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# Particulate Matter Test

# EUBOILER2

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

**Test Date: October 25, 2016**

**December 12, 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**

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AIR QUALITY DIVISION

# 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 10/01/2016 To 12/31/2016

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

| Name of Responsible Official (print or type) | Title | Phone Number |
|---|---|---|
| Norman J. Kapala | Executive Director of Coal Generation | 616-738-3200 |

Signature of Responsible Official: [signature]  Date: 12-13-16

* 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 compliance with the applicable filterable particulate matter (FPM) limit 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]). The testing is also being used to demonstrate qualification as a Low Emitting Electric Generating Unit (LEE) for FPM.

The test program was conducted on October 25, 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. Three 125-minute RM5 tests were performed 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) | MATS LEE Qualification Rate for FPM[1] (lb/mmBtu) |
|---|---|---|---|
| 1 | 0.00144 | 0.003 | - |
| 2 | 0.00123 | 0.003 | - |
| 3 | 0.00151 | 0.003 | - |
| **Average** | **0.00139** | **0.003** | **0.015** |

[1] This emission rate is 50% of the applicable MATS FPM limit of 0.030 lb/mmBtu.

Each individual run, as well as the average of the three runs, was below the MATS LEE qualification emission rate limit of 0.015 pounds of particulate matter per million British thermal unit (mmBtu) heat input. Detailed results are presented in the RCTS Table 1 JHC2PM 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 compliance with the applicable filterable particulate matter (FPM) limit 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]). The testing is also being used to demonstrate qualification as a Low Emitting Electric Generating Unit (LEE) for FPM.

Comparison Testing between USEPA Reference Method 5 (RM5) FPM results and MATS 5 FPM results at the source on August 23-24, 2016 indicated no appreciable difference between the average lb/mmBtu particulate matter emission rates determined by the two different measurement techniques. Based on the August 23-24, 2016 comparison test results, the test team used USEPA Reference Method 5 for the October 25, 2016 test, as approved by the USEPA in a letter dated April 12, 2016.

This was the second test performed of the quarterly testing regimen under MATS. 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. A test protocol was submitted to the Michigan Department of Environmental Quality (MDEQ) on September 23, 2016 and subsequently approved by Mr. Tom Gasloli, MDEQ Environmental Quality Analyst, in his letter dated October 18, 2016.

The applicable particulate emission limitation from MATS is presented in Table 1-1 below.

**Table 1-1**
**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 |

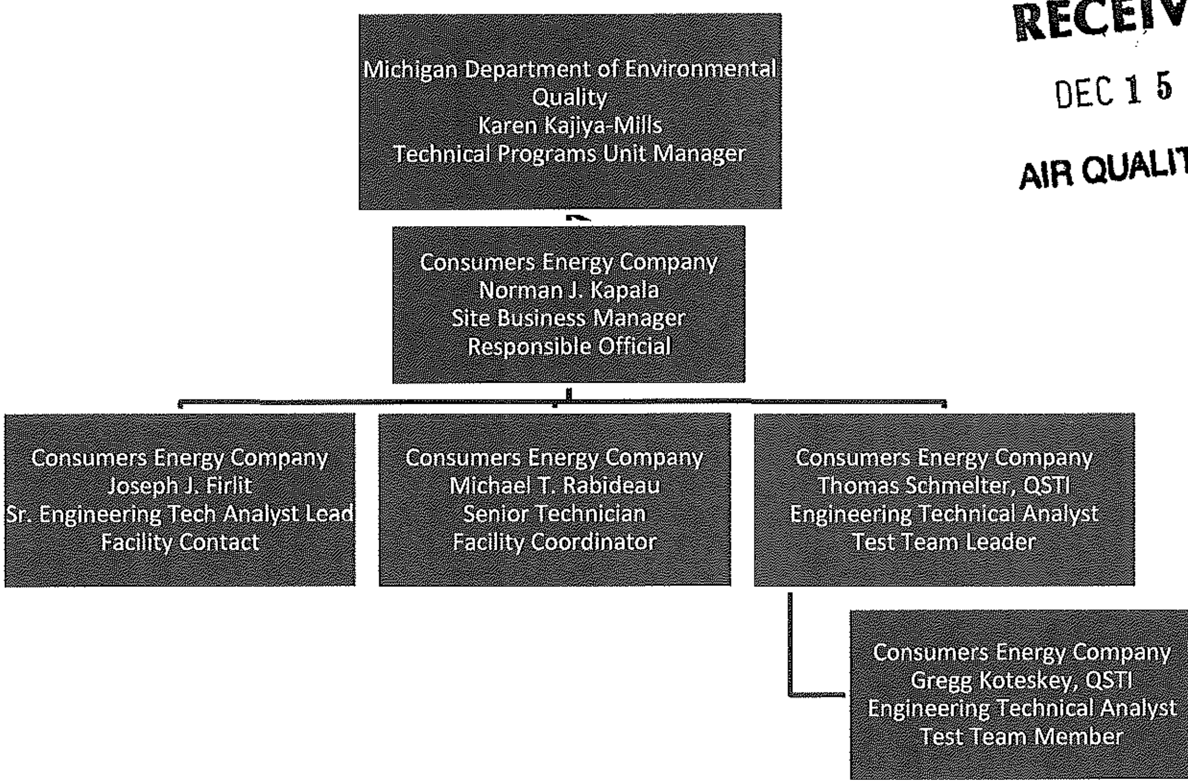
The test was conducted on October 25, 2016 in accordance with applicable requirements and sampling, calibration, and quality assurance procedures specified in 40 CFR 60, Appendix A, reference methods 1, 2, 3A, 4, 5, & 19.

