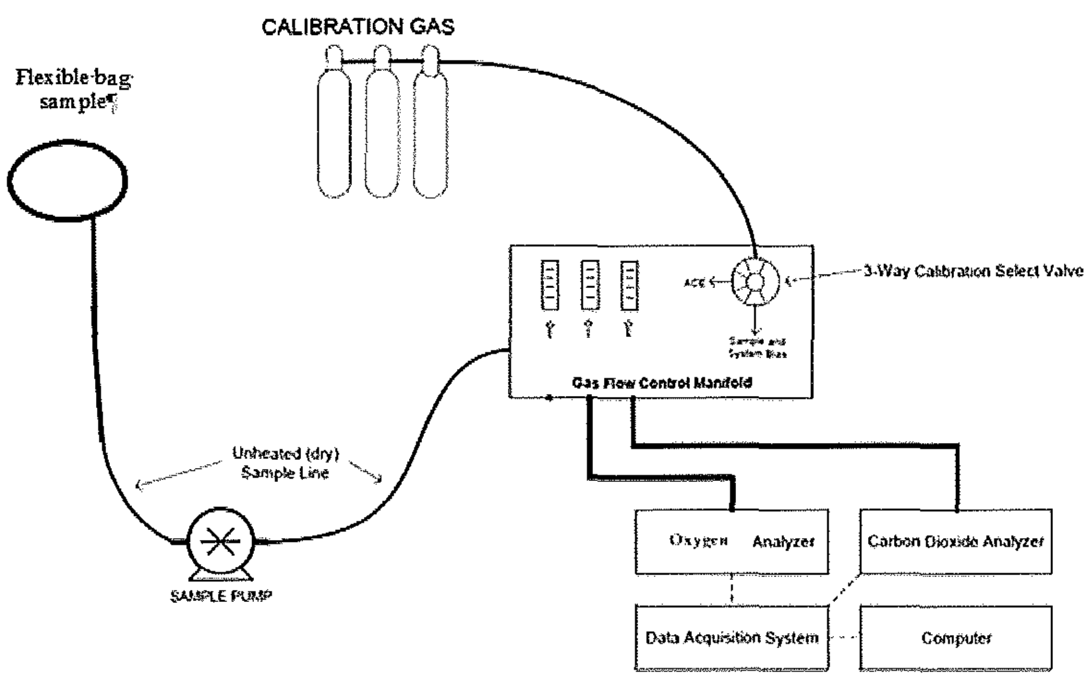
for Unit 2, thus meeting the less than 20° requirement and in the absence of ductwork and/or stack configuration changes, this null angle information is considered to be valid and additional cyclonic flow verification was not performed prior to the PM test.

4.3 Molecular Weight

The exhaust gas composition and molecular weight was measured using the sampling and analytical procedures of U.S. EPA 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 FPM run from each of 12 traverse points into a stainless steel lined probe and Teflon® 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 test runs, 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.

4.4 Moisture Content

The exhaust gas moisture content was determined using U.S. EPA 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.

4.5 Emission Rates (USEPA Method 19)

U.S. EPA 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 4-5 presents the emissions calculation used:

Figure 4-5. U.S. EPA 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

$\%CO_{2d}$ = Concentration of carbon dioxide on a dry basis (%, dry)

Refer to Appendix A for example calculations.

4.6 Particulate Matter

Filterable particulate matter samples were collected isokinetically following the procedures of U.S. EPA Method 5, *Determination of Particulate Matter Emissions from Stationary Sources* with the necessary modifications specified in the MATS Rule for qualifying for low emitting EGU (LEE) status. Specifically, the Method 5 front half temperature was 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 duct, filterable PM adheres to the inside of a nozzle, heated probe, and on a heated quartz-fiber filter. Moisture or water vapor in the gas condenses in a series of impingers following the heated filter. Figure 4-6 depicts the Method 5 sample apparatus and Table 4-2 provides Method 5 impinger configuration detail.

