Consumers Energy
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Particulate Matter CEMS Relative Response Audits

EU-KARN1 & EU-KARN2

Consumers Energy Company
D.E. Karn Generating Station
2742 N. Weadock Highway
Essexville, Michigan 48732
SRN: B2840
FRS: 110000593171

Test Dates: October 17-19, 2016

December 14, 2016

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section – Air Emissions Testing Body
Laboratory Services Section
Work Order No. 26815610
Revision 0

DEQ

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
AIR QUALITY DIVISION

RENEWABLE OPERATING PERMIT REPORT CERTIFICATION

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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 DE Karn 1&2 Plant County Bay

Source Address 2742 N. Weadock Highway City Essexville

AQD Source ID (SRN) B2840 ROP No. MI-ROP-B2840-2014a 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 10/1/2016 To 12/31/2016

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

Annual Relative Response Audit test report for Unit 1 and Unit 2 PM CEMS certification.

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

Scott Hugo	Site Production Mgr I	(989) 891-3268
Name of Responsible Official (print or type)	Title	Phone Number

Scott A Hugo

Signature of Responsible Official

12/14/16

Date

* Photocopy this form as needed.

EQP 5736 (Rev 11-04)

EXECUTIVE SUMMARY

Consumers Energy Company (Consumers Energy) Regulatory Compliance Testing Section (RCTS) completed particulate matter (PM) testing at the single dedicated exhaust stacks of coal-fired boilers EU-KARN1 (Unit 1) and EU-KARN2 (Unit 2) in operation at the D.E. Karn Generation facility located in Essexville, Michigan. The purpose of the test program was to ensure the continued validity of the PM CEMS correlation curve via a relative response audit (RRA) as required in 40 CFR Part 63, Subpart 63.10010(i)(2)(i) utilizing Procedure 2—Quality Assurance Requirements for Particulate Matter Continuous Emission Monitoring Systems at Stationary Sources (40 CFR Part 60 Appendix F). The criteria to pass an RRA described in Section 10.4(6) of Performance Specification 2 are listed below. Secondarily, the test program provides a direct comparison between USEPA Method 5 PM results and MATS 5 PM results.

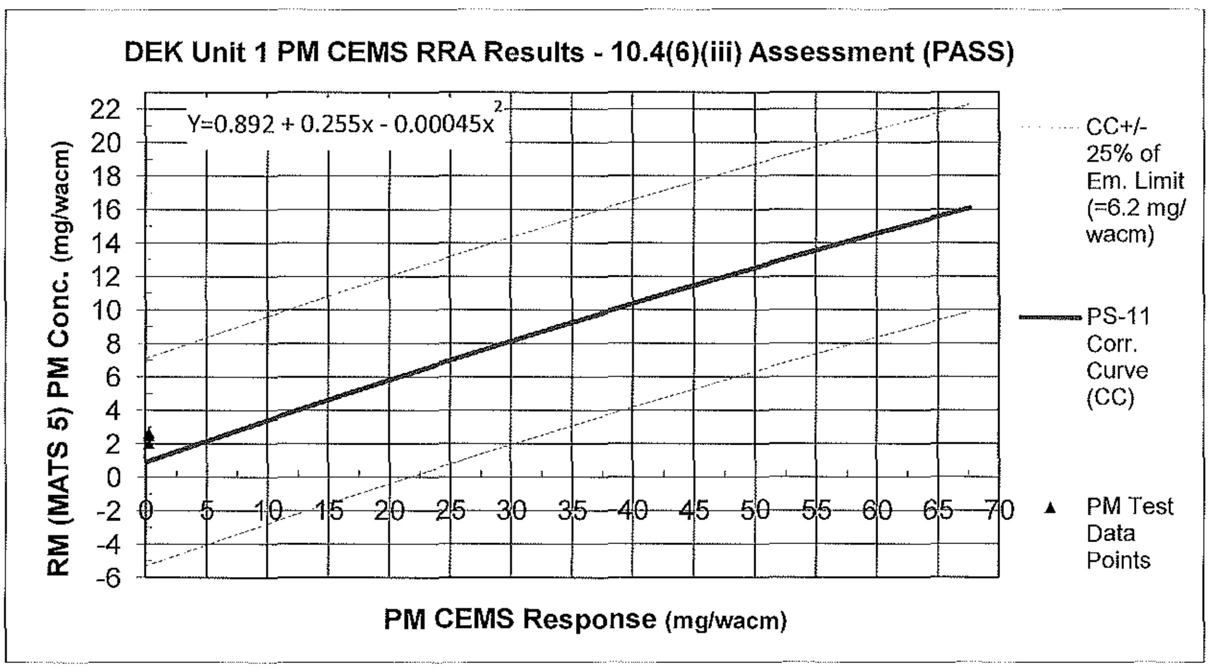
- 10.4(6)(i): For all three test runs (data points), the PM CEMS response value can be no greater than the highest PM CEMS response value used to develop the correlation curve (Unit 1 = 67.60 milligram per wet actual cubic meter [mg/wacm]; Unit 2 = 72.93 mg/wacm).
- 10.4(6)(ii): For two of the three data points, the PM CEMS response value must lie within the PM CEMS output range used to develop the correlation curve (see above for the maximum PM CEMS responses; minimum responses were are as follows: Unit 1 = 0.05 mg/wacm; Unit 2 = 0.08 mg/wacm).
- 10.4(6)(iii): At least two of the three sets of PM CEMS and reference method measurements must fall within the area on a graph of the correlation regression line bounded by two parallel lines at ± 25% of the permit emission limit. (When assessing PM CEMS performance in relation to the "emissions limit", the MATS PM emission limit of 0.030 lb/mmBtu is used. The preceding MATS PM emission limit equates to 24.8 mg/wacm for Unit 1, and 21.7 mg/wacm for Unit 2.)

The test program was conducted on October 17 through 19, 2016 in accordance with applicable requirements and sampling, calibration, and quality assurance procedures specified in 40 CFR 60, Appendix A, reference methods (RM) 1, 2, 3A, 4, 5, 19 and MATS method 5. Three 120-minute RM5 tests were conducted simultaneously with three 120-minute MATS5 tests to measure filterable particulate matter to compare to the PM CEMS response while the boiler was operating under maximum normal operating load. The results are summarized in the following tables and graphs.

Unit 1 Summary of Results

Run	PM Concentration (mg/wacm)		
	Reference Method Result (MATS 5)	PM CEMS Response (Range = 0.05-67.60)	Reference Method Result[1] (M 5)
EU-KARN1			
1	2.50	0.30	2.40
2	2.64	0.29	2.22
3	2.03	0.29	3.71
Average	**2.39**	**0.29**	**2.78**
Procedure 2 Criteria	**10.4(6)(i)**	**PASS** (All PM CEMS responses ≤ 67.60 mg/wacm)	
	10.4(6)(ii)	**PASS** (≥2 PM CEMS responses ≥ 0.05 & ≤ 67.60 mg/wacm)	

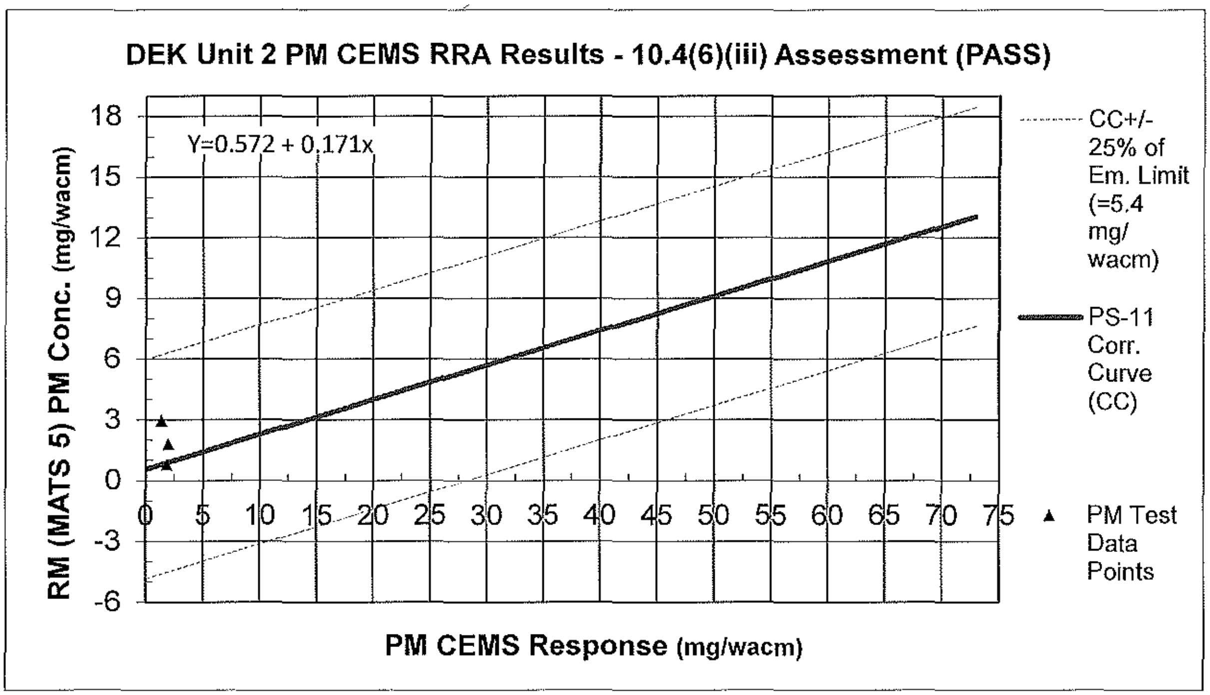
[1] These results based upon the use of Reference Method 5 (versus MATS 5) are presented for informational purposes should Consumers Energy later elect to seek the use of RM 5 versus MATS 5 for purposes of ongoing QA testing for the PM CEMS. The MATS 5 and RM 5 test runs were conducted concurrently with each other.



