Consumers Energy

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NOV-CD PM Test Report

EU-KARN1 & EU-KARN2

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Consumers Energy Company
D.E. Karn Generating Complex
2742 North Weadock Highway
Essexville, Michigan 48732
SRN: B2840

Test Dates: September 10 & 17, 2018

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

EXECUTIVE SUMMARY

Consumers Energy Regulatory Compliance Testing Section (RCTS) conducted filterable particulate matter (FPM) and condensable PM (CPM) testing of the single dedicated exhausts of coal-fired boilers EU-KARN1 (Unit 1) and EU-KARN2 (Unit 2) operating at the D.E. Karn Generating Complex in Essexville, Michigan. Unit 1 and Unit 2 are coal-fired electric utility steam generating units (EGUs) that turn turbines connected to electricity producing generators. The purpose of the test program was to satisfy testing 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. The CD requires filterable and condensable particulate matter (PM) testing of Unit 1 and Unit 2 to in accordance with the requirements in CD Paragraphs 153, 154 and 156.

Triplicate 120-minute PM test runs were conducted on EU-KARN1 on September 17, 2018 and on EU-KARN2 on September 10, 2018. All test runs followed the procedures in 40 CFR 60, Appendix A, reference methods (RM) 1, 2, 3A/3B (ALT-123), 4, 5, 19, and 40 CFR 51, Appendix M, RM 202. Each 120-minute test run collected a minimum of 60 dry standard cubic feet (dscf). There were no deviations from the stack test protocol or the associated USEPA Reference Methods. During testing, Units 1 and 2 were operated at a steady representative load under normal operating conditions. The Unit 1 and 2 FPM and CPM results are summarized below.

Summary of Filterable and Condensable PM Results

Parameter	Units	Run 1	Run 2	Run 3	Average	Emission Limit CD	Emission Limit CD†
EU-KARN1							
FPM	lb/mmBtu	0.0010	0.0017	0.0010	**0.0012**	**0.015**	**0.010**
CPM	lb/mmBtu	0.044	0.053	0.045	**0.047**	**N/A**	
FPM & CPM	lb/mmBtu	0.045	0.055	0.046	**0.049**	**N/A**	
EU-KARN2							
FPM	lb/mmBtu	0.0004	0.0012	0.0004	**0.0007**	**0.015**	**0.010**
CPM	lb/mmBtu	0.032	0.038	0.033	**0.034**	**N/A**	
FPM & CPM	lb/mmBtu	0.033	0.039	0.033	**0.035**	**N/A**	

†: CD Civil Action No.: 14-13580 requires testing every year, rather than every other year, beginning in the year immediately following any test result demonstrating PM emissions are greater than 0.010 lb/mmBtu.

The results of the testing indicate the 3-run average FPM results are in compliance with applicable limits as stipulated in CD Paragraphs 147 and 148.

1.0 INTRODUCTION

This report summarizes the results of FPM and CPM testing conducted on September 10 and 17, 2018 from the single dedicated exhausts of coal fired boilers EU-KARN1 (Unit 1) and EU-KARN2 (Unit 2) operating at the Consumers Energy D.E. Karn Generating Complex.

This document follows the Michigan Department of Environmental Quality (MDEQ) format described in the March 2018 Guidance Document, Format for Submittal of Source Emission Test Plans and Reports. Reproducing only a portion of this report may omit critical substantiating documentation or cause information to be taken out of context. If any portion of this report is reproduced, please exercise due care in this regard.

1.1 IDENTIFICATION, LOCATION, AND DATES OF TESTS

Consumers Energy Regulatory Compliance Testing Section (RCTS) conducted filterable and condensable particulate matter (PM) testing of the dedicated exhaust of coal-fired boiler Unit 1 and Unit 2 in operation at the D.E. Karn Generating Complex in Essexville, Michigan on September 10 and 17, 2018.

1.2 PURPOSE OF TESTING

The purpose of the test program was to satisfy testing 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. The CD requires filterable and condensable particulate matter testing of Unit 1 and Unit 2 to evaluate compliance with the FPM limit set forth in the CD and determine testing frequency.

Table 1-1
EU-KARN1 and EU-KARN2 Consent Decree PM Emission Limit

Parameter	Emission Limit	Units	Applicable Requirement
PM	0.015	lb/mmBtu	Consent Decree Paragraphs 147 & 148

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

1.3 BRIEF DESCRIPTION OF SOURCE

EU-KARN1 and EU-KARN2 are coal-fired electric utility steam generating units (EGUs) that turn turbines connected to electricity producing generators.