Figure 4-6. U.S. EPA Method 5 Sampling Train

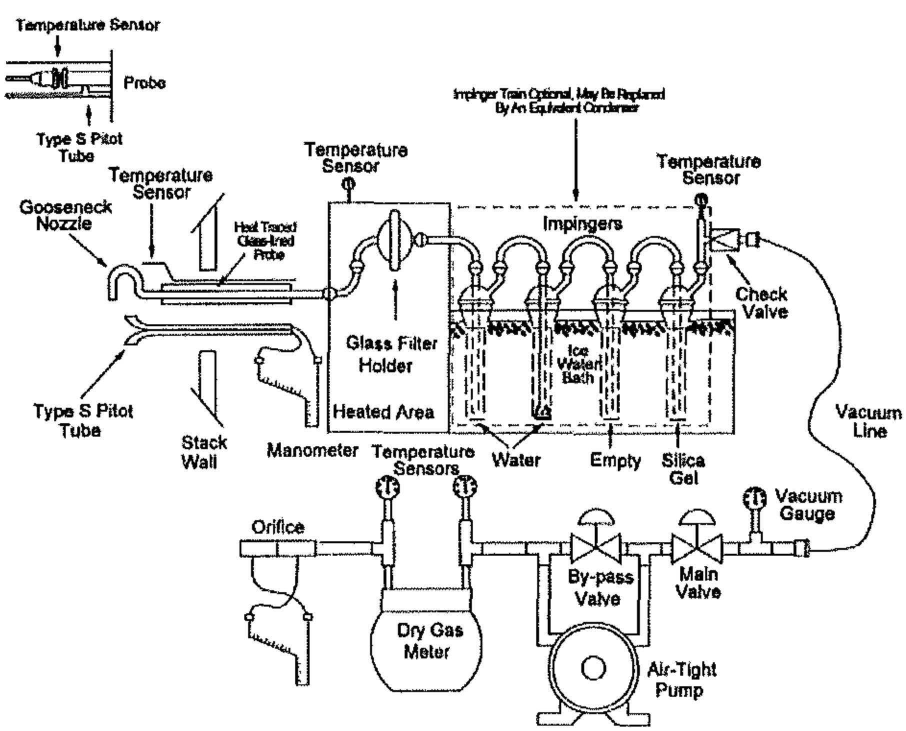


Table 4-2
Method 5 Impinger Configuration

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 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.

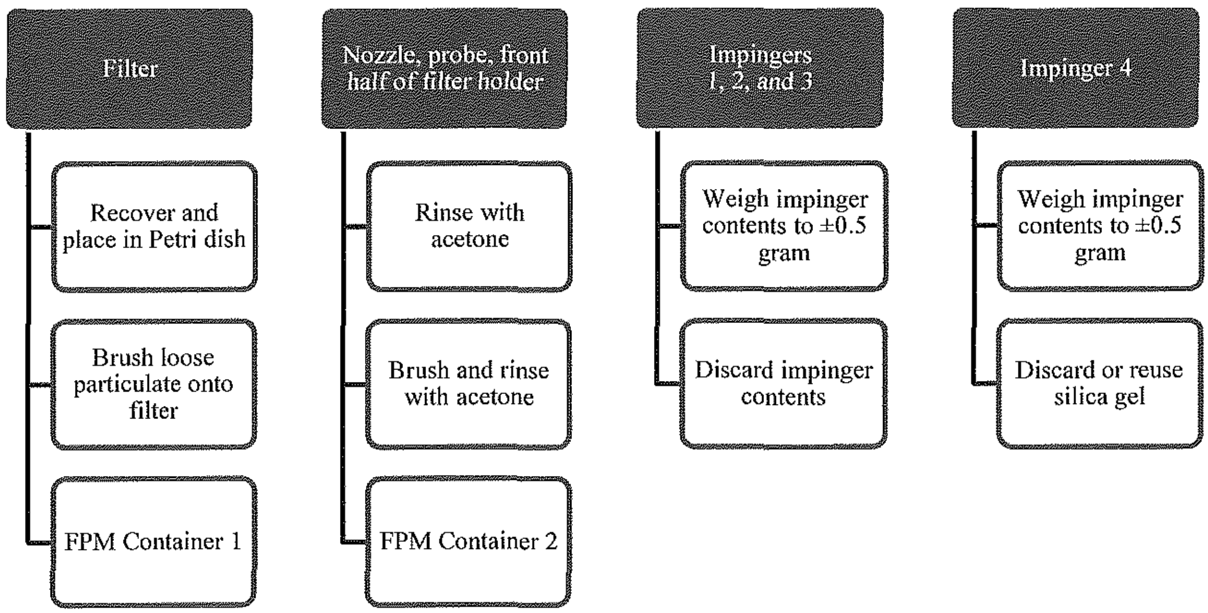
The impact and static pressure openings of the S-Type Pitot tube were leak-checked at or above a velocity head of 3.0 inches of water for a minimum of 15 seconds. The PM sample apparatus was leak-checked by capping the nozzle tip and applying a vacuum of approximately 15 inches of mercury while the dry-gas 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 within 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.