Unit 2 Summary of Results

<table>
<tr><th rowspan="2">Run</th><th colspan="4">PM Concentration (mg/wacm)</th></tr>
<tr><th colspan="2">Reference Method Result (MATS 5)</th><th>PM CEMS Response (Range = 0.08-72.93)</th><th>Reference Method Result[1] (M 5)</th></tr>
<tr><td colspan="5">EU-KARN2</td></tr>
<tr><td>1</td><td colspan="2">0.80</td><td>1.82</td><td>2.42</td></tr>
<tr><td>2</td><td colspan="2">1.81</td><td>1.97</td><td>2.00</td></tr>
<tr><td>3</td><td colspan="2">2.96</td><td>1.38</td><td>1.90</td></tr>
<tr><td>Average</td><td colspan="2">1.85</td><td>1.72</td><td>2.11</td></tr>
<tr><td colspan="2" rowspan="2">Procedure 2 Criteria</td><td>10.4(6)(i)</td><td colspan="2">PASS (All PM CEMS responses ≤ 72.93 mg/wacm)</td></tr>
<tr><td>10.4(6)(ii)</td><td colspan="2">PASS (≥2 PM CEMS responses ≥ 0.08 & ≤ 72.93 mg/wacm)</td></tr>
</table>

[1] These results based upon the use of Reference Method 5 (versus MATS 5) are presented for informational purposes should Consumers Energy later elect to seek the use of RM 5 versus MATS 5 for purposes of ongoing QA testing for the PM CEMS. The MATS 5 and RM 5 test runs were conducted concurrently with each other.



The results of the RRA indicate that each PM CEMS met all the criteria specified in Section 10.4(6) in Procedure 2 of Appendix F to 40 CFR 60. Detailed results are presented in the Results Summary tables behind the tables tab of this report. Example calculations and field data sheets are presented in Appendices A and B, respectively. 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 stacks of coal-fired boilers EU-KARN1 (Unit 1) and EU-KARN2 (Unit 2) in operation at the D.E. Karn Generation facility located in Essexville, Michigan. The purpose of the test program was to ensure the continued validity of the PM CEMS correlation curve via a relative response audit (RRA) as required in 40 CFR Part 63, Subpart 63.10010(i)(2)(i) utilizing Procedure 2—Quality Assurance Requirements for Particulate Matter Continuous Emission Monitoring Systems at Stationary Sources (40 CFR Part 60 Appendix F). The criteria to pass an RRA described in Section 10.4 of Performance Specification 2 are listed below. Secondarily, the test program provides a direct comparison between USEPA Method 5 PM results and MATS 5 PM results.

- 10.4(6)(i): For all three test runs (data points), the PM CEMS response value can be no greater than the highest PM CEMS response value used to develop the correlation curve (Unit 1 = 67.60 milligram per wet actual cubic meter [mg/wacm]; Unit 2 = 72.93 mg/wacm).
- 10.4(6)(ii): For two of the three data points, the PM CEMS response value must lie within the PM CEMS output range used to develop the correlation curve (see above for the maximum PM CEMS responses; minimum responses were are as follows: Unit 1 = 0.05 mg/wacm; Unit 2 = 0.08 mg/wacm).
- 10.4(6)(iii): At least two of the three sets of PM CEMS and reference method measurements must fall within the area on a graph of the correlation regression line bounded by two parallel lines at ± 25% of the permit emission limit. (When assessing PM CEMS performance in relation to the "emissions limit", the MATS PM emission limit of 0.030 lb/mmBtu is used. The preceding MATS PM emission limit equates to 24.8 mg/wacm for Unit 1, and 21.7 mg/wacm for Unit 2.)

Please note that for Unit 1, an error was found within the initial correlation test report dated September 24, 2015 in regards to the lowest PM CEMS response associated with the data set used to develop the correlation curve. Specifically, in "Table 3, PS-11 Correlation Test Data", the PM CEMS response for Run 21 is listed as 0.47 mg/wacm. However, in the Appendix C CEMS data associated with each correlation test run, the PM CEMS response (see the column titled PM1 (MG/WACM)) for Run 21 is listed as 0.05 mg/wacm. Consumers Energy has reviewed the associated 1-minute CEMS data for Run 21 and verified that the correct PM CEMS response for Run 21 should be 0.047 mg/wacm (not the 0.47 mg/wacm listed in Table 3 of the initial correlation test report). Thus, the average Unit 1 PM CEMS responses observed during the RRA were all above the lowest PM CEMS response associated with the data set used to develop the initial correlation curve.

When assessing PM CEMS performance in relation to the "emissions limit", the 40 CFR 63, Subpart UUUUU – National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-fired Electric Utility Steam Generating Units (Mercury Air Toxics Rule [MATS]) PM emission limit of 0.030 lb/mmBtu is used. The particulate emission limitation from MATS is presented in Table 1-1 below.

Table 1-1
MATS Rule PM Emission Limit

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

The test program was conducted on October 17 through 19, 2016 in accordance with applicable requirements and sampling, calibration, and quality assurance procedures specified in 40 CFR 60, Appendix A, Reference Methods 1, 2, 3A, 4, 5, 19 and MATS Method 5. To support a possible future request to utilize RM5 (in lieu of MATS 5) for PM CEMS quality assurance testing, three 120-minute RM5 tests were performed simultaneously with three 120-minute MATS5 tests to measure filterable particulate matter while each boiler was operating under maximum operating load available.

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

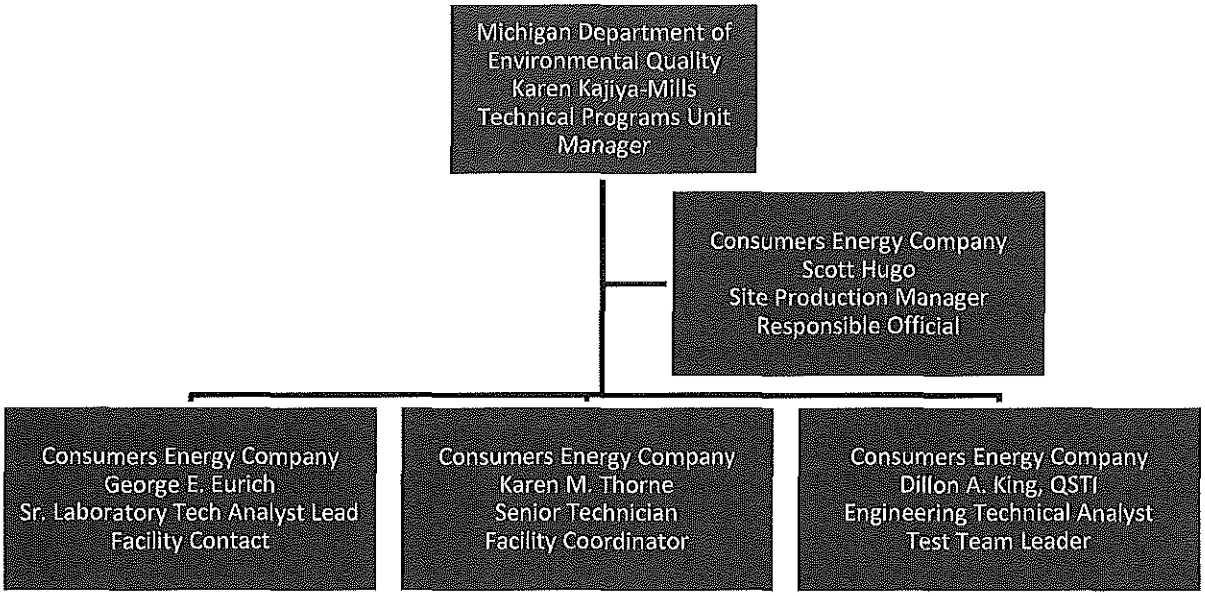


Table 1-2
Contact Information

Program Role	Contact	Address
Regulatory Agency Representative	Ms. Karen Kajiya-Mills Technical Programs Unit Manager 517-335-4874 Kajiya-millsk@michigan.gov	Michigan Department of Environmental Quality Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
Responsible Official	Mr. Scott A. Hugo 989-891-3268 Site Production Manager Scott@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex 2680 N. Weadock Highway Essexville, Michigan 48732
Test Facility	Mr. George E. Eurich 989-891-3317 Sr. Laboratory Tech Analyst Lead George.Eurich@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex 2680 N. Weadock Highway Essexville, Michigan 48732
Test Facility	Ms. Karen M. Thorne 989-891-3168 Senior Technician Karen.Thorne@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex 2680 N. Weadock Highway Essexville, Michigan 48732
Test Team Representative	Mr. Dillon A. King, QSTI 989-891-5585 Engineering Technical Analyst Dillon.King@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex ESD Trailer #4 2742 N. Weadock Highway Essexville, MI 48732

2.0 SUMMARY OF RESULTS

2.1 OPERATING DATA

Units 1 and 2 are rated at nominal gross electrical outputs of 272 MW and 277 MW, respectively. During the quality assurance tests, each boiler was operated at the maximum normal operating load conditions or the maximum load achievable at the time of testing. The quality assurance testing was performed with Unit 1 was operating within the range of 210 MW to 211 MW gross (~77% load) and Unit 2 operating at 251 MW to 252 MW gross (~91% load). Unit 1 had a mill out of service during the test program, and was operated at the maximum operating load available. A summary of the boiler gross megawatt (MW) electrical generation during each test is provided in the Tables section of the report. Refer to Attachment D for detailed operating data, which was recorded using Eastern Standard Time.

2.2 APPLICABLE PERMIT INFORMATION

The D.E. Karn generating station has State of Michigan Registration Number (SRN) B2840 and operates in accordance with air permit MI-ROP-B2840-2014a. The air permit incorporates federal regulations and reports under Federal Registry System (FRS) identification number 110000593171. EU-KARN1 and EU-KARN2 are the emission unit source identifications in the permit and included in the FG-KARN12 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 EU-KARN1 and EU-KARN2 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 D.E. Karn Unit 1 and Unit 2 boiler and pollution control devices.