## 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 |
|---|---|---|
| | | |
| Regulatory Agency Representative | Ms. Karen Kajiya-Mills<br>Technical Programs Unit Manager<br>517-335-4874<br>kajiya-millsk@michigan.gov | Michigan Department of Environmental Quality<br>Technical Programs Unit<br>525 W. Allegan, Constitution Hall, 2nd Floor S<br>Lansing, Michigan 48933 |
| Responsible Official | Mr. Norman J. Kapala<br>616-738-3200<br>Executive Director of Coal Generation<br>Norman.Kapala@cmsenergy.com | Consumers Energy Company<br>J. H. Campbell Power Plant<br>17000 Croswell Street<br>West Olive, Michigan 49460 |
| Test Facility | Mr. Joseph J. Firlit<br>616-738-3260<br>Sr. Engineering Tech Analyst Lead<br>Joseph.Firlit@cmsenergy.com | Consumers Energy Company<br>J. H. Campbell Power Plant<br>17000 Croswell Street<br>West Olive, Michigan 49460 |
| Test Facility | Mr. Michael T. Rabideau<br>616-738-3273<br>Senior Technician<br>Michael.Rabideau@cmsenergy.com | Consumers Energy Company<br>J. H. Campbell Power Plant<br>17000 Croswell Street<br>West Olive, Michigan 49460 |
| Test Team Representative | Mr. Thomas Schmelter, QSTI<br>616-738-3234<br>Sr. Engineering Technical Analyst II<br>Thomas.Schmelter@cmsenergy.com | Consumers Energy Company<br>L&D Training Center<br>17010 Croswell Street<br>West Olive, Michigan 49460 |
| Test Team Representative | Mr. Gregg Koteskey, QSTI<br>616-738-3712<br>Engineering Technical Analyst II<br>gregg.koteskey@cmsenergy.com | Consumers Energy Company<br>L&D Training Center<br>17010 Croswell Street<br>West Olive, Michigan 49460 |

# 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). Unit 2 is capable of firing 100% bituminous (eastern) coal, 100% subbituminous (western) coal, and various mixtures of the two coal types. When all coal mills are available, the preceding nominal ratings can only be achieved when firing at least 40% eastern coal. Unit 2 is limited to approximately 300 MW gross when firing only western sub-bituminous coal.

During the performance test, the boiler fired 100% eastern coal and 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 348 MW to 370 MW (92-99% of the achievable capacity based upon the coal blend). Refer to Attachment D for detailed operating data, which was recorded using Eastern Standard Time. Note that the time convention for the reference method testing was Eastern Daylight Savings Time (EDT), so there is a one hour offset between the RM time stamps and CEMS/process data time stamps (where the CEMS time is one hour ahead of RM time).

## 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 state and federal regulations, and the EPA has assigned the facility a Federal Registry Service (FRS) identification number of 110000411108. EUBOILER2 is the emission unit source identification in the permit and is 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.

## 2.3 RESULTS

As shown in Table 2-3, each individual run, as well as the average of the three runs, was below the MATS LEE qualification emission rate of 0.015 pounds of particulate matter per million British thermal unit heat input. Detailed results are presented in the RCTS Table 1 JHC2 PM Results Summary behind the tables tab of this report.

**Table 2-1**
**Summary of Results**

| Run | PM Concentration (gr/dscf) | PM Emission Rate (lb/mmBtu) | MATS LEE FPM Limit |
|---|---|---|---|
| 1 | 0.00144 | 0.003 | - |
| 2 | 0.00123 | 0.003 | - |
| 3 | 0.00151 | 0.003 | - |
| **Average** | **0.00139** | **0.003** | **0.015** |

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.