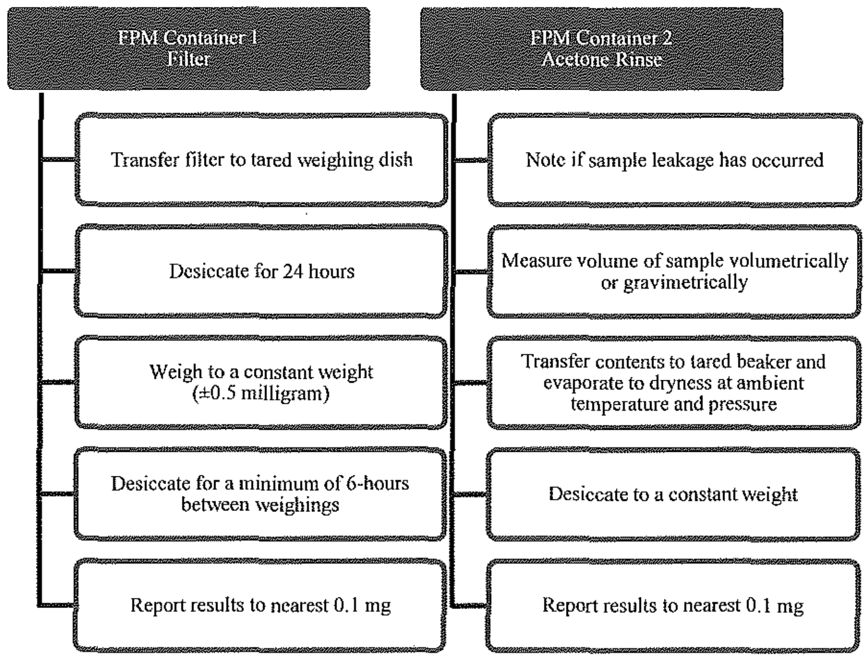
The filter was recovered from the filter housing and placed in a Petri dish, sealed with Teflon tape, and labeled as "FPM Container 1." The nozzle and probe liner, and the front half of the filter housing were triple rinsed with acetone to collect particulate matter. The acetone rinses were collected 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 4-7 for the U.S. EPA Method 5 sample recovery scheme.

Figure 4-7. U.S. EPA 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 U.S. EPA Method 5 procedures as summarized in the analytical scheme presented in Figure 4-8. Refer to Appendix C for laboratory data sheets.

Figure 4-8. U.S. EPA Method 5 Analytical Scheme



5.0 TEST RESULTS AND DISCUSSION

The test program results described herein demonstrate compliance with MATS Rule quarterly performance testing requirements and emission limits as the average of three-run lb/mmBtu emission rates indicate compliance. Furthermore, both EUBOILER01 and EUBOILER02 achieved MATS LEE qualification criteria for the third consecutive calendar quarter.

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. As noted in Table 3-1, the Unit 2 SDA atomizer was changed out during Run 3 of the PM test; such change out is part of the routine weekly maintenance activities conducted by the plant.

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.

5.3 FIELD QUALITY ASSURANCE / QUALITY CONTROL PROCEDURES

The U.S. EPA 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 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	Measure null angles	Pre-test	≤20°	Yes

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria	QA/QC Met
	flow				
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 U.S. EPA 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 introduced directly into analyzers	Pre-test	±2.0% of the calibration span	Yes
M3A: System Bias and Analyzer Drift	Evaluates ability of sampling system to deliver stack gas to analyzers	Calibration gases introduced 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	≥1.0 dscm (≥2.0 dscm for LEE testing)	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 U.S. EPA 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 a leak free assembly. Refer to field data sheets for verification of Pitot tube leak checks.