1.4 CONTACT INFORMATION

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

Figure 1-1. Test Program Organization

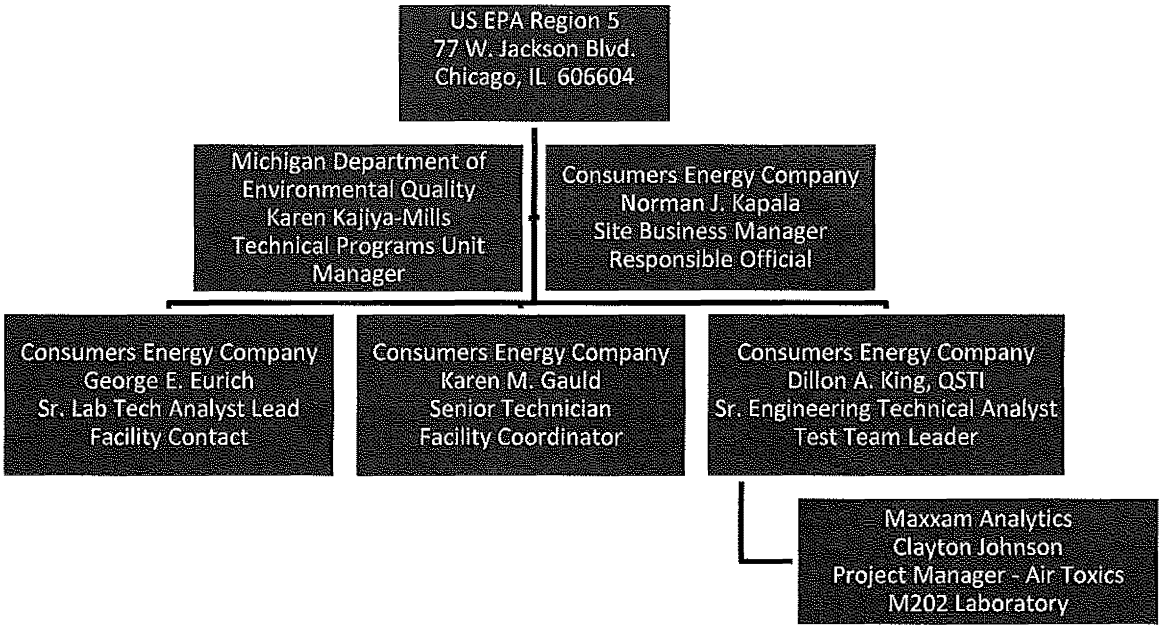


Table 1-2
Contact Information

Program Role	Contact	Address
EPA Regional Contact	Air Enforcement and Compliance Assurance Branch U.S. Environmental Protection Agency – Region V 77 W. Jackson Boulevard Chicago, Illinois 60604	
State Regulatory Administrator	Ms. Karen Kajiya-Mills Technical Programs Unit Manager 517-335-4874 Kajiya-Millsk@michigan.gov	Michigan Department of Environmental Quality Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
Responsible Official	Mr. Norman J. Kapala Executive Director Coal Generation 616-738-3200 Norman.Kapala@cmsenergy.com	Consumers Energy Company J.H. Campbell Power Plant 17000 Croswell Street West Olive, Michigan 49460
Test Facility	Mr. George E. Eurich Senior Laboratory Technical Analyst 989-891-3317 George.Eurich@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex 2742 N Weadock Highway Essexville, Michigan 48732
Test Facility	Ms. Karen M. Gauld Sr. Technician 989-891-3168 Karen.Gauld@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex 2742 N. Weadock Highway, ESD Trailer #4 Essexville, Michigan 48732
Test Team Representative	Mr. Dillon A. King, QSTI Sr. Engineering Technical Analyst I 989-891-5585 Dillon.King@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex 2742 N. Weadock Highway, ESD Trailer #4 Essexville, Michigan 48732
Laboratory	Mr. Clayton Johnson Project Manager – Air Toxics 905-817-5769 CJohnson@maxxam.ca	Maxxam Analytics 6740 Campobello Road Mississauga, Ontario L5N 2L8

2.0 SUMMARY OF RESULTS

2.1 OPERATING DATA

During the performance test, EU-KARN1 and EU-KARN2 fired 100% western coal and were operated at maximum normal operating load conditions. The testing on EU-KARN1 was performed while the boiler was operating within the range of 251.2 MWg to 253.2 MWg (92.4-93.1% of the achievable capacity). The testing on EU-KARN2 was performed while the boiler was operating within the range of 240.8 MWg to 241.9 MWg (86.9-87.3% of the achievable capacity). Unit 2 had a coal pulverizer out of service during the test program and was operated at the maximum normal operating load available.

Refer to Attachment D for detailed operating data, which was recorded in Eastern Standard Time. Note the time convention for the reference method (RM) testing was Eastern Daylight Savings Time (EDT); therefore, there is a one hour offset between the RM time stamps and continuous emissions monitoring system (CEMS)/process data time stamps.

2.2 APPLICABLE PERMIT INFORMATION

The D.E. Karn generating station has the State of Michigan Registration Number (SRN) B2840 and operates in accordance with air permit MI-ROP-B2840-2014c. The air permit incorporates federal regulations and reports under Federal Registry Service (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 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.

2.3 RESULTS

The results of the testing indicate the 3-run average FPM and CPM results for Unit 1 and Unit 2 are in compliance with applicable limits. Refer to Table 2-1 for a summary of the PM results in comparison to emission limits.

Table 2-1
Summary of Filterable and Condensable PM Results

Parameter	Units	Run 1	Run 2	Run 3	Average	Emission Limit CD	Emission Limit CD†
EU-KARN1							
FPM	lb/mmBtu	0.0010	0.0017	0.0010	**0.0012**	**0.015**	**0.010**
CPM	lb/mmBtu	0.044	0.053	0.045	**0.047**	**N/A**	
FPM & CPM	lb/mmBtu	0.045	0.055	0.046	**0.049**	**N/A**	
EU-KARN2							
FPM	lb/mmBtu	0.0004	0.0012	0.0004	**0.0007**	**0.015**	**0.010**
CPM	lb/mmBtu	0.032	0.038	0.033	**0.034**	**N/A**	
FPM & CPM	lb/mmBtu	0.033	0.039	0.033	**0.035**	**N/A**	

†: CD Civil Action No.: 14-13580 requires testing every year, rather than every other year, beginning in the year immediately following any test result demonstrating PM emissions are greater than 0.010 lb/mmBtu.

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

3.0 SOURCE DESCRIPTION

EU-KARN1 and EU-KARN2 are coal-fired EGUs that turn turbines connected to electricity producing generators.

3.1 PROCESS

EU-KARN1 is a dry bottom tangential coal fired boiler with fuel oil startup capabilities and supplemental co-firing for flame stabilization and mill outages. EU-KARN2 is a dry bottom wall coal fired boiler also with fuel oil startup capabilities and supplemental co-firing for flame stabilization and mill outages.

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

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 (NO_x), and EU-KARN2 also has low NOx burners for additional control of NO_x. 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 (SO_2) 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

The normal fuel utilized in Units 1 and 2 is 100% western subbituminous coal. The boilers are classified as coal-fired units not firing low rank virgin coal. For this test, both units were burning 100% western subbituminous coal.

3.4 RATED CAPACITY

Unit 1 has a nominally rated heat input capacity of 2,500 million BTU per hour and can generate a gross electrical output of approximately 272 megawatts (MWg). Unit 2 has a nominally rated heat input capacity of 2,540 million BTU per hour and can generate a gross electrical output of approximately 277 megawatts (MWg).

The boilers operate in a continuous manner in order to meet the electrical demands of Midcontinent Independent System Operator, Inc. (MISO) and Consumers Energy customers. Both units are considered baseload units because they are designed to operate 24 hours a day, 365 days a year.

3.5 Process Instrumentation

The process was continuously monitored by boiler operators, environmental technicians, and data acquisition systems during testing. One-minute data for the following parameters were collected during each PM test runs:

- PM (mg/wacm)
- load (MWg)
- CO_2 concentration (vol-%, Wet)
- Opacity (%)
- Volumetric Flowrate (kscfh)
- NO_x (ppm)
- Pressure (in Hg)
- SO_2 (ppm)
- Stack temp (°F)

The control equipment process instrumentation and reference method data is recorded on Eastern Daylight Time (EDT), whereas the continuous emissions monitoring systems record data on Eastern Standard Time (EST). During the test program, EDT was one hour later than EST. (i.e., 8:00 am EDT = 7:00 am EST). Refer to Appendix D for operating data.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Consumers Energy RCTS tested for PM emissions using the USEPA test methods presented in Table 4-1. The sampling and analytical procedures associated with each parameter are described in the following sections.

Table 4-1
Test Methods

Parameter	Method	USEPA 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/3B ALT-123	Alternative Test Method for Diluent Measurement to Support Particulate Testing under 40 CFR 63, Subpart UUUUU
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
Condensable Particulate Matter	202	Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources

4.1 Description of Sampling Train and Field Procedures

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

Table 4-2
Test Matrix

Date (2018)	Run	Sample Type	Start Time (EDT)	Stop Time (EDT)	Test Duration (min)	EPA Test Method	Comment
EU-KARN1							
Sept 17	1	FPM, CPM	10:10	12:27	120	M5/202	24 traverse points; isokinetic sampling; 120 minute test duration; minimum sample volume of 60 dscf
Sept 17	2	FPM, CPM	12:55	15:15	120	M5/202	
Sept 17	3	FPM, CPM	15:41	18:00	120	M5/202	
EU-KARN2							
Sept 10	1	FPM, CPM	09:00	11:19	120	M5/202	24 traverse points; isokinetic sampling; 120 minute test duration; minimum sample volume of 60 dscf
Sept 10	2	FPM, CPM	11:45	14:05	120	M5/202	
Sept 10	3	FPM, CPM	14:35	16:52	120	M5/202	