2.3 RESULTS

As shown in the tables and graphs below, each monitor met all the criteria specified by Section 10.4(6) in Procedure 2 of Appendix F to 40 CFR 60. Furthermore, the comparative concurrent test runs conducted using MATS 5 and RM 5 yielded very similar results. Detailed results are presented in the Reference Method 5 PM Results Summary and MATS 5 PM Results Summary behind the tables tab of this report.

Table 2-1
Unit 1 Summary of Results

Run	PM Concentration (mg/wacm)			
	Reference Method Result (MATS 5)		PM CEMS Response (Range = 0.05-67.60)	Reference Method Result[1] (M 5)
EU-KARN1				
1	2.50		0.30	2.40
2	2.64		0.29	2.22
3	2.03		0.29	3.71
Average	**2.39**		**0.29**	**2.78**
Procedure 2 Criteria		**10.4(6)(i)**	**PASS (All PM CEMS responses ≤ 67.60 mg/wacm)**	
		10.4(6)(ii)	**PASS (≥2 PM CEMS responses ≥ 0.05 & ≤ 67.60 mg/wacm)**	

[1] These results based upon the use of Reference Method 5 (versus MATS 5) are presented for informational purposes should Consumers Energy later elect to seek the use of RM 5 versus MATS 5 for purposes of ongoing QA testing for the PM CEMS. The MATS 5 and RM 5 test runs were conducted concurrently with each other.

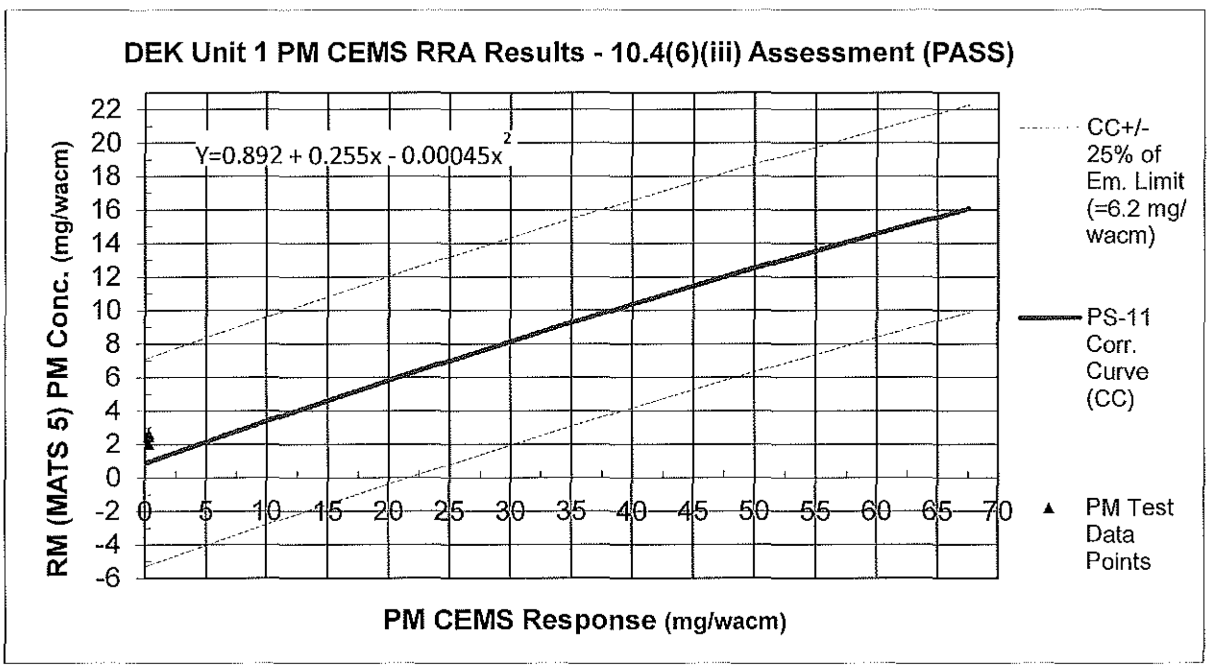
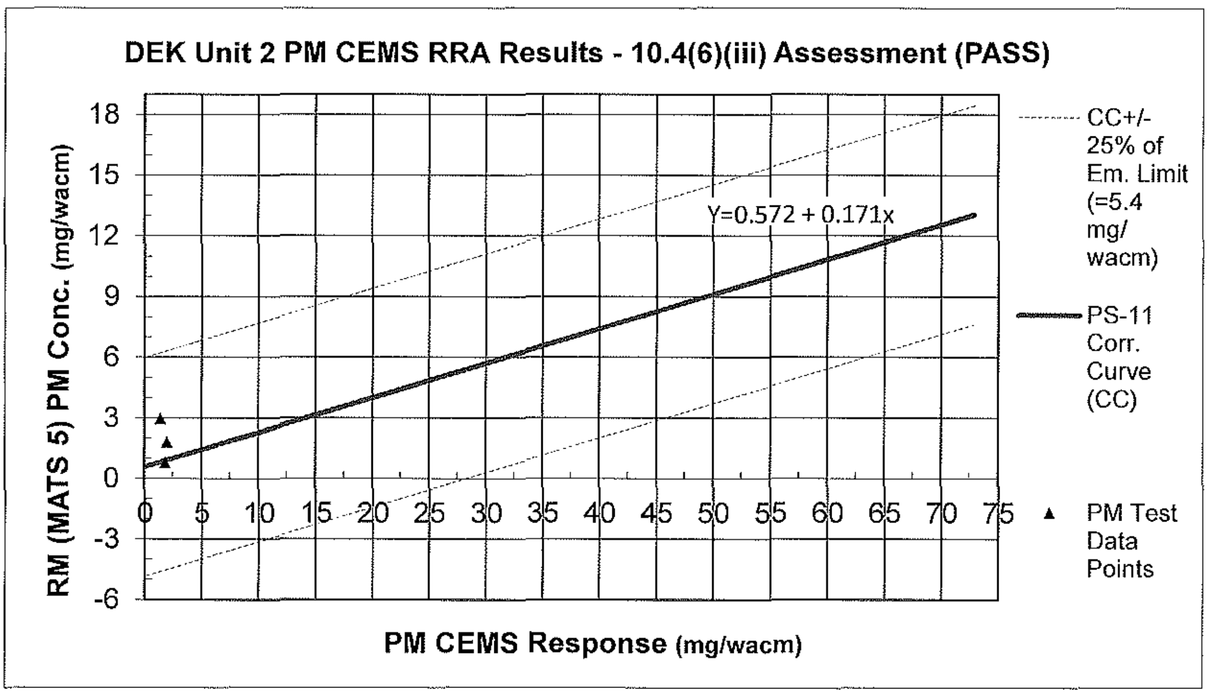


Table 2-2
Unit 2 Summary of Results

Run	PM Concentration (mg/wacm)		
	Reference Method Result (MATS 5)	PM CEMS Response (Range = 0.08-72.93)	Reference Method Result[1] (M 5)
EU-KARN2			
1	0.80	1.82	2.42
2	1.81	1.97	2.00
3	2.96	1.38	1.90
Average	**1.85**	**1.72**	**2.11**
Procedure 2 Criteria	**10.4(6)(i)**	**PASS** (All PM CEMS responses ≤ 72.93 mg/wacm)	
	10.4(6)(ii)	**PASS** (≥2 PM CEMS responses ≥ 0.08 & ≤ 72.93 mg/wacm)	

[1] These results based upon the use of Reference Method 5 (versus MATS 5) are presented for informational purposes should Consumers Energy later elect to seek the use of RM 5 versus MATS 5 for purposes of ongoing QA testing for the PM CEMS. The MATS 5 and RM 5 test runs were conducted concurrently with each other.



It should be noted that for this RRA test program, only the MATS5 results were used to evaluate the validity of the PM correlation curve. Example calculations and field data sheets are presented in Appendix A and B. Laboratory data is presented in Appendix C.

3.0 SOURCE DESCRIPTION

3.1 PROCESS AND RATED CAPACITY

EU-KARN1 is a 2500 million BTU per hour dry bottom tangential coal fired boiler with fuel oil startup capabilities and supplemental co-firing for flame stabilization and mill outages. Karn Unit 1 has a full load rating of 272 MW gross, and 255 MW net. EU-KARN2 is a 2540 million BTU per hour dry bottom wall coal fired boiler with fuel oil startup capabilities and supplemental co-firing for flame stabilization and mill outages. Karn Unit 2 has a full load rating of 277 MW gross, and 260 MW net.

3.2 PROCESS FLOW

The flue gas generated through coal combustion is controlled by multiple pollution control devices for each unit. Both EU-KARN1 and EU-KARN2 have a Selective Catalytic Reduction (SCR) system for the control of nitrogen oxides (NOx), and EU-KARN2 also has low NOx burners for additional control of nitrogen oxides (NOx). Further, both units are equipped with pulse jet fabric filter (PJFF) baghouses for Particulate Matter (PM) control and Spray Dryer Absorbers (SDAs) for the control of sulfur dioxide (SO2) and other acid gases. Each unit is also equipped with Activated Carbon Injection (ACI) for the control of mercury (used on an as needed basis to comply with the applicable MATS mercury emission limit).

3.3 MATERIALS PROCESSED

Both units burn a blend of Eastern bituminous and Western sub-bituminous coal. The blend ratio for the units ranges from 75% Western to 100% Western, with the balance consisting of Eastern coal depending on economics and load demand. During this test program each unit burned approximately 75% Western coal with the 25% balance consisting of Eastern coal.