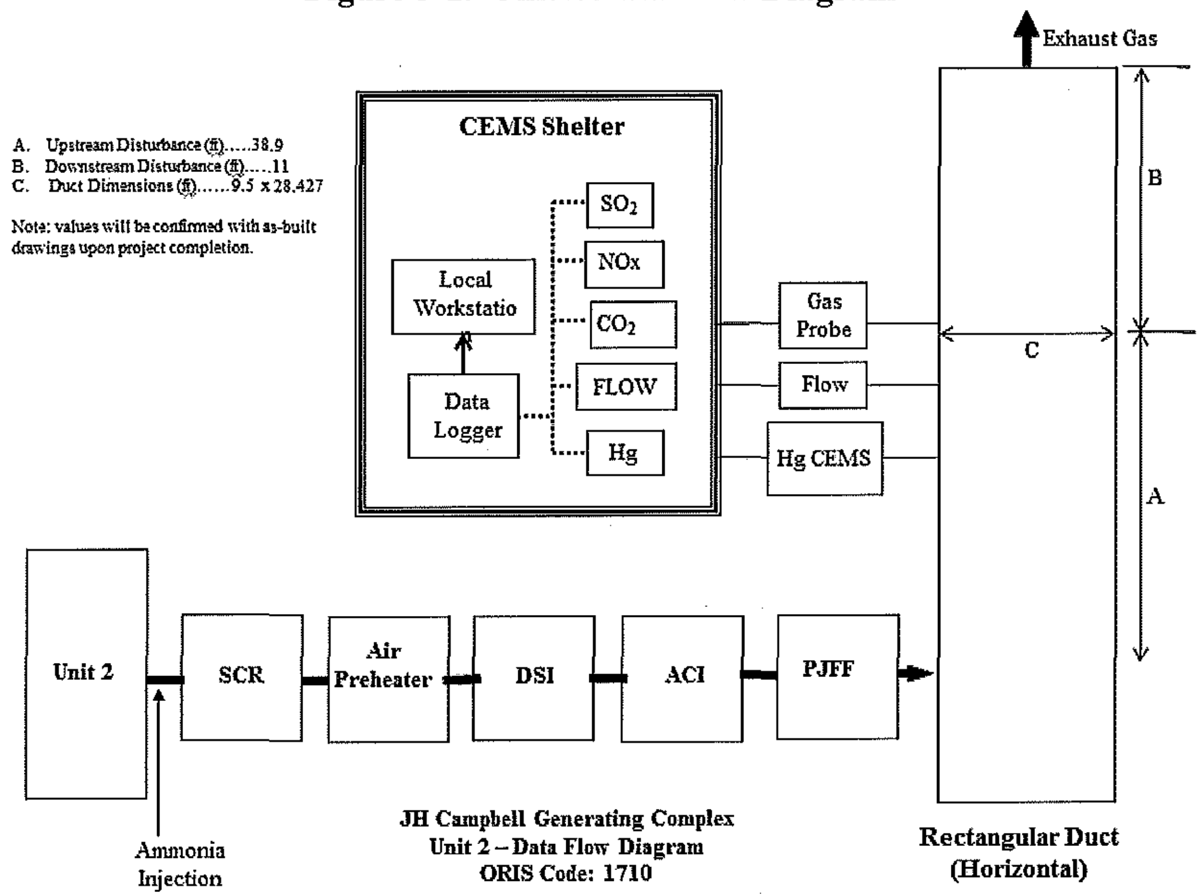
## 3.1 PROCESS

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.

**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. The boiler is classified as a coal-fired unit not firing low rank virgin coal as described in Table 2 to Subpart UUUUU. For this quarterly compliance test, Boiler 2 was burning 100% eastern coal.

## 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.

## 3.5 Process Instrumentation

The process was continuously monitored by boiler operators and environmental technicians, and 1-minute data for the following parameters was collected during each PM test run: Load (MW), CO2 Concentration (Vol-%, Wet), Opacity and $SO_2$ Emission Rate (lb/mmBtu). 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). Refer to Appendix D for detailed operating data.

# 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 |
| 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**

| 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 | Emission rate | M19 | Consumers Energy | - | Stoichiometric calculation | Consumers Energy |

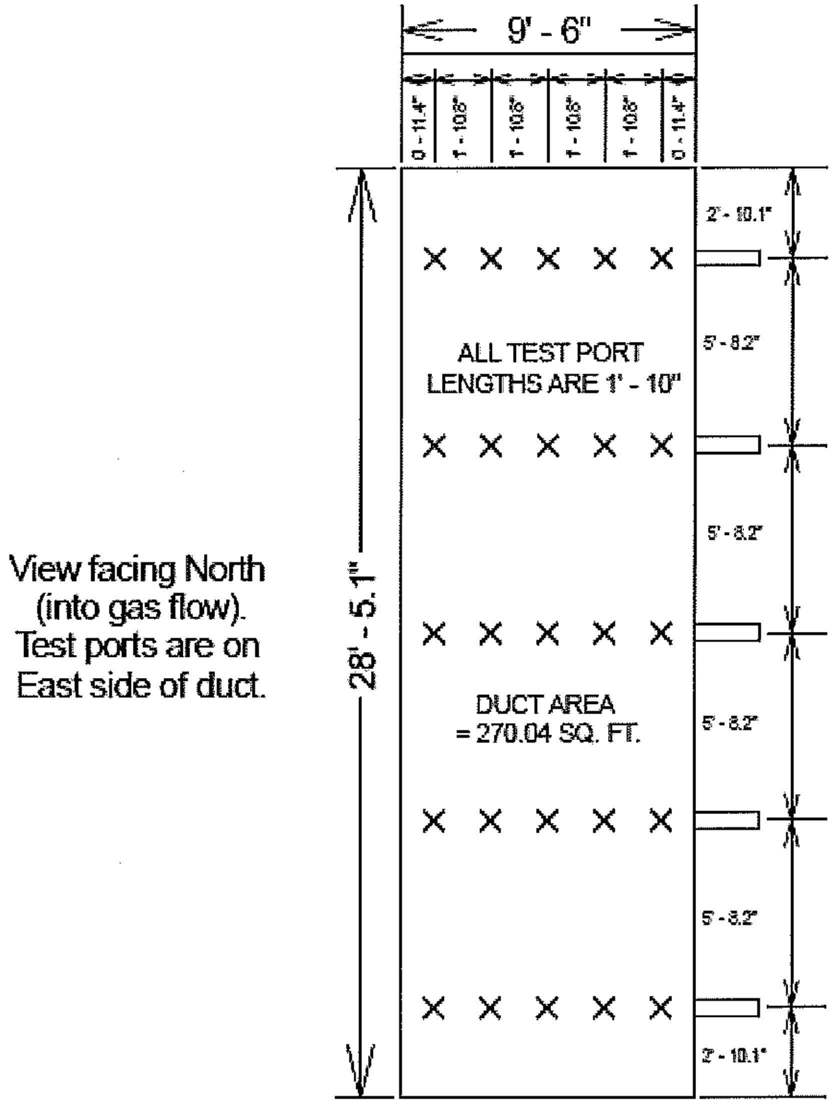
### 4.1.1 Sample Location and Traverse Points