4.1.1 Sample Location and Traverse Points (USEPA Method 1)

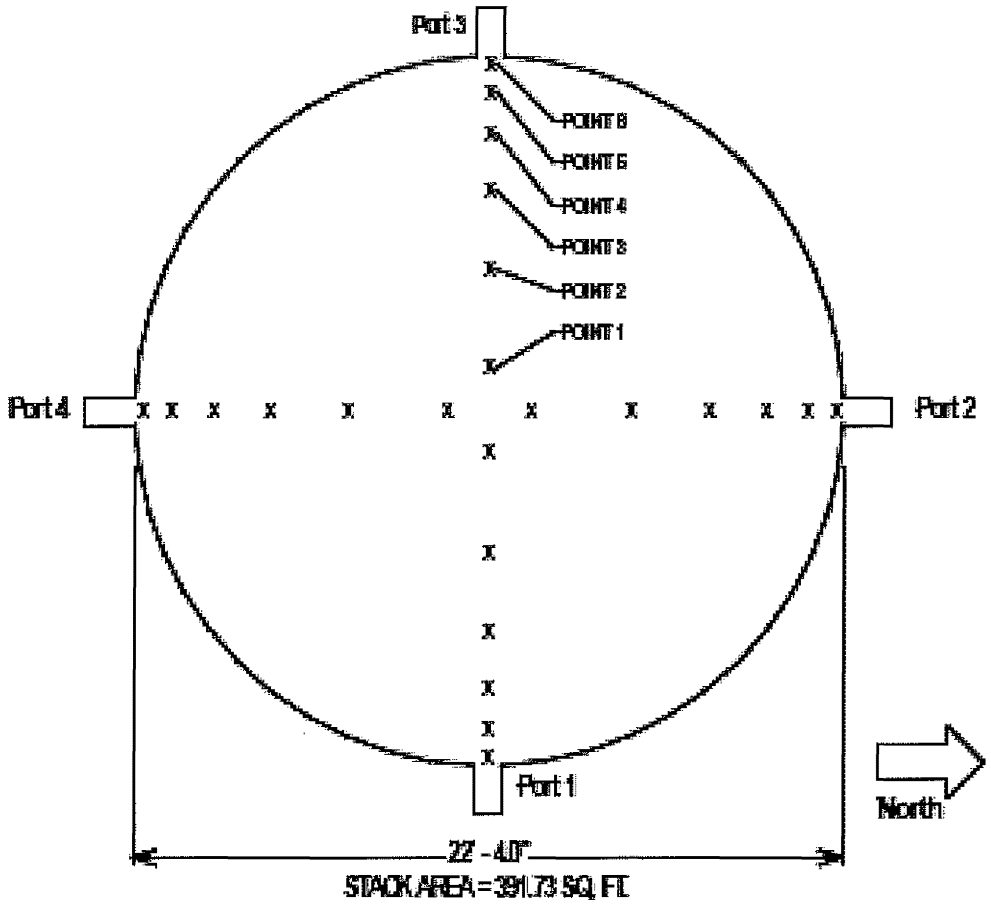
The number and location of traverse points for determining particulate concentrations and exhaust gas velocity/ volumetric air-flow was determined in accordance with USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources.* Four test ports are located in the horizontal plane of the vertical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

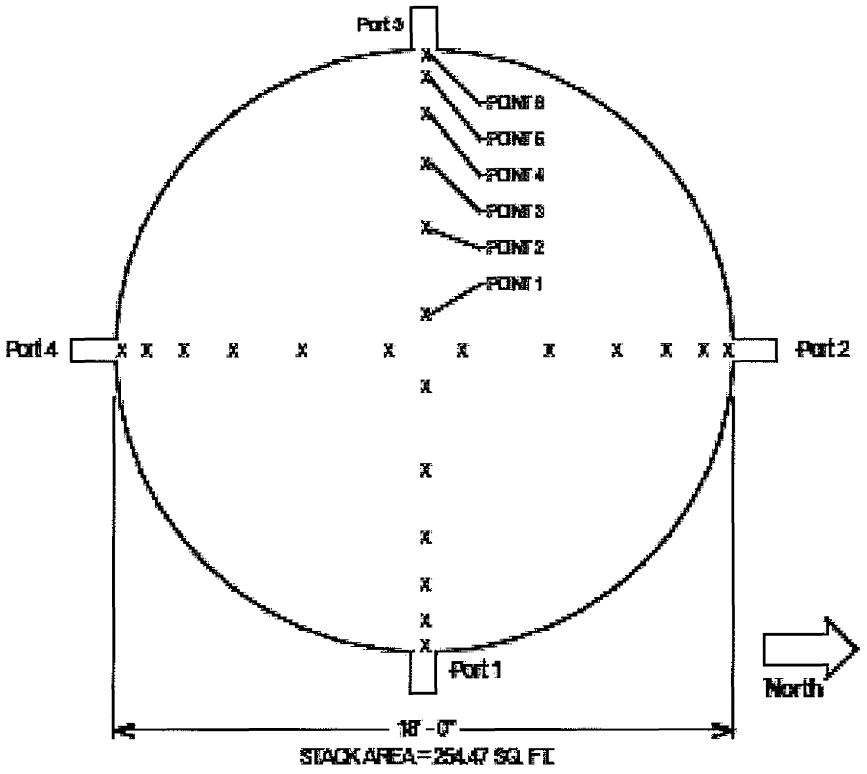
Note: Test Port Length = 24" from inside stack wall to outside flange.

DISTANCES FROM INSIDE STACK WALL

Point 1	95.27"
Point 2	66.90"
Point 3	47.35"
Point 4	31.58"
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



STACK AREA = 254.47 SQ. FT.