3.4 PROCESS INSTRUMENTATION

The process was continuously monitored by boiler operators and environmental technicians. As the continuous emissions monitoring systems record data on Eastern Standard Time (EST), sampling times (in Eastern Daylight Time [EDT]) were correlated to instrumentation time. 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
Filterable particulate matter	MATS 5[a]	Determination of Particulate Matter Emissions from Stationary Sources (with a front half filter temperature of 320±25°F)
Emission rate	19	Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates

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

4.1 DESCRIPTION OF SAMPLING TRAIN AND FIELD PROCEDURES

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

Table 4-2
Test Matrix

Sampling Locations	No. of Runs	Sample/Type Pollutant	Sampling Method	Sampling Organization	Sample Run Time (min)	Analytical Method	Analytical Laboratory
EU-KARN1 and EU-KARN2 Exhaust Stacks	3	Sample location and traverse points	M1	Consumers Energy	-	Field measurement and area calculations	Consumers Energy
		Velocity and volumetric flowrate	M2	Consumers Energy	120	Velocity head and temperature measurements	Consumers Energy
		Molecular weight (O_2 and CO_2)	M3A	Consumers Energy	120	Paramagnetic and infrared analyzers	Consumers Energy
		Moisture	M4	Consumers Energy	120	Gravimetric	Consumers Energy
	3	Filterable particulate matter	M5	Consumers Energy	120	Gravimetric	Consumers Energy
	3	Filterable particulate matter	MATS 5	Consumers Energy	120	Gravimetric	Consumers Energy
	3	Emission rate	M19	Consumers Energy	-	Stoichiometric calculation	Consumers Energy

4.1.1 Sample Location and Traverse Points

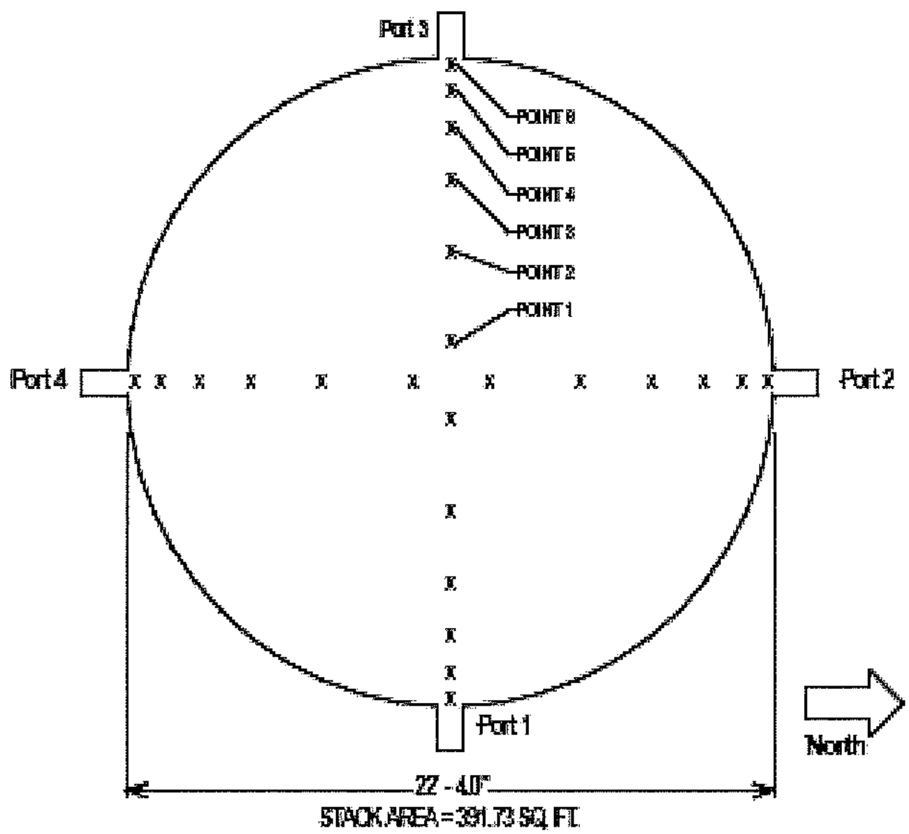
The number and location of traverse points for determining exhaust gas velocity and volumetric air-flow was determined in accordance with USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources.* Four test ports are located in the horizontal plane of the duct dividing the cross-section into a number of equal areas based on the existing air flow disturbances. The Unit 1 duct diameter is 22 feet 4 inches; Unit 2 has a duct diameter of 18 feet. The ports are situated:

- Approximately 70 feet downstream of the breechings entering the exhaust stack, and
- Approximately 200 feet upstream of the exhaust stack exit.

The sample ports are 6-inches in diameter and extend 24 inches beyond the stack wall. Flue gas was sampled for five minutes at six traverse points from each of the four sample ports, for a total of 24 sample points and 120 minutes. Drawings of the Unit 1 and Unit 2 traverse points are presented as Figures 4-1 and 4-2, while a drawing of the Units 1 and 2 Test Port Locations is presented as Figure 4-3.

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

D E KARN UNIT 1 PARTICULATE EMISSION TEST POINT LOCATIONS



PARTICULATE EMISSION TEST POINT LOCATIONS

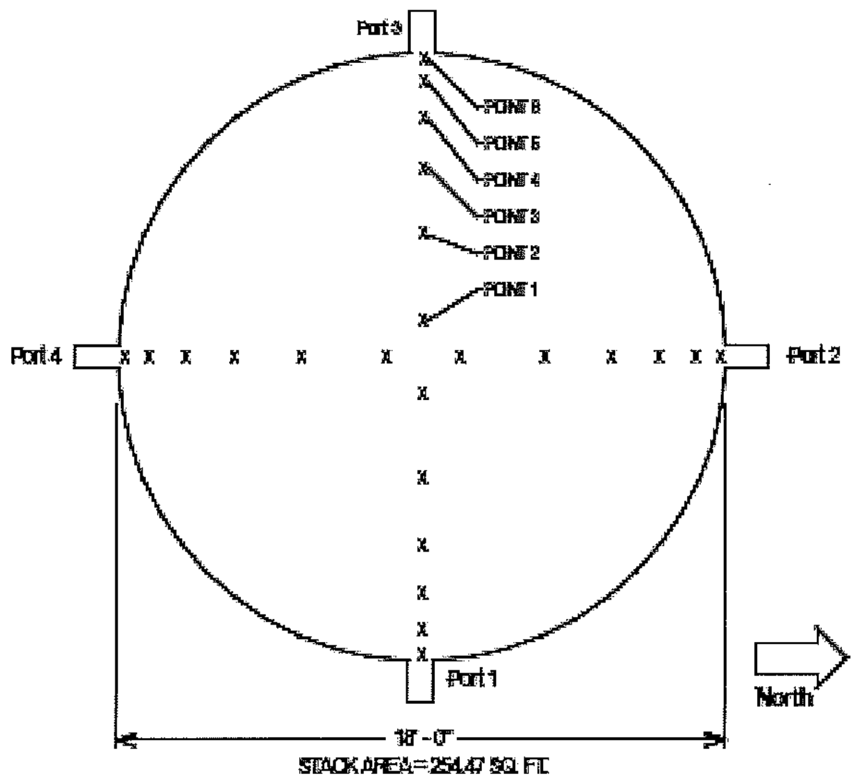
Note: Test Port Length = 24" from inside stack wall to outside flange.

DISTANCES FROM INSIDE STACK WALL

Point 1	95.27"
Point 2	66.90"
Point 3	47.37"
Point 4	31.53"
Point 5	17.93"
Point 6	5.62"

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

D E KARN UNIT 2 PARTICULATE EMISSION TEST POINT LOCATIONS



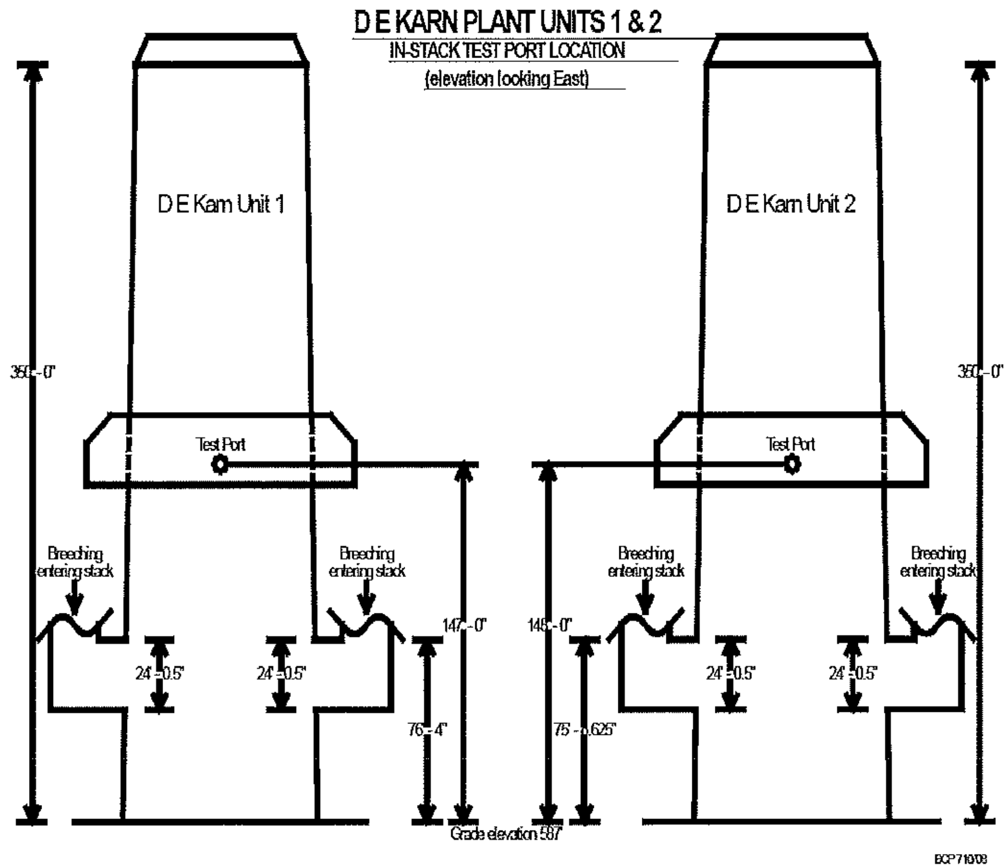
PARTICULATE EMISSION TEST POINT LOCATIONS

Note: Test Port Length = 14" from inside stack wall to outside flange.