5.3.2 Dry Gas Meter QA/QC Checks

The dry-gas meter calibration checks in comparison to the U.S. EPA tolerance were acceptable. Refer to the PM Results Summary Table for calibration data.

5.3.3 Thermocouple QA/QC Checks

The thermocouples used to measure the exhaust gas temperature were calibrated according to procedures outlined in the *Quality Assurance Handbook for Air Pollution Measurement Systems:* Volume III, Stationary Source-Specific Methods, Method 2, Type S Pitot Tube Inspection, and the *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 2500°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 a thermocouple system is operating within ± 1.0 percent of the absolute measured temperature, while taking into account the presence of disconnected wire junctions, other loose connections or a potential miscalibrated temperature display. Refer to the PM Results Summary Table for calibration data.

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 4.3 was audited for measurement accuracy and data reliability. The analyzers passed the applicable calibration, bias and drift criteria. Refer to Appendix E for additional calibration data.

5.3.6 QA/QC Blanks

Reagent and filter blanks were analyzed for the parameters of interest. The results of the blanks are presented in the Table 5-2.

Table 5-2
QA/QC Blanks

Sample Identification	Result (mg)	Comment
Method 5 Acetone Field Blank	1.6	Reagent volume: 181 milliliters Field blank correction applied
Method 5 Laboratory Filter Blank	0.1	Reporting limit: 0.1 milligrams

Note that as the acetone blank result equated to an acetone blank residue concentration of greater than 0.001 percent, the acetone blank adjustment was based upon 0.001% in accordance with Sections 7.2 and 12.8 of Method 5.

5.4 LABORATORY QUALITY ASSURANCE / QUALITY CONTROL PROCEDURES

Laboratory quality assurance and quality control procedures were performed in accordance with U.S. EPA 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.

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Table 1 - Particulate Matter Results