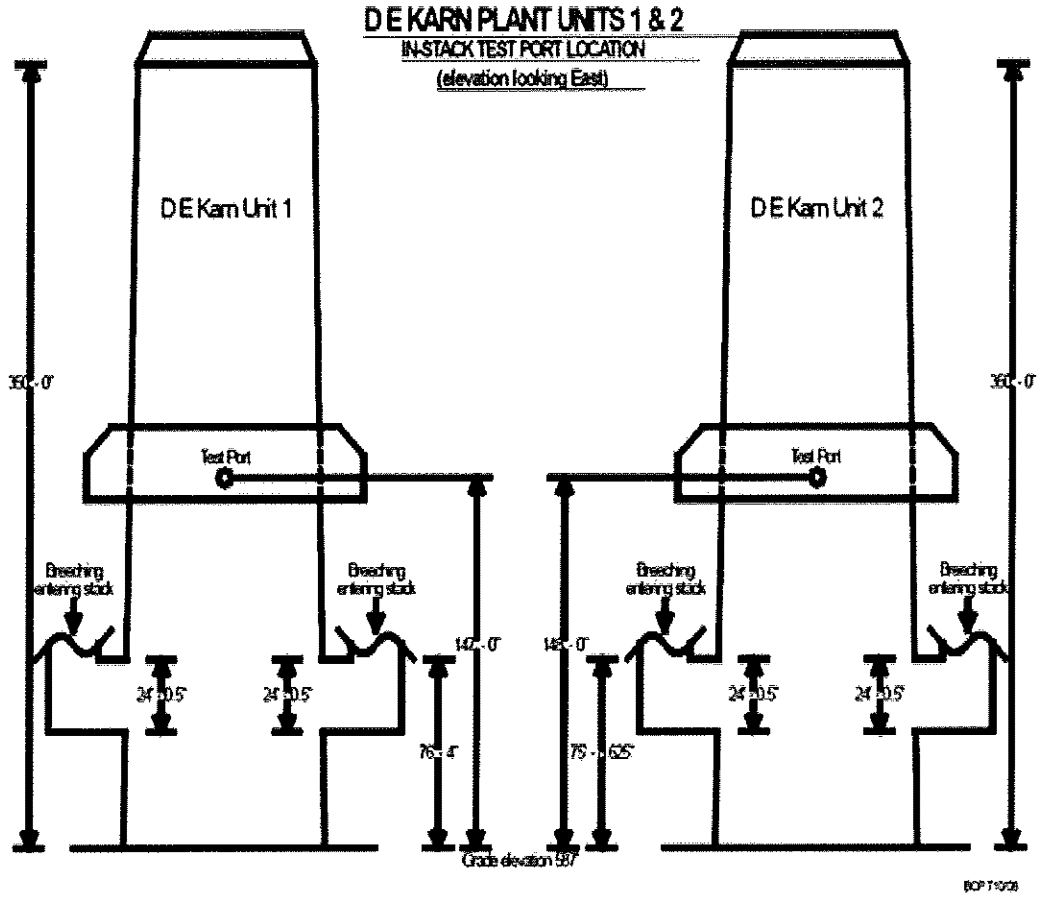
PARTICULATE EMISSION TEST POINT LOCATIONS

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

DISTANCES FROM INSIDE STACK WALL

Point 1	76.90"
Point 2	54.00"
Point 3	39.23"
Point 4	25.49"
Point 5	14.47"
Point 6	4.54"

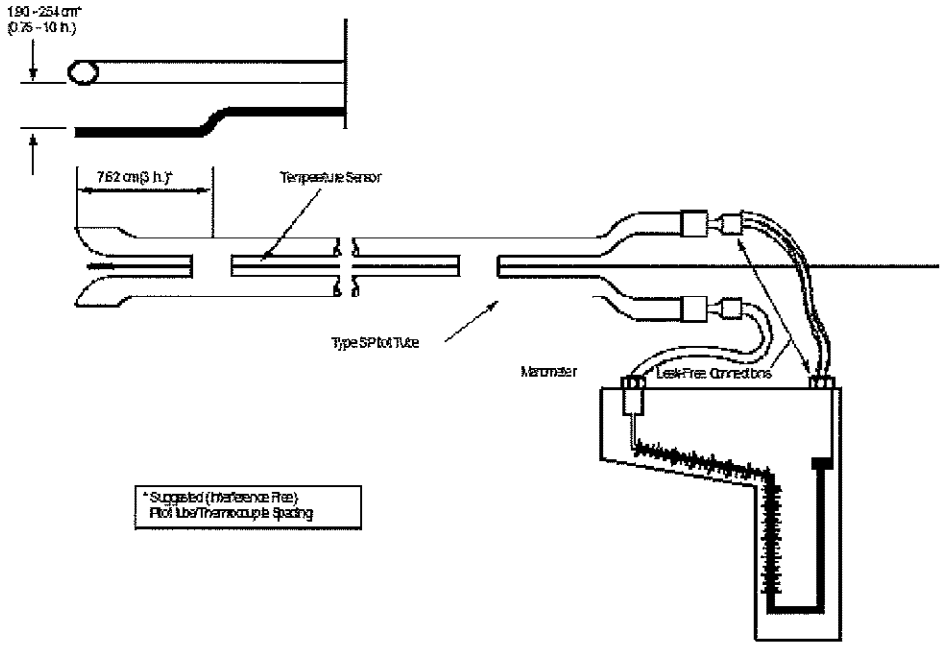
Figure 4-3. Units 1&2 Test Port Locations



4.1.2 Velocity and Temperature (USEPA Method 2)

The exhaust gas velocity and temperature were measured using USEPA Method 2, *Determination of Stack Gas Temperature and Velocity (Type S Pitot Tube)*. The pressure differential (ΔP) across the positive impact and negative static 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 nickel-chromium/nickel-alumel "Type K" thermocouple and a temperature indicator. Refer to Figure 4-4 for the Method 2 Pitot tube, thermocouple, and inclined oil-filled manometer configuration.

Figure 4-4. Method 2 Sample Apparatus



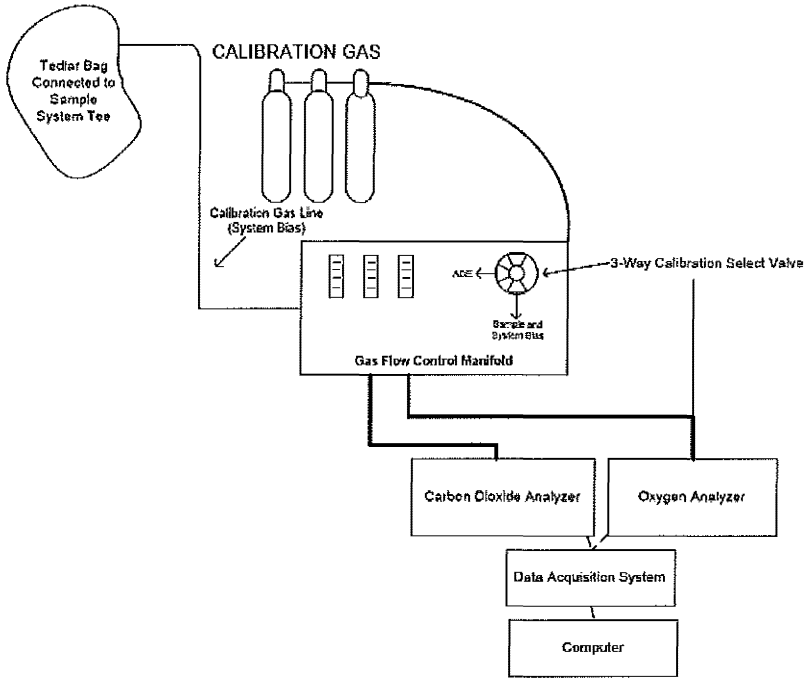
Appendix B of this report includes cyclonic flow test data as verification of the absence of cyclonic flow at the sample location. Method 1, § 11.4.2 states "if the average (null angle) is greater than 20°, the overall flow condition in the stack is unacceptable, and alternative methodology...must be used." The average null yaw angle measured at the Unit 1 exhaust on September 25, 2017 was observed to be 2.96°, and the average null yaw angle at the Unit 2 exhaust (measured September 7, 2018) was observed to be 6.92° thus meeting the less than 20° requirement.