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 five 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 Figure 4-1.

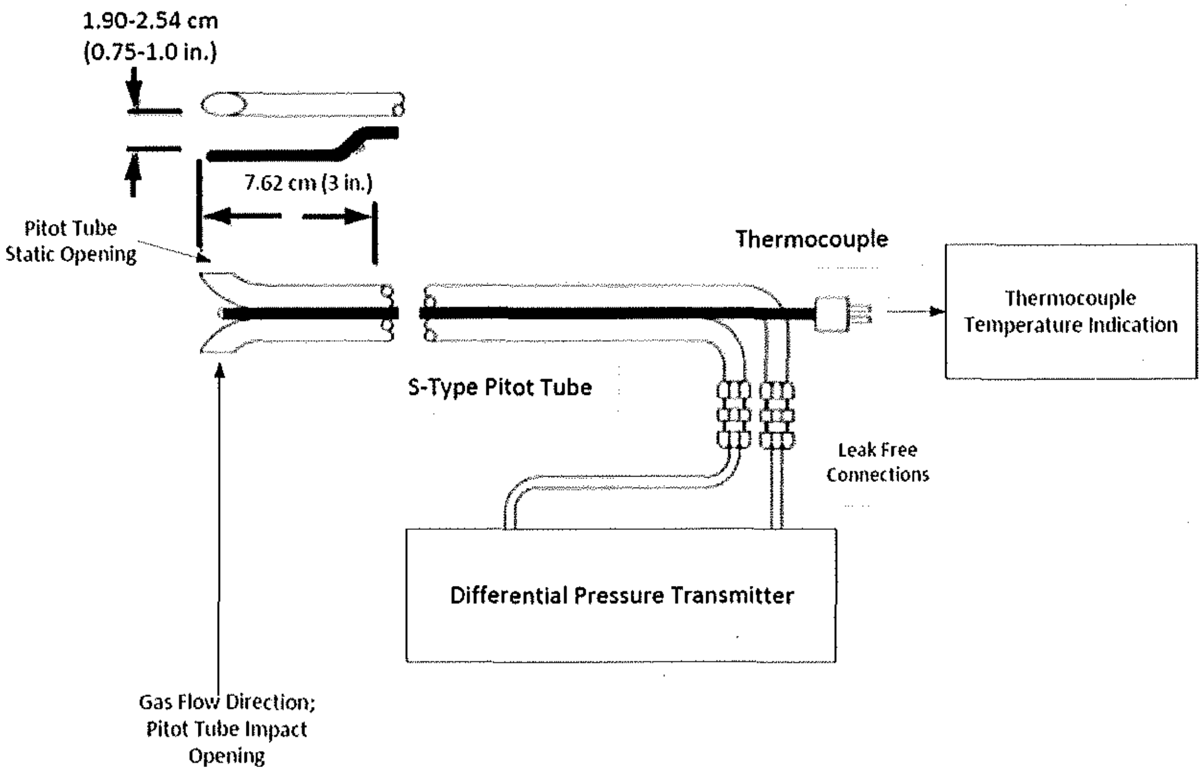
**Figure 4-1. Unit 2 Duct Cross Section and Test Port/Traverse Point Detail**