Facility and Source Information	Units	Run 1	Run 2	Run 3	Average
Customer:		TES Filer City Station			
Source:		Unit 1			
Work Order:		4101582			
Date:		5/16/2017	5/16/2017	5/17/2017	
Unit Load:	MW_g				#DIV/0!
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	29.21	29.15	29.10	29.15
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	-0.70	-0.77
Nozzle Diameter, D_n	inches	0.212	0.212	0.212	0.212
Run Start Time	hr:mm	12:30	15:25	9:00	
Run Stop Time	hr:mm	14:40	17:35	11:05	
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	442.82	541.91	639.91	541.55
Dry Gas Meter Final Volume	ft^3	536.17	639.15	733.19	636.17
Average Pressure Difference across the Orifice Meter, ΔH	inches of H_2O	1.95	2.05	1.88	1.96
Average Dry Gas Meter Temperature, T_m	°F	80.0	84.0	83.8	82.6
Average Square Root Velocity Head, √Δp	√inches H_2O	1.1561	1.1756	1.1506	1.1608
Stack Gas Temperature, $T_{s(abavg)}$	°F	178.3	180.4	177.0	178.6
Source Moisture Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Volume of Water Vapor Condensed in Silica Gel, $V_{wsg(std)}$	scf	0.9	0.9	1.2	1.0
Total Volume of Water Vapor Condensed, $V_{w(std)}$	scf	16.069	15.208	15.409	15.562
Volume of Gas Sample as Measured by the Dry Gas Meter, V_m	dcf	93.350	97.237	93.279	94.622
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscf	89.415	92.295	88.377	90.029
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscm	2.532	2.614	2.503	2.55
Moisture Content of Stack Gas, B_{ws}	% H_2O	15.23	14.15	14.85	14.74
Gas Analysis Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Carbon Dioxide, %CO_2	%, dry	11.7	11.8	11.6	11.7
Oxygen, %O_2	%, dry	7.9	7.7	8.2	7.9
Nitrogen, %N	%, dry	80.43	80.52	80.21	80.39
Dry Molecular Weight, M_d	lb/lb-mole	30.18	30.19	30.19	30.19
Wet Molecular Weight, M_s	lb/lb-mole	28.33	28.47	28.38	28.39
Percent Excess Air, %EA	%	59.14	56.73	62.79	59.55
Fuel F-Factor, F_o:	dimensionless	1.114	1.121	1.095	1.110
Fuel F-Factor, F_c:	scf/mmBtu	1,801	1,801	1,800	1,801
Fuel F-Factor, F_d:	dscf/mmBtu				
Gas Volumetric Flow Rate Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Average Stack Gas Velocity, v_s	ft/s	73.0	74.2	72.6	73.3
Stack Gas Volumetric Flow Rate, Q	acfm	137,968	140,323	137,296	138,529
Stack Gas Standard Volumetric Flow Rate, Q_s	scfm	111,188	112,486	110,488	111,387
Stack Gas Dry Standard Volumetric Flow Rate, Q_{sd}	dscfm	94,250	96,573	94,084	94,969
Percent of Isokinetic Sampling, I	%	101.7	102.4	100.7	101.6
Gas Concentrations and Emission Rates		**Run 1**	**Run 2**	**Run 3**	**Average**
Mass of Filterable PM Collected, m_n	mg	8.08	8.98	9.48	8.85
Filterable PM Concentration, c_s	gr/dscf	0.00139	0.00150	0.00165	0.00151
Filterable PM Concentration at Stack Conditions, $c_{s@stack\ conditions}$	mg/wacm	2.180	2.365	2.596	2.38031
Filterable PM Concentration, C_s [Actual Conditions, Wet Basis]	lb/1,000 lbs	0.002	0.003	0.003	0.003
Filterable PM Concentration, C_{s50} [Actual Conditions, Wet Basis]	lb/1,000 lbs @ 50% EA	0.002	0.003	0.003	0.003
Filterable PM Mass Emission Rate, E	lb/hr	1.12	1.24	1.33	1.23
Filterable PM, lb/mmBtu, E	lb/mmBtu	0.0031	0.0033	0.0037	0.0033
Filterable PM, tpy [Assumes 8,760 Hrs/Yr Operation]	tpy	4.92	5.43	5.84	5.40
Dry Gas Metering System Calibration Check [1]		**Run 1**	**Run 2**	**Run 3**	**Average**
Dry Gas Meter Calibration Factor (Y_d):	dimensionless	0.999	0.999	0.999	0.999
Y_{qa} (calculated):	dimensionless	0.996	0.988	0.987	0.990
Assigned Δ H (@ 0.75 SCFM) of the meter system:	dimensionless	1.83	1.83	1.83	1.83
Allowable Y_{qa} (+/-) 5%:	dimensionless	0.949 to 1.049	0.949 to 1.049	0.949 to 1.049	-----
Actual Yds Deviation, %:	%	0.26	1.15	1.24	0.88
Dry Gas Metering System Thermocouple Calibration Check [2]		**Reference, °F**	**Module, °F**	**Difference**	**Requirement**
Stack	°F	79	80	1	±2° F
Probe	°F	80	80	0	±2° F
Filter	°F	80	80	0	±2° F
Dryer	°F	79	79	0	±2° F
Auxiliary	°F	79	79	0	±2° F

[1] Emission Measurement Center Approved Alternative Meter Calibration Method (ALT-009)

[2] Emission Measurement Center Approved Alternative Thermocouple Calibration Method (ALT-011)

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Table 1 - Particulate Matter Results