4.1.3 Molecular Weight (USEPA ALT-123)

The exhaust gas composition and molecular weight were measured using the sampling and analytical procedures of USEPA ALT-123, *Alternative Test Method for Diluent Measurement to Support Particulate Matter Testing Under 40 CFR 63, Subpart UUUUU*. ALT-123 combines the sample collection procedures of USEPA Method 3B, *Gas Analysis for the Determination of Emission Rate Correction Factor or Excess Air* with the analytical procedures of USEPA Method 3A, *Oxygen and Carbon Dioxide Concentrations from Stationary Sources – (Instrumental Analyzer Procedure.)* The flue gas oxygen and carbon dioxide concentrations were used to calculate molecular weight, flue gas velocity, and emissions in lb/mmBtu.

Flue gas was extracted from the stack during each test from each of the 24 traverse points through a stainless steel lined probe and inert tubing into a flexible sample bag. The sample was then withdrawn from the flexible bag and conveyed into a multi gas analyzer that measured oxygen and carbon dioxide concentrations. Figure 4-5 depicts the ALT-123 sampling system.

Figure 4-5. Method 3A Sampling System



Prior to sampling flue gas, the analyzer was calibrated by performing a calibration error test where zero-, mid-, and high-level calibration gases were introduced directly to the analyzer. The calibration error check was performed to evaluate if the analyzer response was within ±2.0% of the calibration gas span. Analyzer system-bias and drift tests were performed by filling inert flexible sample bags with zero- and mid- or high- calibration gases and introducing these calibration standards into the gas analyzer to measure the ability of the system to respond to within ±5.0 percent of span.

At the conclusion of the bag sample analysis, an additional system bias check was performed to evaluate the drift from the pre- and post-test system bias checks. The system-bias checks evaluated if the analyzer drift was 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 Appendices B and E for analyzer calibration data and supporting documentation.

4.1.4 Moisture Content (USEPA Method 4)

The exhaust gas moisture content was measured using USEPA Method 4, *Determination of Moisture in Stack Gases* in conjunction with the Method 5/202 sample apparatus. Sampled gas was drawn through a series of impingers immersed in an ice bath to condense and remove water from 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 Filterable 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.*

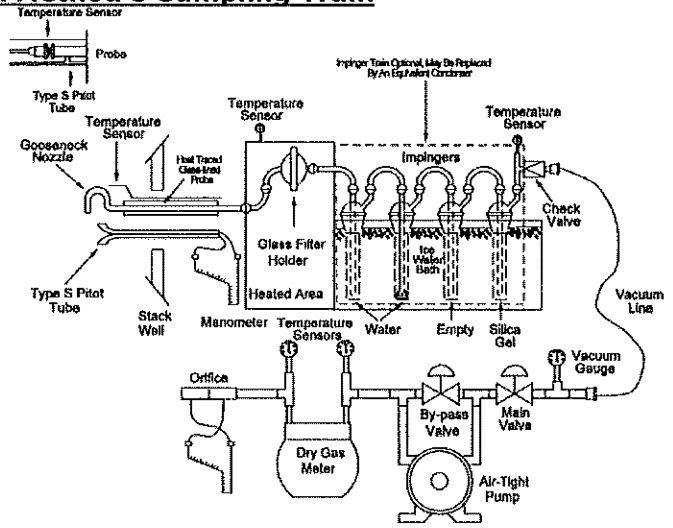
In the Method 5 (in conjunction with Method 202) sampling apparatus the flue gas is passed through a nozzle, heated probe, quartz-fiber filter, and into a series of impingers with the configuration presented in Table 4-3. The filter collects filterable particulate matter while the impingers collect water vapor and/or condensable particulate matter. Figure 4-6 depicts the USEPA Method 5 sampling apparatus.

Before testing, representative flow data from previous measurements were reviewed to calculate an ideal nozzle size that allows isokinetic sampling to be performed. A pre-cleaned nozzle that has an inner diameter that approximates the calculated value was measured with calipers across three cross-sectional chords, rinsed and brushed with 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 opening and applying a vacuum of approximately 15 inches of mercury. The dry-gas meter was monitored for approximately 1 minute to verify the sample apparatus 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 before sampling. After the desired operating conditions were coordinated with the facility, testing was initiated. Stack and sampling apparatus parameters (e.g., flue velocity, temperature) were monitored to establish the isokinetic sampling rate that was within 100±10 % for the duration of the test.

Figure 4-6. USEPA Method 5 Sampling Train



At the conclusion of a test run and the post-test leak check, the sampling train was disassembled and the impingers and FPM 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 was 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. Refer to Figure 4-7 for the USEPA Method 5 sample recovery scheme.

The sample containers, including blanks were transported to the laboratory for analysis. The sample analysis followed USEPA Method 5 procedures as summarized in the sample recovery scheme presented in Figure 4-8.

Figure 4-7. USEPA Method 5 Sample Recovery Scheme

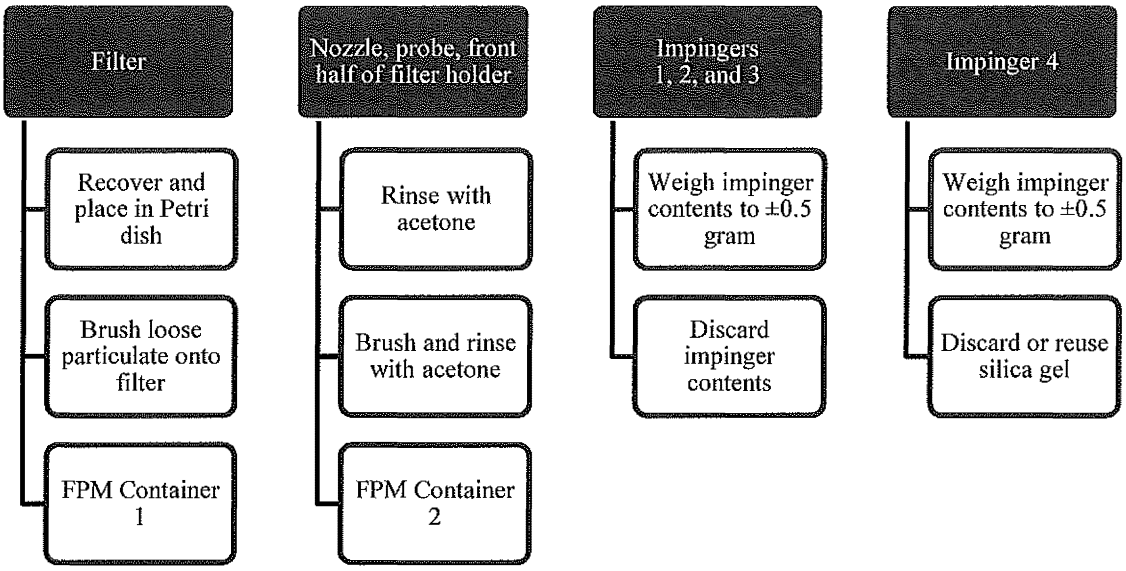
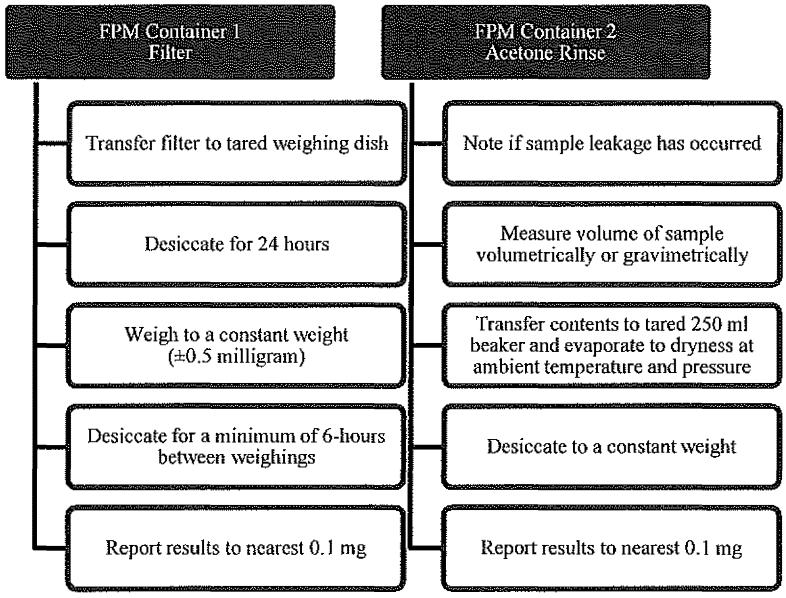