### 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



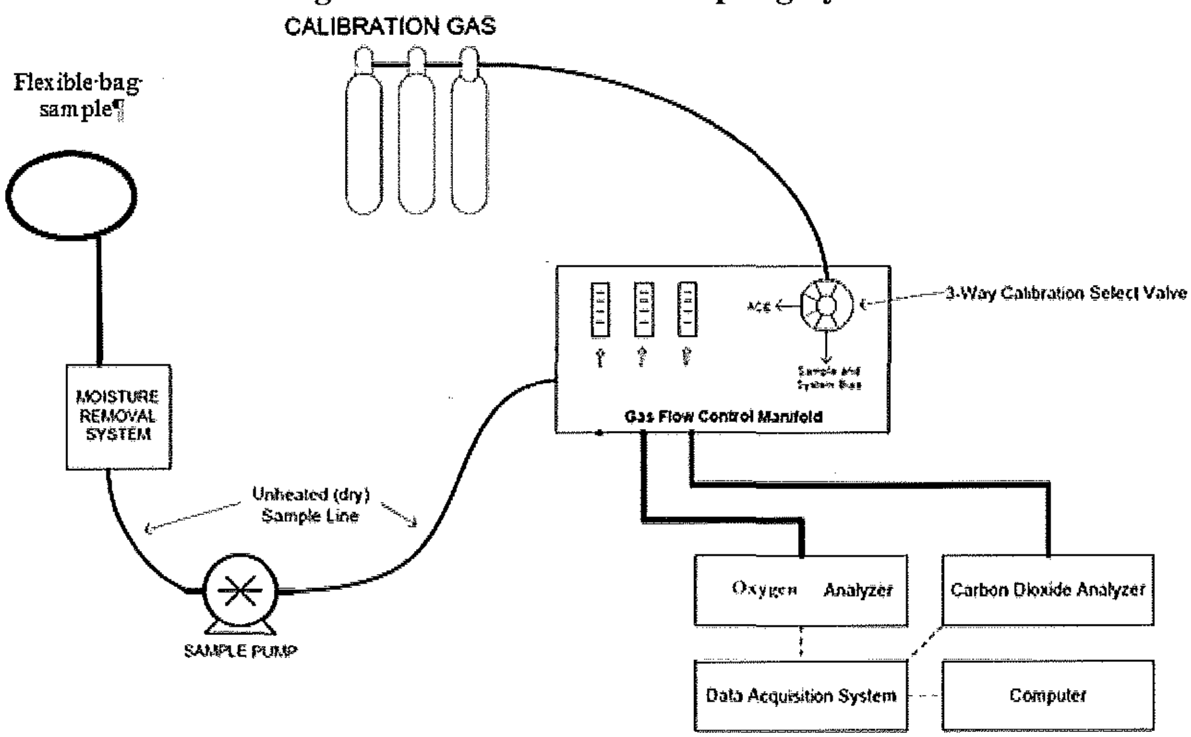

Appendix B of this report includes cyclonic flow test data as verification of the absence of cyclonic flow at the sample location. Method 1, § 11.4.2 indicates *if the average* (null angle) *is greater than 20°, the overall flow condition in the stack is unacceptable, and alternative methodology...must be used.* The average null yaw angle measured at the Unit 2 exhaust on August 23, 2016, prior to the MATS 5 / RM 5 PM Test, was observed to be 3.4°, 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 October 25, 2016 PM Test.

### 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) |

The Unit 2 CEMS utilize the fuel factor provisions in 40 CFR Part 75, Appendix F, Section 3.3.6.5 whereby the worst case fuel factor for any of the fuels combusted in the unit is used to calculate lb/mmBtu emission rates. Although 100% eastern coal was fired during the PM test, the fuel factor for western coal has been used to calculate the PM lb/mmBtu emission rates (consistent with the fuel factor employed for Part 75 monitoring; i.e., "worst-case" fuel factor). This approach is conservative, as using the fuel factor for eastern coal would have resulted in slightly lower lb/mmBtu emission rates.

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 USEPA Method 5, *Determination of Particulate Matter Emissions from Stationary Sources.*

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

The Method 5 sampling apparatus was setup and operated in accordance with the method. 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 sampling train.

## Table 4-3
## Method 5 Impinger Configuration

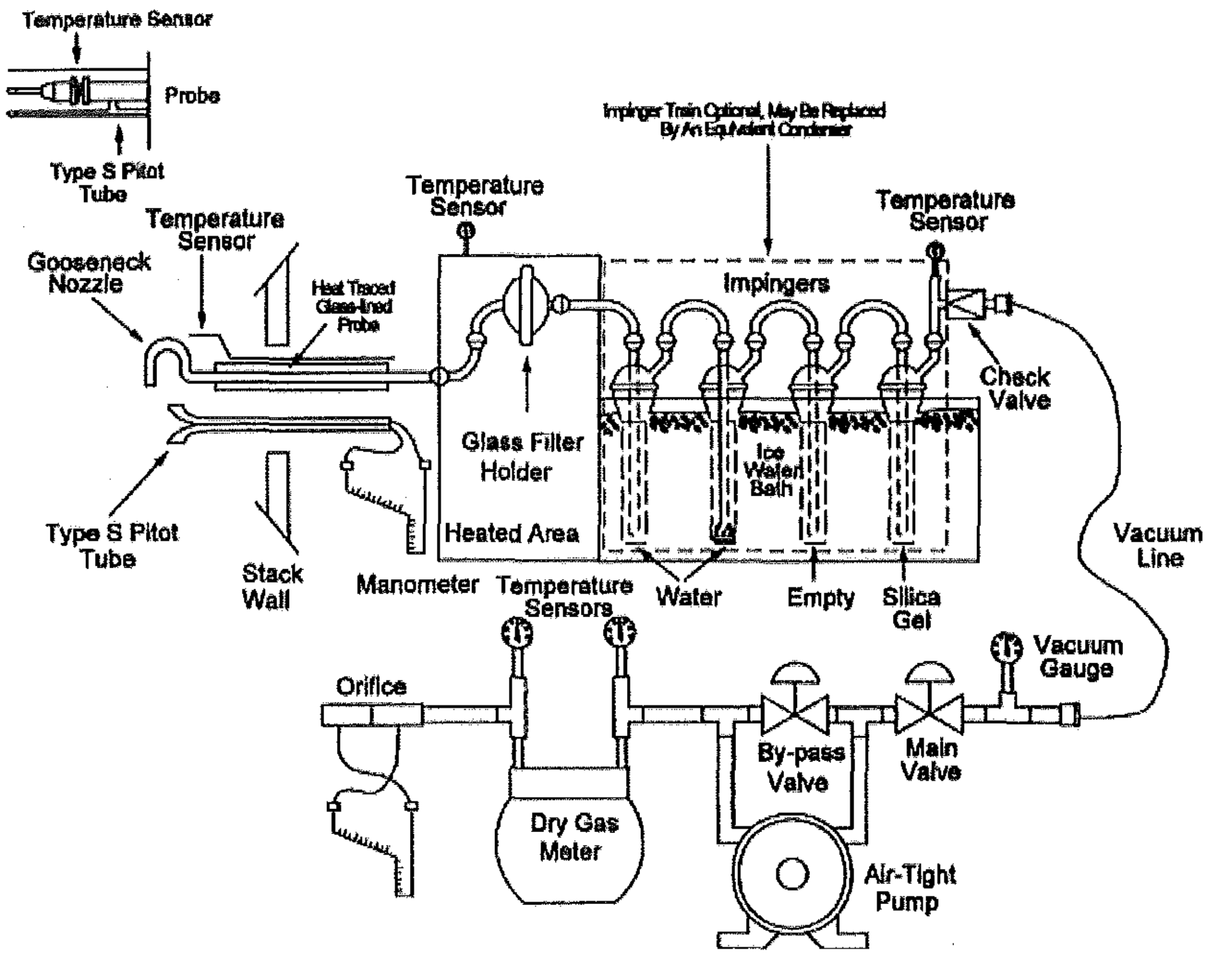
| Impinger Order (Upstream to Downstream) | Impinger Type | Impinger Contents | Amount (gram) |
|---|---|---|---|
| 1 | Modified | Water | 100 |
| 2 | Greenburg-Smith | Water | 100 |
| 3 | Modified | Empty | 0 |
| 4 | Modified | Silica gel desiccant | ~200-300 |