DISTANCES FROM INSIDE STACK WALL

Point 1	75.97"
Point 2	54.07"
Point 3	38.23"
Point 4	25.43"
Point 5	14.47"
Point 6	4.54"

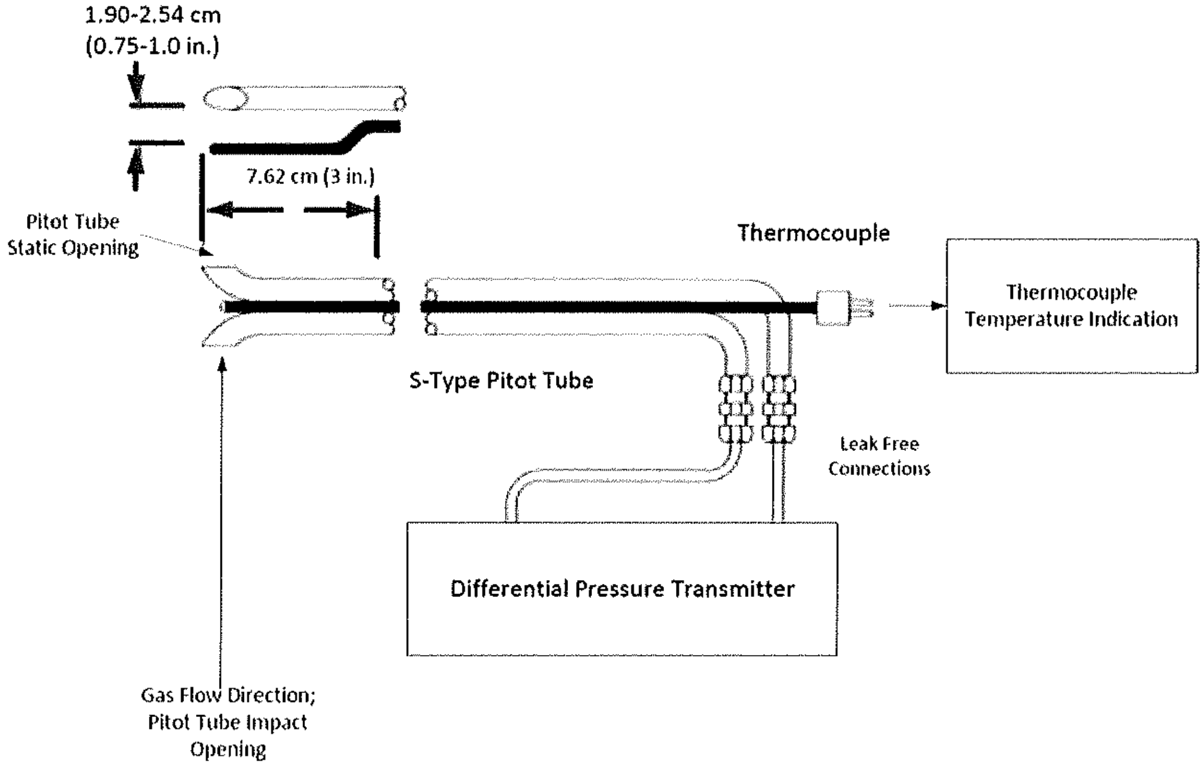
Figure 4-3. Unit 1 and 2 Test Port Locations



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 4-4 for the Method 2 Pitot tube and thermocouple configuration.

Figure 4-4. Method 2 Sample Apparatus



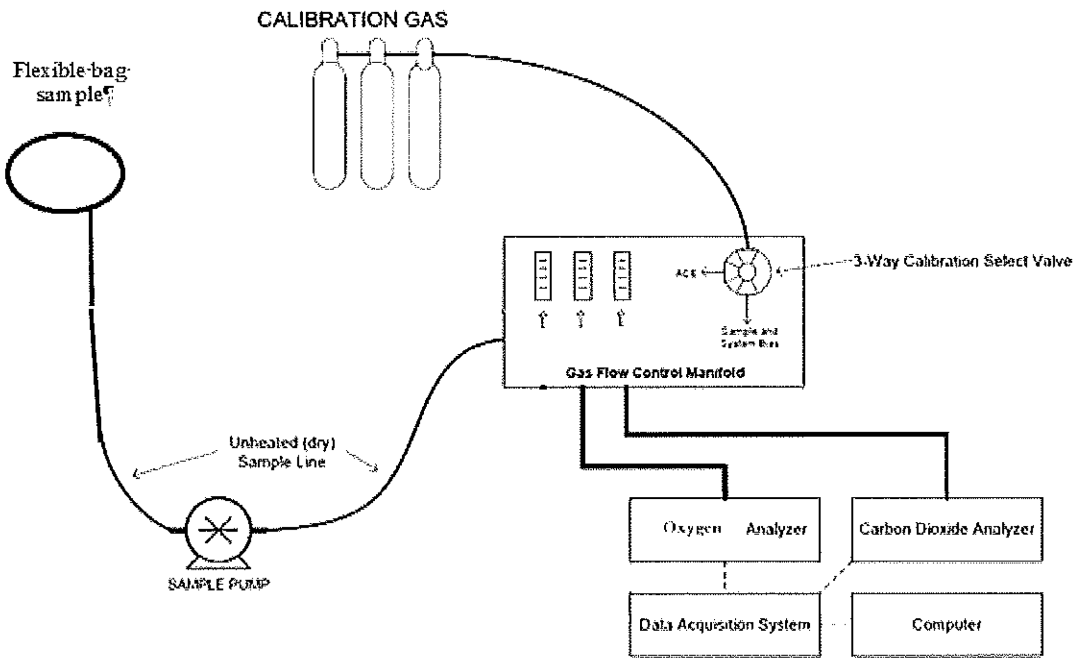
Flue gas velocity and velocity vector measurements (cyclonic flow evaluation) were measured following the procedures in USEPA Method 2 at the sampling location. Cyclonic flow is defined as a flow condition with an average null angle greater than 20 degrees. The direction of flow can be determined by aligning the Pitot tube to obtain zero (null) velocity head reading—the direction would be parallel to the Pitot tube face openings or perpendicular to the null position. By measuring the angle of the Pitot tube face openings in relation to the stack walls when a null angle is obtained, the direction of flow is measured. If the absolute average of the flow direction angles is greater than 20 degrees, the flue gas is considered to be cyclonic at that sampling location and an alternative location should be found. Appendix B of this report includes cyclonic flow test data as verification of the absence of cyclonic flow at the Unit 1 and 2 stack test locations. 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 1 exhaust in October 2005 was observed to be 4.0° and the average null yaw angle measured at the Unit 2 exhaust in October 2005 was observed to be 2.9°, 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.

4.1.3 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 to paramagnetic and infrared gas analyzers that measure oxygen and carbon dioxide concentrations. Figure 4-5 depicts the Method 3A sampling system.

Figure 4-5. 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 analyzers 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 24 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 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 4-6 presents the emissions calculation used:

Figure 4-6. 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

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

Refer to Appendix A for example calculations.

4.1.6 Particulate Matter

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

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

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

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

In anticipation of submitting a similar request for DE Karn Units 1 and 2, simultaneous test runs with two particulate matter sampling trains were employed for this test program, consisting of a Method 5 sampling train and a MATS Method 5 sampling train. Results of this testing may be used to submit a request to EPA to conduct future RRAs utilizing Method 5 even though the Initial PS-11 testing was conducted with MATS 5.

The MATS 5 and the Method 5 sampling apparatus are setup and operated similarly. The flue gas was passed through a nozzle, heated probe, quartz-fiber filter, and into a series of impingers with the configuration presented in Table 4-3. The filter collects filterable particulate matter while the impingers collect water vapor. Figure 4-7 depicts the USEPA Method 5/MATS 5 sampling train.