Figure 4-8. USEPA Method 5 Analytical Scheme



4.1.6 CONDENSABLE PARTICULATE MATTER

Condensable PM (CPM) was collected in conjunction with USEPA Method 5 using 40 CFR Part 51, EPA Method 202, *Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources* using clean, baked glassware consisting of a glass coil type condenser, a dropout impinger, a modified Greenburg-Smith (GS) impinger with an open tube tip, a CPM filter holder containing a Teflon filter, one impinger containing 100 mL

of water and one impinger containing silica gel for moisture collection. Table 4-3 below presents the Method 5/202 impinger configuration. The CPM filter temperature was maintained between 65 and 85°F throughout each test run using a water recirculation pump attached to the condenser.

Figure 4-9. USEPA Method 202 Sampling Train

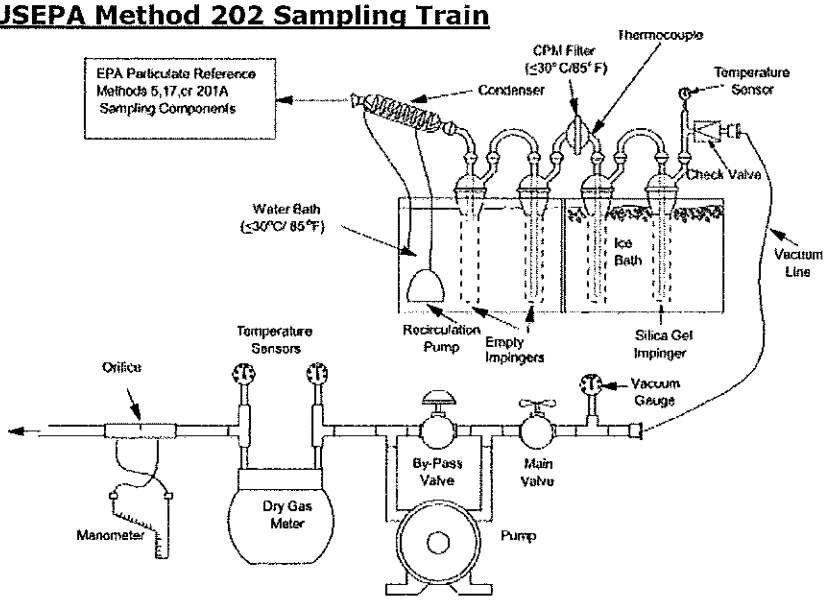


Table 4-3 Method 5/202 Impinger Configuration

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

Upon test completion, each impinger is weighed for the purpose of determining exhaust gas moisture content, after which the condenser, dropout impinger and GS impinger followed by the CPM filter housing were re-assembled. An ultra-high purity nitrogen source was then connected to the condenser inlet and the apparatus was purged at a rate of approximately 14 liters per minute for a minimum of one hour to remove any dissolved sulfur dioxide gases from the condensed impinger water. During the purge, the condenser recirculation pump remained in service and the CPM filter exit temperature was monitored to ensure the impinger contents did not evaporate.

After the purge, the dropout impinger and GS impinger condensate was transferred to a clean sample bottle labeled as CPM Container #1, Aqueous Liquid Impinger. The back half of the Method 5 filter bell, condenser, impingers and connecting glassware was then rinsed twice with deionized, ultra-filtered water into the same container. The water rinses were

followed by an acetone rinse and duplicate hexane rinses into a separate sample bottle identified as CPM Container #2 (organic rinse). The CPM filter was removed prior to the water and organic rinses and placed in a clean Petri dish identified as CPM Container #3. Liquid levels on the sample bottles were marked and all samples were sealed and transported to Maxxam Analytics laboratory in Mississauga, Ontario for analysis. Refer to Figure 4-10 for the USEPA Method 202 sample recovery scheme. The sample analysis followed USEPA Method 202 procedures as summarized in the sample recovery scheme presented in Figure 4-11.