Prior to testing, representative velocity head and temperature data from a recently performed high load flow 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 train was 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 temperature was allowed to stabilize to a temperature of 248±25°F. 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

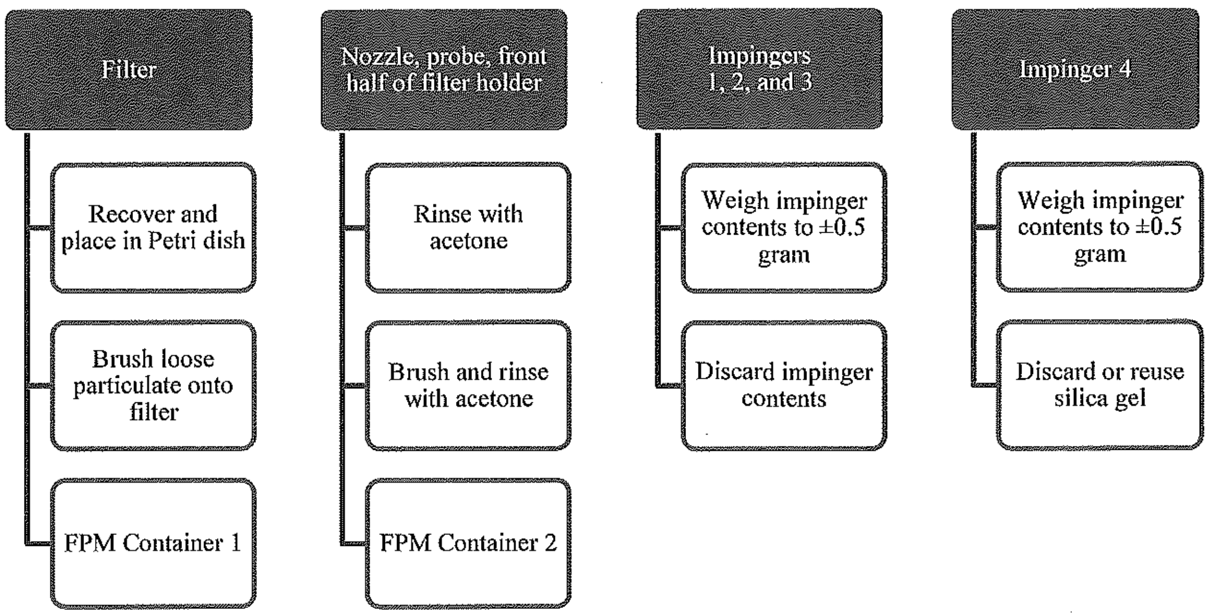



At the conclusion of a test run and the post-test leak check, the sampling apparatus were disassembled and the impingers and filter housing were transported to the recovery area.