Table 4-3
Method 5/MATS 5 Impinger Configuration

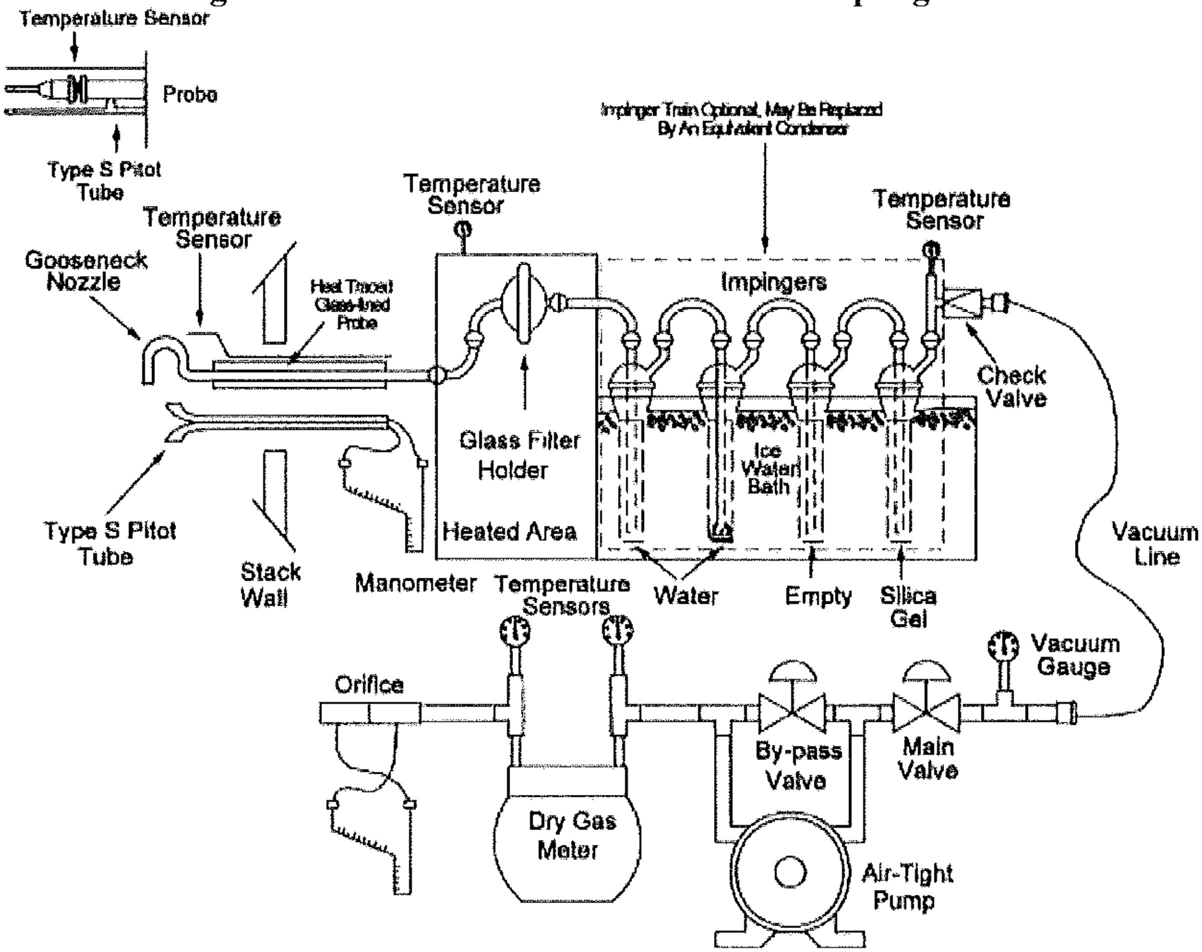
Impinger Order (Upstream to Downstream)	Impinger Type	Impinger Contents	Amount (gram)
1	Modified	Water	100
2	Greenburg-Smith	Water	100
3	Modified	Empty	0
4	Modified	Silica gel desiccant	~200-300

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

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

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

Figure 4-7. 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 4-8 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 4-9. Refer to Appendix C for laboratory data sheets.

Figure 4-8. USEPA Method 5/MATS 5 Sample Recovery Scheme

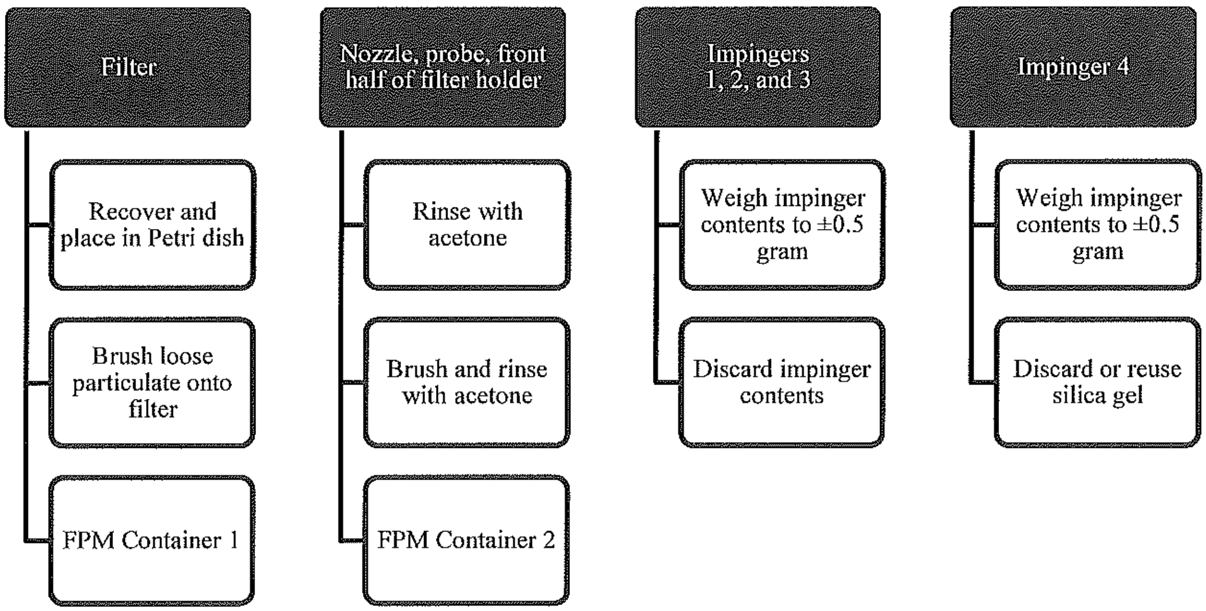
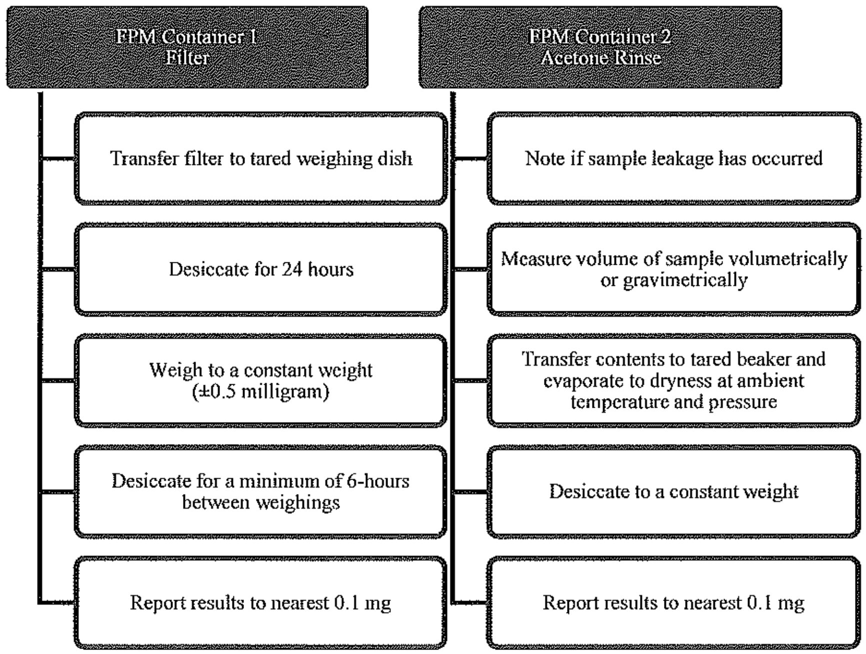


Figure 4-9. USEPA Method 5/MATS 5 Analytical Scheme



5.0 TEST RESULTS AND DISCUSSION

The purpose of the test program was to ensure the continued validity of the PM CEMS correlation curve via a relative response audit (RRA) as required in 40 CFR Part 63, Subpart 63.10010(i)(2)(i) utilizing Procedure 2—Quality Assurance Requirements for Particulate Matter Continuous Emission Monitoring Systems at Stationary Sources (40 CFR Part 60 Appendix F). Three 120-minute tests were performed following USEPA procedures for each test method. The results of the testing in are presented in Tables 2-1 and 2-2.

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

5.1 VARIATIONS AND UPSET CONDITIONS

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

5.2 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
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

5.2.1 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.

5.2.2 Dry Gas Meter QA/QC Checks

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

5.2.3 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 PM Results Summary Tables for calibration data.

5.2.4 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.

5.2.5 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.

5.2.6 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	0.1	Reporting limit is 0.1 milligrams.

5.3 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.