Figure 4-10. USEPA Method 202 Sample Recovery Scheme

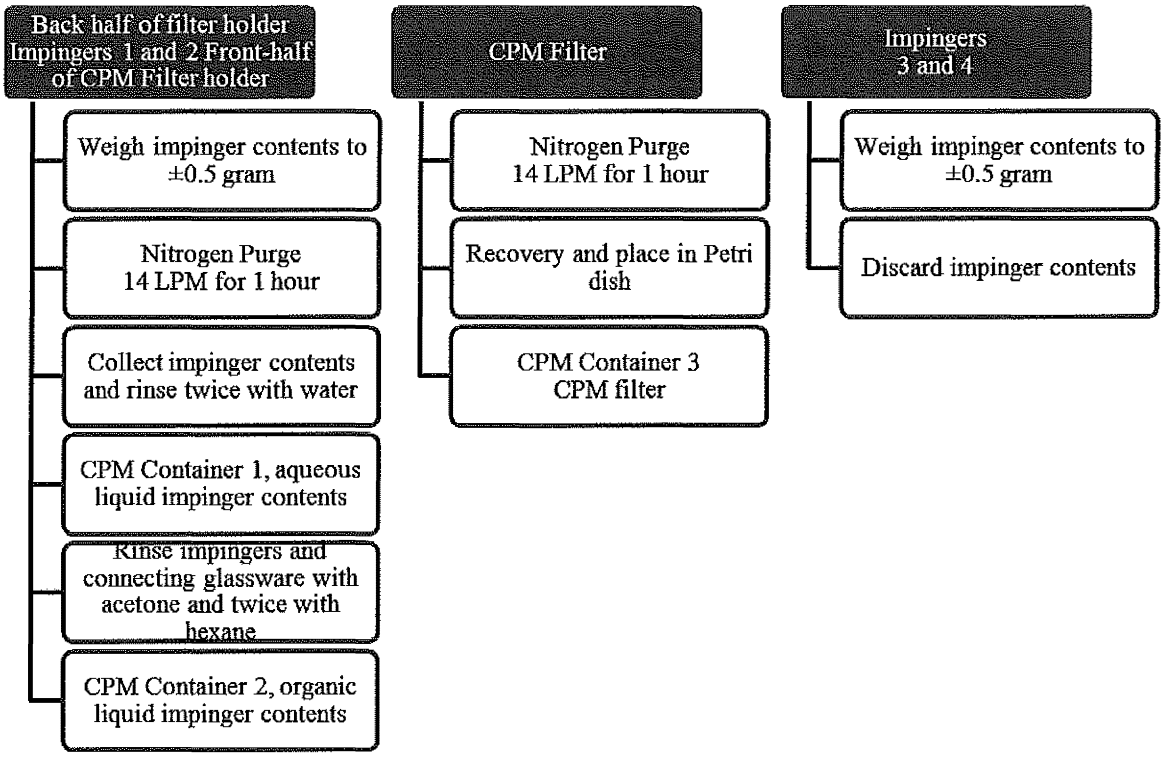
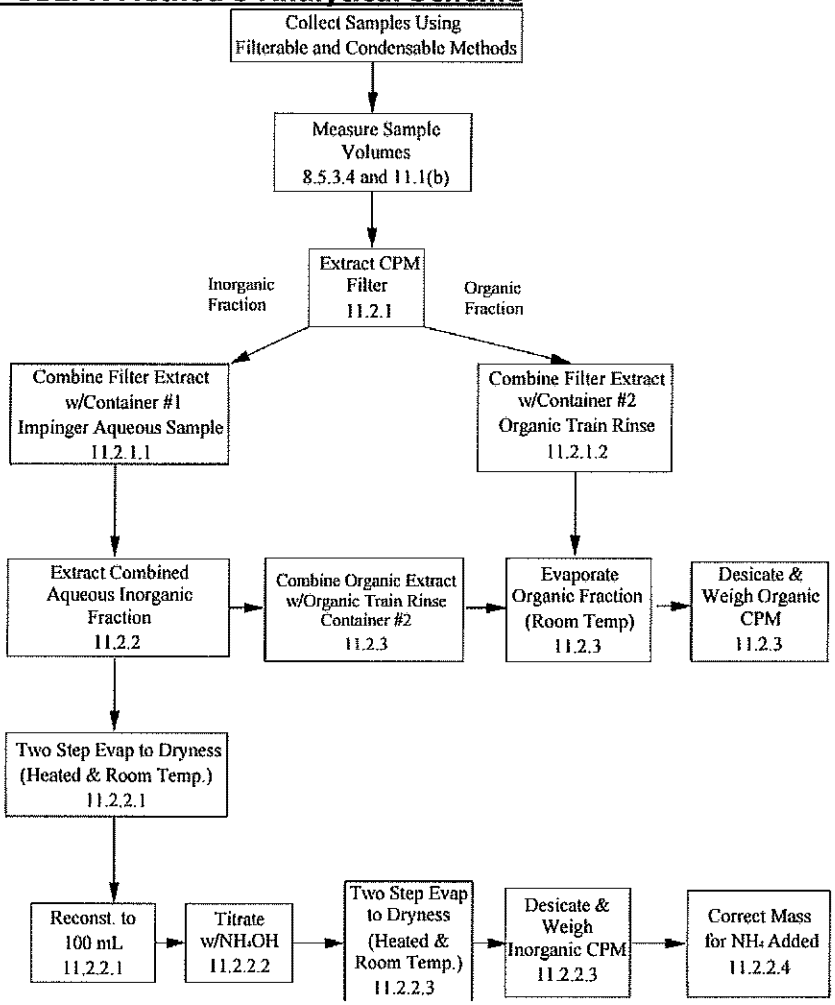


Figure 4-11. USEPA Method 5 Analytical Scheme



4.1.7 EMISSION RATE

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 4-12 presents the equation used to calculate lb/mmBtu emission rate:

Figure 4-12. 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 1,840 scf CO_2/mmBtu for subbituminous coal from 40 CFR 75, Appendix F, Table 1

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

5.0 TEST RESULTS AND DISCUSSION

The testing was performed to satisfy testing 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.

5.1 TABULATION OF RESULTS

The results of the testing indicate the 3-run average FPM results for each Unit are in compliance with their applicable CD limit of 0.015 lb/mmBtu. Refer to Section 2.3 for tabulated results.

5.2 SIGNIFICANCE OF RESULTS

The results of this test program indicate EU-KARN1 and EU-KARN2 are operating in compliance with the applicable emission limits. Since the FPM results were less than 0.010 lb/mmBtu, filterable and condensable PM testing will continue to occur every two years as provided for in the CD.

5.3 VARIATIONS FROM SAMPLING OR OPERATING CONDITIONS

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

5.4 PROCESS OR CONTROL EQUIPMENT UPSET CONDITIONS

No process or control equipment upset conditions occurred during the testing.

5.5 AIR POLLUTION CONTROL DEVICE MAINTENANCE

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

5.6 RE-TEST DISCUSSION

Based on the results of this test program, a re-test is not required.

5.7 RESULTS OF AUDIT SAMPLES

Audit samples for the reference methods utilized during this test program are not available from USEPA Stationary Source Audit Sample Program providers. The USEPA reference methods performed state reliable results are obtained by persons equipped with a thorough knowledge of the techniques associated with each method. Factors with the potential to cause measurement errors are minimized by implementing quality control (QC) and assurance (QA) programs into the applicable components of field testing. QA/QC components were 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
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.
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
M1: Cyclonic flow evaluation	Evaluate the sampling location for cyclonic flow	Measure null angles	Pre-test	≤20°
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
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
M3A/ALT-123: Calibration gas standards	Ensure accurate calibration standards	Traceability protocol of calibration gases	Pre-test	Calibration gas uncertainty ≤2.0%
M3A/ALT-123: Calibration Error	Evaluates operation of analyzers	Calibration gases introduced directly into analyzers	Pre-test	±2.0% of the calibration span
M3A/ALT-123: System bias and analyzer drift	Evaluates ability of sampling system to delivery stack gas to analyzers	Calibration gases introduced into flexible bags and then 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
M5: Nozzle diameter measurements	Verify nozzle diameter used to calculate sample rate	Measure inner diameter across three cross-sectional chords	Pre-test	Three measurements agree within ±0.004 inch
M5: Sample rate	Ensure representative sample collection	Calculate isokinetic sample rate	During and post-test	100±10% isokinetic sample rate
M5: Sample volume	Ensure sufficient sample volume is collected	Record pre- and post-test dry gas meter volume reading	Post test	≥ 60 dscf (required by CD)
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
M5: Post-test meter audits	Evaluates accurate measurement equipment for sample volume	Calibrate DGM pre- and post-test; compare calibration factors (Y)	Pre-test Post-test	±5 %

5.8 Calibration Sheets

Calibration and inspection sheets for dry gas meter, Pitot tube, and other equipment are presented in Appendix E.

5.9 Sample Calculations

Sample calculations and formulas used to compute emissions data are presented in Appendix A.

5.10 Field Data Sheets

Field data sheets are presented in Appendix B.

5.11 Laboratory Quality Assurance / Quality Control Procedures

Laboratory quality assurance and quality control procedures were performed in accordance with USEPA Method 5/202. Specific QA/QC procedures include evaluation of reagent and filter blanks, laboratory conditions, and the application of blank corrections. Refer to Appendix C for the laboratory data sheets.