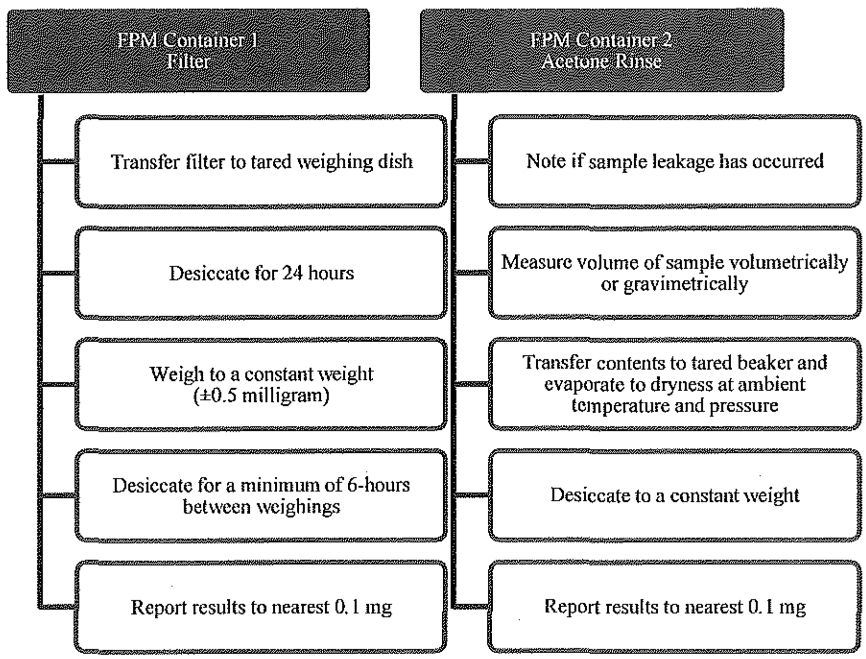
The filter was recovered from the filter housing and placed in a Petri dish, sealed with Teflon tape, and labeled as "FPM Container 1." The nozzle and probe liner, and the front half of the filter housing were triple rinsed with acetone to collect particulate matter. The acetone rinses were collected 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 compliance with the applicable FPM limit 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]). Three 125-minute tests were performed following USEPA Method 5. The results of the testing are presented in Table 2-3. The testing is also being used to demonstrate qualification as a Low Emitting Electric Generating Unit (LEE) for FPM.

Each individual run, as well as the average of the three runs, was below the FPM emission limit of 0.030 pounds of particulate matter per million British thermal unit heat input. The preceding was also true in regards to the LEE qualification emission rate of 0.015 lb/mmBtu (i.e., ½ of the FPM emission limit).

Detailed results are presented in the RCTS 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

Each of the USEPA reference methods performed during the test program 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 from flexible bag samples directly 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 |

## Table 5-1
## QA/QC Procedures

| QA/QC Activity | Purpose | Procedure | Frequency | Acceptance Criteria | QA/QC Met |
|---|---|---|---|---|---|
| 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

The dry-gas meter calibration checks in comparison to the USEPA tolerance were acceptable. Refer to the RCTS-Table 1- JHC2 PM Results Summary for calibration data.

### 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. Refer to the RCTS- Table 1- JHC2 PM Results Summary 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 4.1 were audited for measurement accuracy and data reliability. The analyzers passed the applicable calibration 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 | 0.9 | Sample volume was 200 milliliters. Acetone blank corrections were applied. |
| Method 5 Laboratory Filter Blank | 0.2 | 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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## Regulatory Compliance Testing Services
## Table 1 - JHC2 PM Results