Regulatory Compliance Testing Services
MATS5 PM Summary Audit Sheet

Facility and Source Information				
Customer:	D.E. Kam			
Source:	Unit 1		Unit Load:	High
Work Order:	26815610			
Date:	10/17/2016	10/17/2016	10/18/2016	
Stack Diameter, inches:	268	268	268	
Stack Area, Square Feet:	391.74	391.74	391.74	
Source Pollutant Test Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Barometric Pressure, inches mercury:	28.73	28.73	28.61	28.69
Meter Calibration Factor:	1.003	0.999	0.999	1.000
Pitot Tube Calibration Factor:	0.84	0.84	0.84	0.84
Stack Static Pressure, inches water:	-0.60	-0.60	-0.60	-0.60
Nozzle Diameter, inches:	0.317	0.317	0.317	0.317
Run Start Time:	13:16	16:30	8:20	
Run Stop Time:	15:44	18:55	10:43	
Duration of Sample, minutes:	120	120	120	120
Meter Leak Rate, ft3/min:	0.000	0.000	0.000	0.000
Meter Start Volume, cf:	681.19	396.33	483.75	520.42
Meter Final Volume, cf:	768.93	483.32	571.29	607.85
Average Meter Pressure, inches water:	1.74	1.67	1.70	1.70
Average Meter Temperature, degrees F:	86.0	90.1	85.0	87.0
Average Square Root Pitot Pressure, inches water:	0.4906	0.4824	0.4867	0.4866
Stack Gas Temperature, degrees F:	187.1	187.2	187.2	187.2
Source Moisture Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Liquid Volume Collected, grams:	314.3	313.1	299.4	308.9
Water Vapor Volume at STP, scf:	14.817	14.760	14.117	14.565
Meter Volume, Actual Cubic Feet:	87.737	86.992	87.547	87.425
Meter Volume, STP, dscf:	82.0	80.4	81.3	81.26
Meter Volume, STP, dscm:	2.323	2.277	2.304	2.30
Total Gas Sampled, scf, wet:	96.86	95.17	95.46	95.83
Total Gas Sampled, acf, wet:	103.58	102.96	102.74	103.09
Percent Stack Gas Moisture:	15.30	15.51	14.79	15.20
Gas Analysis Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Percent Carbon Dioxide, dry:	13.43	12.51	11.74	12.56
Percent Oxygen, dry:	6.19	6.47	7.92	6.86
Percent Nitrogen:	80.38	81.01	80.34	80.58
Dry Molecular Weight, lb/lb-Mole:	30.397	30.261	30.195	30.284
Molecular Weight, at Stack Condition, lb/lb-Mole:	28.500	28.359	28.392	28.42
Calculated Fuel Factor, F_o:	1.095	1.153	1.105	1.118
Fuel F-Factor, F_c:	1840	1840	1840	1840
Percent Excess Air:	41.16	43.40	59.60	48.05
Gas Calculations	**Run 1**	**Run 2**	**Run 3**	**Average**
Density Dry at STP, lb/cf:	0.0786	0.0782	0.0781	0.0783
Density Wet at STP (68 deg. F, 29.92 in. Hg), lb/cf:	0.0737	0.0733	0.0734	0.073
Density Wet at Stack Cond, lb/cf:	0.0576	0.0573	0.0572	0.057
Pounds of Gas Sampled, Dry:	6.4474	6.2904	6.3500	6.363
Pounds of Gas Sampled, Wet:	7.1363	6.9768	7.0065	7.040
Gas Volumetric Flow Rate Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Average Stack Gas Velocity, ft/s:	31.3	30.9	31.2	31.2
Stack Gas Flow Rate, ACFM:	736,735	726,258	733,879	732,291
Stack Gas Flow Rate, SCFM:	576,126	567,824	571,382	571,777
Stack Gas Flow Rate, DSCFM:	487,995	479,754	486,885	484,878
Percent of Isokinetic Sampling Rate:	100.2	99.8	99.5	99.84
Gas Concentrations and Emission Rates	**Run 1**	**Run 2**	**Run 3**	**Average**
Filterable PM Weight, mg:	8.74	9.08	7.05	8.29
Filterable PM, gr/dscf:	0.00164	0.00174	0.00134	0.00157
Filterable PM, mg/wacm	2.98	3.11	2.42	2.84
Filterable PM, mg/wacm at Stack Conditions	2.50	2.64	2.03	2.39
Filterable PM, lbs/hr:	6.9	7.2	5.6	6.5
Filterable PM, lb/mmBtu:	0.003	0.004	0.003	0.003
Filterable PM, lb/1000 lb gas flow:	0.003	0.003	0.002	0.003
Filterable PM, lb/1000 Lb Gas Flow @ 50% Excess Air:	0.003	0.003	0.002	0.003
Filterable PM, tpy:	30.1	31.4	24.5	28.6
Dry Gas Metering System Calibration Check [1]	**Run 1**	**Run 2**	**Run 3**	**Average**
Dry Gas Meter Calibration Factor (Y_d):	1.003	0.999	0.999	1.000
Y_{qa} (calculated):	1.00	1.01	1.01	1.01
Assigned Δ H (@ 0.75 SCFM) of the meter system:	1.87	1.83	1.83	1.84
Allowable Y_{qa} (+/-) 5%:	0.953 to 1.053	0.949 to 1.049	0.949 to 1.049	
Actual Yds Deviation, %:	0.14	-0.78	-0.93	-0.53
Dry Gas Metering System Thermocouple Calibration Check [2]	**Reference, °F**	**Module, °F**	**Difference**	**Requirement**
Stack	69	68	-1	±2° F
Probe	69	68	-1	±2° F
Filter	69	68	-1	±2° F
Dryer	69	68	-1	±2° F
Auxillary	69	68	-1	±2° F

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

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

Regulatory Compliance Testing Services
Method 5 PM Summary Audit Sheet

Facility and Source Information				
Customer:	D.E. Karn			
Source:	Unit 1		Unit Load:	High
Work Order:	24038047			
Date:	10/17/2016	10/17/2016	10/17/2016	
Stack Diameter, inches:	268	268	268	
Stack Area, Square Feet:	391.74	391.74	391.74	
Source Pollutant Test Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Barometric Pressure, inches mercury:	29.73	28.73	28.61	29.02
Meter Calibration Factor:	0.999	1.003	1.003	1.002
Pitot Tube Calibration Factor:	0.84	0.84	0.84	0.84
Stack Static Pressure, inches water:	-0.60	-0.60	-0.60	-0.60
Nozzle Diameter, inches:	0.317	0.317	0.317	0.317
Run Start Time:	13:16	16:30	8:20	
Run Stop Time:	15:44	18:55	10:43	
Duration of Sample, minutes:	120	120	120	120
Meter Leak Rate, ft3/min:	0.000	0.000	0.000	0.000
Meter Start Volume, cf:	307.31	771.32	858.68	645.77
Meter Final Volume, cf:	393.70	858.46	942.00	731.39
Average Meter Pressure, inches water:	1.69	1.65	1.60	1.65
Average Meter Temperature, degrees F:	85.8	90.6	84.6	87.0
Average Square Root Pitot Pressure, inches water:	0.4883	0.4713	0.4796	0.4798
Stack Gas Temperature, degrees F:	187.1	186.3	186.6	186.7
Source Moisture Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Liquid Volume Collected, grams:	308.8	310.4	283.3	300.8
Water Vapor Volume at STP, scf:	14.560	14.636	13.355	14.184
Meter Volume, Actual Cubic Feet:	86.394	87.138	83.323	85.618
Meter Volume, STP, dscf:	83.3	80.8	77.8	80.61
Meter Volume, STP, dscm:	2.359	2.288	2.202	2.28
Total Gas Sampled, scf:	97.84	95.43	91.11	94.79
Total Gas Sampled, acf, wet:	101.50	102.92	97.63	100.69
Percent Stack Gas Moisture:	14.88	15.34	14.66	14.96
Gas Analysis Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Percent Carbon Dioxide, dry:	13.43	12.51	11.74	12.56
Percent Oxygen, dry:	6.19	6.47	7.92	6.86
Percent Nitrogen:	80.38	81.01	80.34	80.58
Dry Molecular Weight, lb/lb-Mole:	30.397	30.261	30.195	30.284
Molecular Weight, at Stack Condition, lb/lb-Mole:	28.552	28.380	28.408	28.45
Calculated Fuel Factor, F_o:	1.095	1.153	1.105	1.118
Fuel F-Factor, F_c:	1840	1840	1840	1840
Percent Excess Air:	41.16	43.40	59.60	48.05
Gas Calculations	**Run 1**	**Run 2**	**Run 3**	**Average**
Density Dry at STP, lb/cf:	0.0786	0.0782	0.0781	0.0783
Density Wet at STP (68 deg. F, 29.92 in. Hg), lb/cf:	0.0738	0.0734	0.0734	0.074
Density Wet at Stack Cond, lb/cf:	0.0598	0.0575	0.0573	0.058
Pounds of Gas Sampled, Dry:	6.5447	6.3207	6.0702	6.312
Pounds of Gas Sampled, Wet:	7.2217	7.0013	6.6912	6.971
Gas Volumetric Flow Rate Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Average Stack Gas Velocity, ft/s:	30.6	30.2	30.7	30.5
Stack Gas Flow Rate, ACFM:	720,231	708,790	722,645	717,222
Stack Gas Flow Rate, SCFM:	582,817	554,952	563,179	566,983
Stack Gas Flow Rate, DSCFM:	496,087	469,839	480,630	482,185
Percent of Isokinetic Sampling Rate:	100.0	102.4	96.4	99.61
Gas Concentrations and Emission Rates	**Run 1**	**Run 2**	**Run 3**	**Average**
Filterable PM Weight, mg:	8.19	7.65	12.26	9.37
Filterable PM, gr/dscf:	0.00152	0.00146	0.00243	0.00180
Filterable PM, mg/wacm	2.85	2.63	4.44	3.30
Filterable PM, mg/wacm at Stack Conditions	2.40	2.22	3.71	2.78
Filterable PM, lbs/hr:	6.5	5.9	10.0	7.5
Filterable PM, lb/mmBtu:	0.003	0.003	0.005	0.004
Filterable PM, lb/1000 lb gas flow:	0.002	0.002	0.004	0.003
Filterable PM, lb/1000 Lb Gas Flow @ 50% Excess Air:	0.002	0.002	0.004	0.003
Filterable PM, tpy:	28.27	25.78	43.92	32.65
Dry Gas Metering System Calibration Check [1]	**Run 1**	**Run 2**	**Run 3**	**Average**
Dry Gas Meter Calibration Factor (Y_d):	0.999	1.003	1.003	1.002
Y_{qa} (calculated):	1.00	0.99	1.02	1.00
Assigned Δ H (@ 0.75 SCFM) of the meter system:	1.83	1.87	1.87	1.86
Allowable Y_{qa} (+/-) 5%:	0.949 to 1.049	0.953 to 1.053	0.953 to 1.053	
Actual Yds Deviation, %:	0.23	1.26	-1.21	0.09
Dry Gas Metering System Thermocouple Calibration Check [2]	**Reference, °F**	**Module, °F**	**Difference**	**Requirement**
Stack	69	68	-1	±2° F
Probe	69	68	-1	±2° F
Filter	69	68	-1	±2° F
Dryer	69	68	-1	±2° F
Auxiliary	69	68	-1	±2° F

[1] Emission Measurement Center Approved Alternative Meter Calibration Method (ALT-009)
[2] Emission Measurement Center Approved Alternative Thermocouple Calibration Method (ALT-011)