Facility and Source Information	Units	Run 1	Run 2	Run 3	Average
Customer:		TES Filer City Station			
Source:		Unit 2			
Work Order:		4101582			
Date:		5/15/2017	5/15/2017	5/16/2017	
Unit Load:	MW_g				#DIV/0!
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	29.42	29.39	29.25	29.35
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	0.212	0.212	0.212	0.212
Run Start Time	hr:mm	15:35	18:00	9:37	
Run Stop Time	hr:mm	17:47	20:11	11:50	
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	150.41	248.30	346.68	248.46
Dry Gas Meter Final Volume	ft^3	247.55	346.19	441.84	345.19
Average Pressure Difference across the Orifice Meter, ΔH	inches of H_2O	2.13	2.16	2.08	2.13
Average Dry Gas Meter Temperature, T_m	°F	84.1	88.1	71.6	81.3
Average Square Root Velocity Head, √Δp	√inches H_2O	1.2033	1.1759	1.2126	1.1973
Stack Gas Temperature, $T_{s(abavg)}$	°F	175.6	175.3	177.0	176.0
Source Moisture Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Volume of Water Vapor Condensed in Silica Gel, $V_{wsg(std)}$	scf	1.5	1.1	1.8	1.5
Total Volume of Water Vapor Condensed, $V_{w(std)}$	scf	16.017	16.022	15.159	15.732
Volume of Gas Sample as Measured by the Dry Gas Meter, V_m	dcf	97.140	97.893	95.160	96.731
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscf	93.057	93.005	92.749	92.937
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscm	2.635	2.634	2.627	2.63
Moisture Content of Stack Gas, B_{ws}	% H_2O	14.68	14.70	14.05	14.48
Gas Analysis Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Carbon Dioxide, $\%CO_2$	%, dry	11.6	11.4	11.7	11.6
Oxygen, $\%O_2$	%, dry	8.6	8.9	8.3	8.6
Nitrogen, %N	%, dry	79.78	79.68	80.02	79.83
Dry Molecular Weight, M_d	lb/lb-mole	30.20	30.18	30.20	30.20
Wet Molecular Weight, M_s	lb/lb-mole	28.41	28.39	28.49	28.43
Percent Excess Air, %EA	%	69.05	73.38	64.28	68.90
Fuel F-Factor, F_o:	dimensionless	1.059	1.051	1.079	1.063
Fuel F-Factor, F_c:	scf/mmBtu	1,801	1,801	1,800	1,801
Fuel F-Factor, F_d:	dscf/mmBtu				
Gas Volumetric Flow Rate Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Average Stack Gas Velocity, v_s	ft/s	75.4	73.7	76.2	75.1
Stack Gas Volumetric Flow Rate, Q	acfm	142,549	139,399	144,034	141,994
Stack Gas Standard Volumetric Flow Rate, Q_s	scfm	116,237	113,597	116,509	115,448
Stack Gas Dry Standard Volumetric Flow Rate, Q_{sd}	dscfm	99,168	96,904	100,142	98,738
Percent of Isokinetic Sampling, I	%	100.6	102.8	99.2	100.9
Gas Concentrations and Emission Rates		**Run 1**	**Run 2**	**Run 3**	**Average**
Mass of Filterable PM Collected, m_n	mg	10.44	9.64	16.86	12.31
Filterable PM Concentration, c_s	gr/dscf	0.00173	0.00160	0.00280	0.00204
Filterable PM Concentration at Stack Conditions, $c_{s@stack\ conditions}$	mg/wacm	2.757	2.544	4.463	3.25458
Filterable PM Concentration, C_s [Actual Conditions, Wet Basis]	lb/1,000 lbs	0.003	0.003	0.005	0.003
Filterable PM Concentration, C_{s50} [Actual Conditions, Wet Basis]	lb/1,000 lbs @ 50% EA	0.003	0.003	0.005	0.004
Filterable PM Mass Emission Rate, E	lb/hr	1.47	1.33	2.40	1.73
Filterable PM, lb/mmBtu, E	lb/mmBtu	0.0038	0.0036	0.0061	0.0045
Filterable PM, tpy [Assumes 8,760 Hrs/Yr Operation]	tpy	6.43	5.81	10.52	7.59
Dry Gas Metering System Calibration Check [1]		**Run 1**	**Run 2**	**Run 3**	**Average**
Dry Gas Meter Calibration Factor (Y_d):	dimensionless	0.999	0.999	0.999	0.999
Y_{qa} (calculated):	dimensionless	1.001	1.005	1.003	1.003
Assigned Δ H (@ 0.75 SCFM) of the meter system:	dimensionless	1.83	1.83	1.83	1.83
Allowable Y_{qa} (+/-) 5%:	dimensionless	0.949 to 1.049	0.949 to 1.049	0.949 to 1.049	-----
Actual Yds Deviation, %:	%	-0.22	-0.62	-0.37	-0.40
Dry Gas Metering System Thermocouple Calibration Check [2]		**Reference, °F**	**Module, °F**	**Difference**	**Requirement**
Stack	°F	79	80	1	±2° F
Probe	°F	80	80	0	±2° F
Filter	°F	80	80	0	±2° F
Dryer	°F	79	79	0	±2° F
Auxiliary	°F	79	79	0	±2° F

[1] Emission Measurement Center Approved Alternative Meter Calibration Method (ALT-009)

[2] Emission Measurement Center Approved Alternative Thermocouple Calibration Method (ALT-011)