| Facility and Source Information | | | | |
|---|---|---|---|---|
| Customer: | J.H. Campbell | | | |
| Source: | EUBOILER2 | | Unit Load: | High |
| Work Order: | 25319513 | | | |
| Date: | 10/25/2016 | 10/25/2016 | 10/25/2016 | |
| Stack Length, inches: | 114 | 114 | 114 | |
| Stack Width, inches: | 341 | 341 | 341 | |
| Stack Area, Square Feet: | 269.96 | 269.96 | 269.96 | |
| **Source Pollutant Test Data** | **Run 1** | **Run 2** | **Run 3** | **Average** |
| Barometric Pressure, inches mercury: | 29.85 | 29.85 | 29.85 | 29.85 |
| Meter Calibration Factor: | 0.999 | 0.999 | 0.999 | 0.999 |
| Pitot Tube Calibration Factor: | 0.84 | 0.84 | 0.84 | 0.84 |
| Stack Static Pressure, inches water: | 2.00 | 2.00 | 2.00 | 2.00 |
| Nozzle Diameter, inches: | 0.251 | 0.251 | 0.251 | 0.251 |
| Run Start Time: | 8:35 | 11:25 | 14:03 | |
| Run Stop Time: | 10:58 | 13:41 | 16:25 | |
| Duration of Sample, minutes: | 125 | 125 | 125 | 125 |
| Meter Leak Rate, ft3/min: | 0.000 | 0.000 | 0.000 | 0.000 |
| Meter Start Volume, cf: | 844.99 | 954.76 | 65.17 | 621.64 |
| Meter Final Volume, cf: | 954.42 | 1064.91 | 176.76 | 732.03 |
| Average Meter Pressure, inches water: | 2.72 | 2.71 | 2.78 | 2.74 |
| Average Meter Temperature, degrees F: | 51.9 | 65.0 | 64.1 | 60.4 |
| Average Square Root Pitot Pressure, inches water: | 1.0650 | 1.0334 | 1.0342 | 1.0442 |
| Stack Gas Temperature, degrees F: | 301.4 | 302.7 | 304.2 | 302.7 |
| **Source Moisture Data** | **Run 1** | **Run 2** | **Run 3** | **Average** |
| Liquid Volume Collected, grams: | 207.8 | 192.9 | 241.6 | 214.1 |
| Water Vapor Volume at STP, scf: | 9.798 | 9.095 | 11.391 | 10.095 |
| Meter Volume, Actual Cubic Feet: | 109.435 | 110.152 | 111.595 | 110.394 |
| Meter Volume, STP, dscf: | 113.2 | 111.1 | 112.8 | 112.4 |
| Meter Volume, STP, dscm: | 3.206 | 3.146 | 3.194 | 3.182 |
| Total Gas Sampled, scf: | 123.00 | 120.19 | 124.17 | 122.45 |
| Percent Stack Gas Moisture: | 7.97 | 7.57 | 9.17 | 8.24 |
| **Gas Analysis Data** | **Run 1** | **Run 2** | **Run 3** | **Average** |
| Percent Carbon Dioxide, dry: | 13.18 | 12.98 | 12.78 | 12.98 |
| Percent Oxygen, dry: | 6.19 | 6.22 | 6.65 | 6.36 |
| Percent Nitrogen: | 80.63 | 80.80 | 80.57 | 80.66 |
| Dry Molecular Weight, lb/lb-Mole: | 30.357 | 30.326 | 30.310 | 30.331 |
| Molecular Weight, at Stack Condition, lb/lb-Mole: | 29.372 | 29.393 | 29.181 | 29.315 |
| Calculated Fuel Factor, $F_o$: | 1.116 | 1.131 | 1.115 | 1.121 |
| Fuel F-Factor, $F_d$: | 9820 | 9820 | 9820 | 9820 |
| Percent Excess Air: | 41.04 | 41.20 | 45.49 | 42.58 |
| **Gas Calculations** | **Run 1** | **Run 2** | **Run 3** | **Average** |
| Density Dry at STP, lb/cf: | 0.0785 | 0.0784 | 0.0784 | 0.0784 |
| Density Wet at STP (68 deg. F, 29.92 in. Hg), lb/cf: | 0.0759 | 0.0760 | 0.0754 | 0.0758 |
| Density Wet at Stack Cond, lb/cf: | 0.0528 | 0.0527 | 0.0523 | 0.0526 |
| Pounds of Gas Sampled, Dry: | 8.8841 | 8.7101 | 8.8375 | 8.8106 |
| Pounds of Gas Sampled, Wet: | 9.3397 | 9.1330 | 9.3672 | 9.2800 |
| **Gas Volumetric Flow Rate Data** | **Run 1** | **Run 2** | **Run 3** | **Average** |
| Average Stack Gas Velocity, ft/s: | 71.1 | 69.0 | 69.4 | 69.8 |
| Stack Gas Flow Rate, ACFM: | 1,151,537 | 1,117,970 | 1,124,008 | 1,131,172 |
| Stack Gas Flow Rate, SCFM: | 800,323 | 775,649 | 778,328 | 784,766 |
| Stack Gas Flow Rate, DSCFM: | 736,571 | 716,953 | 706,923 | 720,149 |
| Percent of Isokinetic Sampling Rate: | 96.6 | 97.4 | 100.3 | 98.1 |
| **Gas Concentrations and Emission Rates** | **Run 1** | **Run 2** | **Run 3** | **Average** |
| Filterable PM Weight, mg: | 10.55 | 8.83 | 11.01 | 10.13 |
| Filterable PM, gr/dscf: | 0.00144 | 0.00123 | 0.00151 | 0.00139 |
| Filterable PM, lbs/hr: | 9.08 | 7.54 | 9.13 | 8.58 |
| Filterable PM, lb/mmBtu: | 0.0029 | 0.0025 | 0.0031 | 0.0028 |
| Filterable PM, lb/1000 lb gas flow: | 0.002 | 0.002 | 0.003 | 0.002 |
| Filterable PM, lb/1000 Lb Gas Flow @ 50% Excess Air: | 0.002 | 0.002 | 0.003 | 0.002 |
| Filterable PM, tpy: | 39.75 | 33.02 | 40.00 | 37.59 |
| | | | | |
| **Dry Gas Metering System Calibration Check** | **Run 1** | **Run 2** | **Run 3** | **Average** |
| Dry Gas Meter Calibration Factor ($Y_d$): | 0.999 | 0.999 | 0.999 | 0.999 |
| $Y_{qa}$ (calculated): | 1.00 | 1.01 | 1.01 | 1.01 |
| Assigned Δ H (@ 0.75 SCFM) of the meter system: | 1.83 | 1.83 | 1.83 | 1.83 |
| Allowable $Y_{qa}$ (+/-) 5%: | 0.949 to 1.049 | 0.949 to 1.049 | 0.949 to 1.049 | ----- |
| Actual Yds Deviation, %: | -0.44 | -1.14 | -1.08 | -0.89 |
| **Dry Gas Metering System Thermocouple Calibration Check** | **Reference, °F** | **Module, °F** | **Difference** | **Requirement** |
| Stack | 74 | 74 | 0 | ±2° F |
| Probe | 74 | 74 | 0 | ±2° F |

## Regulatory Compliance Testing Services
## Table 1 - JHC2 PM Results

| | | | | |
|---|---|---|---|---|
| Filter | 74 | 74 | 0 | ±2° F |
| Dryer | 74 | 74 | 0 | ±2° F |
| Auxillary | 74 | 74 | 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)