Regulatory Compliance Testing Services
MATS 5 PM Summary Audit Sheet

Facility and Source Information				
Customer:	D.E. Karn			
Source:	Unit 2		Unit Load:	High
Work Order:	26815610			
Date:	10/18/2016	10/18/2016	10/19/2016	
Stack Diameter, inches:	216	216	216	
Stack Area, Square Feet:	254.47	254.47	254.47	
Source Pollutant Test Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Barometric Pressure, inches mercury:	28.62	28.62	29.20	28.81
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:	-0.50	-0.50	-0.50	-0.50
Nozzle Diameter, inches:	0.242	0.242	0.242	0.242
Run Start Time:	13:48	16:55	8:10	
Run Stop Time:	16:32	19:27	10:30	
Duration of Sample, minutes:	120	120	120	120
Meter Leak Rate, ft3/min:	0.000	0.000	0.015	0.005
Meter Start Volume, cf:	571.84	664.61	755.80	664.08
Meter Final Volume, cf:	663.82	755.23	844.46	754.50
Average Meter Pressure, inches water:	1.89	1.88	1.82	1.86
Average Meter Temperature, degrees F:	82.2	87.3	69.8	79.8
Average Square Root Pitot Pressure, inches water:	0.8749	0.8684	0.8663	0.8699
Stack Gas Temperature, degrees F:	188.4	188.8	186.3	187.8
Source Moisture Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Liquid Volume Collected, grams:	297.0	303.7	286.8	295.8
Water Vapor Volume at STP, scf:	14.004	14.319	13.523	13.949
Meter Volume, Actual Cubic Feet:	91.985	90.617	88.660	90.421
Meter Volume, STP, dscf:	86.0	83.9	86.5	85.47
Meter Volume, STP, dscm:	2.435	2.376	2.450	2.42
Total Gas Sampled, scf, wet:	99.98	98.23	100.04	99.41
Total Gas Sampled, acf, wet:	106.97	106.08	102.52	105.19
Percent Stack Gas Moisture:	14.01	14.58	13.52	14.03
Gas Analysis Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Percent Carbon Dioxide, dry:	11.52	11.65	12.45	11.87
Percent Oxygen, dry:	8.42	7.82	7.62	7.95
Percent Nitrogen:	80.06	80.53	79.93	80.18
Dry Molecular Weight, lb/lb-Mole:	30.180	30.177	30.297	30.218
Molecular Weight, at Stack Condition, lb/lb-Mole:	28.474	28.402	28.635	28.50
Calculated Fuel Factor, F_o:	1.084	1.123	1.067	1.091
Fuel F-Factor, F_c:	1840	1840	1840	1840
Percent Excess Air:	66.15	58.20	56.47	60.27
Gas Calculations	**Run 1**	**Run 2**	**Run 3**	**Average**
Density Dry at STP, lb/cf:	0.0780	0.0780	0.0783	0.0781
Density Wet at STP (68 deg. F, 29.92 in. Hg), lb/cf:	0.0736	0.0734	0.0740	0.074
Density Wet at Stack Cond, lb/cf:	0.0573	0.0571	0.0589	0.058
Pounds of Gas Sampled, Dry:	6.7082	6.5462	6.7764	6.677
Pounds of Gas Sampled, Wet:	7.3593	7.2120	7.4052	7.326
Gas Volumetric Flow Rate Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Average Stack Gas Velocity, ft/s:	56.1	55.7	54.7	55.5
Stack Gas Flow Rate, ACFM:	856,189	851,184	835,615	847,663
Stack Gas Flow Rate, SCFM:	665,815	661,540	665,096	664,150
Stack Gas Flow Rate, DSCFM:	572,556	565,101	575,191	570,949
Percent of Isokinetic Sampling Rate:	99.7	98.6	99.9	99.39
Gas Concentrations and Emission Rates	**Run 1**	**Run 2**	**Run 3**	**Average**
Filterable PM Weight, mg:	2.89	6.46	10.52	6.62
Filterable PM, gr/dscf:	0.00052	0.00119	0.00188	0.00119
Filterable PM, mg/wacm:	0.95	2.15	3.62	2.24
Filterable PM, mg/wacm at Stack Conditions	0.80	1.81	2.96	1.85
Filterable PM, lbs/hr:	2.5	5.8	9.2	5.8
Filterable PM, lb/mmBtu:	0.001	0.003	0.004	0.003
Filterable PM, lb/1000 lb gas flow:	0.001	0.002	0.003	0.002
Filterable PM, lb/1000 Lb Gas Flow @ 50% Excess Air:	0.001	0.002	0.003	0.002
Filterable PM, tpy:	11.16	25.20	40.50	25.62
Dry Gas Metering System Calibration Check [1]	**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):	1.01	1.03	1.00	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, %:	-0.82	-2.74	-0.48	-1.35
Dry Gas Metering System Thermocouple Calibration Check [2]	**Reference, °F**	**Module, °F**	**Difference**	**Requirement**
Stack	69	68	-1	±2° F
Probe	69	68	-1	±2° F
Filter	69	68	-1	±2° F
Dryer	69	68	-1	±2° F
Auxiliary	69	68	-1	±2° F

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

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

Regulatory Compliance Testing Services
Method 5 PM Summary Audit Sheet

Facility and Source Information				
Customer:	D.E. Karn			
Source:	Unit 2		Unit Load:	High
Work Order:	24038047			
Date:	10/18/2016	10/18/2016	10/19/2016	
Stack Diameter, inches:	216	216	216	
Stack Area, Square Feet:	254.47	254.47	254.47	
Source Pollutant Test Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Barometric Pressure, inches mercury:	28.62	28.62	29.20	28.81
Meter Calibration Factor:	1.003	1.003	1.003	1.003
Pitot Tube Calibration Factor:	0.84	0.84	0.84	0.84
Stack Static Pressure, inches water:	-0.50	-0.50	-0.50	-0.50
Nozzle Diameter, inches:	0.242	0.242	0.242	0.242
Run Start Time:	13:48	16:55	8:10	
Run Stop Time:	16:32	19:27	10:30	
Duration of Sample, minutes:	120	120	120	120
Meter Leak Rate, ft3/min:	0.000	0.000	0.000	0.000
Meter Start Volume, cf:	945.40	36.61	132.78	371.60
Meter Final Volume, cf:	1036.11	131.74	222.80	463.55
Average Meter Pressure, inches water:	1.93	2.05	1.98	1.99
Average Meter Temperature, degrees F:	82.8	87.9	69.4	80.0
Average Square Root Pitot Pressure, inches water:	0.8737	0.8926	0.8895	0.8853
Stack Gas Temperature, degrees F:	187.5	187.6	185.1	186.7
Source Moisture Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Liquid Volume Collected, grams:	343.3	322.2	310.6	325.4
Water Vapor Volume at STP, scf:	16.184	15.192	14.645	15.340
Meter Volume, Actual Cubic Feet:	90.718	95.125	90.018	91.954
Meter Volume, STP, dscf:	85.1	88.4	88.3	87.24
Meter Volume, STP, dscm:	2.409	2.503	2.500	2.47
Total Gas Sampled, scf:	101.24	103.56	102.93	102.58
Total Gas Sampled, acf, wet:	107.98	111.48	104.95	108.14
Percent Stack Gas Moisture:	15.99	14.67	14.23	14.96
Gas Analysis Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Percent Carbon Dioxide, dry:	11.52	11.65	12.45	11.87
Percent Oxygen, dry:	8.42	7.82	7.51	7.92
Percent Nitrogen:	80.06	80.53	80.03	80.21
Dry Molecular Weight, lb/lb-Mole:	30.180	30.177	30.293	30.217
Molecular Weight, at Stack Condition, lb/lb-Mole:	28.233	28.390	28.544	28.39
Calculated Fuel Factor, F_o:	1.084	1.123	1.075	1.094
Fuel F-Factor, F_c:	1840	1840	1840	1840
Percent Excess Air:	66.15	58.20	55.19	59.84
Gas Calculations	**Run 1**	**Run 2**	**Run 3**	**Average**
Density Dry at STP, lb/cf:	0.0780	0.0780	0.0783	0.0781
Density Wet at STP (68 deg. F, 29.92 in. Hg), lb/cf:	0.0730	0.0734	0.0738	0.073
Density Wet at Stack Cond, lb/cf:	0.0569	0.0572	0.0589	0.058
Pounds of Gas Sampled, Dry:	6.6363	6.8945	6.9139	6.815
Pounds of Gas Sampled, Wet:	7.3889	7.6010	7.5949	7.528
Gas Volumetric Flow Rate Data	**Run 1**	**Run 2**	**Run 3**	**Average**
Average Stack Gas Velocity, ft/s:	56.2	57.3	56.2	56.6
Stack Gas Flow Rate, ACFM:	858,117	874,311	858,502	863,643
Stack Gas Flow Rate, SCFM:	668,215	680,695	684,636	677,849
Stack Gas Flow Rate, DSCFM:	561,392	580,844	587,223	576,487
Percent of Isokinetic Sampling Rate:	100.6	101.0	99.8	100.48
Gas Concentrations and Emission Rates	**Run 1**	**Run 2**	**Run 3**	**Average**
Filterable PM Weight, mg:	8.90	7.53	6.93	7.79
Filterable PM, gr/dscf:	0.00161	0.00132	0.00121	0.00138
Filterable PM, mg/wacm	2.91	2.39	2.33	2.54
Filterable PM, mg/wacm at Stack Conditions	2.42	2.00	1.90	2.11
Filterable PM, lbs/hr:	7.8	6.5	6.1	6.8
Filterable PM, lb/mmBtu:	0.004	0.003	0.003	0.003
Filterable PM, lb/1000 lb gas flow:	0.003	0.002	0.002	0.002
Filterable PM, lb/1000 Lb Gas Flow @ 50% Excess Air:	0.003	0.002	0.002	0.002
Filterable PM, tpy:	34.02	28.69	26.70	29.80
Dry Gas Metering System Calibration Check [1]	**Run 1**	**Run 2**	**Run 3**	**Average**
Dry Gas Meter Calibration Factor (Y_d):	1.003	1.003	1.003	1.003
Y_{qa} (calculated):	1.02	1.01	1.02	1.02
Assigned Δ H (@ 0.75 SCFM) of the meter system:	1.87	1.87	1.87	1.87
Allowable Y_{qa} (+/-) 5%:	0.953 to 1.053	0.953 to 1.053	0.953 to 1.053	
Actual Yds Deviation, %:	-1.88	-0.87	-1.52	-1.42
Dry Gas Metering System Thermocouple Calibration Check [2]	**Reference, °F**	**Module, °F**	**Difference**	**Requirement**
Stack	69	68	-1	±2° F
Probe	69	68	-1	±2° F
Filter	69	68	-1	±2° F
Dryer	69	68	-1	±2° F
Auxiliary	69	68	-1	±2° F

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

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