5.11.1 QA/QC Blanks

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

Table 5-2
QA/QC Blanks

Sample Identification	Result		Comment
	DEK1	DEK2	
Method 5 Acetone Field Blank	0.0 mg		Sample volume was approximately 200 milliliters. Acetone blank corrections were not applied.
Method 5 Laboratory Filter Blank	0.1 mg		Reporting limit is 0.1 milligrams.
Method 202 Deionized H_2O Blank	0.8 mg	0.9 mg	
Method 202 Acetone Blank	<1.0 mg	<1.0 mg	
Method 202 Hexane Blank	<1.0 mg	<1.0 mg	
Field Train Recovery Blank	<3.8 mg	4.1 mg	Maximum allowable blank correction of 2.0 mg applied to CPM results

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DEK1 FPM and CPM Test Results

Facility and Source Information	Units	Run 1	Run 2	Run 3	Average
Customer:		D.E. Karn			
Source:		DEK1 Stack			
Work Order:		26815610			
Date:		9/17/2018	9/17/2018	9/17/2018	
Unit Load:	MWg	252.1	252.0	251.9	252.0
Stack Diameter	inches	268.0	268.0	268.0	
Cross-sectional Area of Stack, A	ft^2	391.73	391.73	391.73	
Source Pollutant Test Data	**Units**	**Run 1**	**Run 2**	**Run 3**	**Average**
Barometric Pressure, P_{bar}	inches of Hg	29.15	29.14	29.10	29.13
Dry Gas Meter Calibration Factor, Y	dimensionless	0.999	0.999	0.999	0.999
Pitot Tube Coefficient, C_p	dimensionless	0.84	0.84	0.84	0.84
Stack Static Pressure, P_g	inches of H_2O	-1.00	-1.00	-1.00	-1.00
Nozzle Diameter, D_n	inches	0.321	0.321	0.321	0.321
Run Start Time	hr:mm	10:10	12:55	15:41	
Run Stop Time	hr:mm	12:27	15:15	18:00	
Duration of Sample, θ	minutes	120	120	120	120
Dry Gas Meter Leak Rate, L_p	cfm	0.000	0.000	0.000	0.000
Dry Gas Meter Start Volume	ft^3	140.50	252.36	365.13	252.66
Dry Gas Meter Final Volume	ft^3	251.80	364.50	477.97	364.76
Average Pressure Difference across the Orifice Meter, ΔH	inches of H_2O	2.69	2.78	2.73	2.73
Average Dry Gas Meter Temperature, T_m	°F	93.4	98.4	103.3	98.4
Average Square Root Velocity Head, √Δp	√inches H_2O	0.5921	0.5897	0.5857	0.5892
Stack Gas Temperature, $T_{s(absvg)}$	°F	197.4	191.3	191.8	193.5
Source Moisture Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Volume of Water Vapor Condensed in Silica Gel, $V_{wsg(std)}$	scf	2.7	2.4	2.1	2.4
Total Volume of Water Vapor Condensed, $V_{w(std)}$	scf	20.152	21.515	21.161	20.942
Volume of Gas Sample as Measured by the Dry Gas Meter, V_m	dcf	111.300	112.131	112.843	112.091
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscf	104.012	103.847	103.443	103.767
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscm	2.946	2.941	2.929	2.94
Moisture Content of Stack Gas, B_{ws}	% H_2O	16.23	17.16	16.98	16.79
Gas Analysis Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Carbon Dioxide, %CO_2	%, dry	13.3	12.4	13.7	13.1
Oxygen, %O_2	%, dry	6.3	7.2	5.9	6.4
Nitrogen, %N	%, dry	80.4	80.4	80.4	80.4
Dry Molecular Weight, M_d	lb/lb-mole	30.38	30.27	30.43	30.36
Wet Molecular Weight, M_s	lb/lb-mole	28.37	28.17	28.32	28.29
Percent Excess Air, %EA	%	42.01	51.47	38.11	43.86
Fuel F-Factor, F_o:	dimensionless	1.099	1.103	1.096	1.099
Fuel F-Factor, F_c:	scf/mmBtu	1,840.0	1,840.0	1,840.0	1,840.0
Gas Volumetric Flow Rate Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Average Stack Gas Velocity, v_s	ft/s	38.0	37.8	37.5	37.7
Stack Gas Volumetric Flow Rate, Q	acfm	892,129	887,667	880,344	886,713
Stack Gas Standard Volumetric Flow Rate, Q_s	scfm	696,307	699,145	691,847	695,766
Stack Gas Dry Standard Volumetric Flow Rate, Q_{sd}	dscfm	583,296	579,157	574,353	578,936
Percent of Isokinetic Sampling, I	%	103.6	104.2	104.7	104.2
Gas Concentrations and Emission Rates		**Run 1**	**Run 2**	**Run 3**	**Average**
Mass of Filterable PM Collected, m_n	mg	3.30	5.30	3.60	4.07
Filterable PM Concentration, c_s	gr/dscf	0.00049	0.00079	0.00054	0.00060
Filterable PM Concentration at Stack Conditions, $c_{s@stack\ conditions}$	mg/wacm	0.732	1.176	0.802	0.903
Filterable PM Mass Emission Rate, E	lb/hr	2.44	3.90	2.64	2.99
Filterable PM, lb/mmBtu, E	lb/mmBtu	0.0010	0.0017	0.0010	0.0012
Filterable PM, tpy [Assumes 8,760 Hrs/Yr Operation]	tpy	10.70	17.09	11.56	13.12
Mass of Organic CPM, m_o	mg	1.0	1.0	1.0	1.0
Organic Condensable PM Concentration	gr/dscf	0.00015	0.00015	0.00015	0.00015
Organic Condensable PM, Mass Emission Rate	lb/hr	0.74	0.74	0.73	0.74
Organic Condensable PM, Mass Emission Rate	lb/mmBtu	0.0003	0.0003	0.0003	0.0003
Organic Condensable PM, Mass Emission Rate	tpy	3.24	3.22	3.21	3.2
Mass of Inorganic Condensable PM, m_i	mg	150.0	170.0	160.0	160.0
Inorganic Condensable PM Concentration	gr/dscf	0.02221	0.02521	0.02382	0.02375
Inorganic Condensable PM Mass Emission Rate	lb/hr	111.04	125.15	117.27	117.82
Inorganic Condensable PM Mass Emission Rate	lb/mmBtu	0.0439	0.0534	0.0456	0.0476
Inorganic Condensable PM Mass Emission Rate [Assumes 8,760 Hrs/Yr Operation]	tpy	486.34	548.15	513.63	516.04
Mass of Total CPM in Field Train Recovery Blank Correction, m_{fb}	mg	2.0	2.0	2.0	2.0
Mass of Total Condensable PM, m_{cpm}	mg	149.0	169.0	159.0	159.0
Condensable PM Concentration	gr/dscf	0.02206	0.02506	0.02367	0.02360
Condensable PM Mass Emission Rate	lb/hr	110.30	124.41	116.53	117.08
Condensable PM Mass Emission Rate	lb/mmBtu	0.0436	0.0531	0.0453	0.0473
Condensable PM Mass Emission Rate [Assumes 8,760 Hrs/Yr Operation]	tpy	483.10	544.93	510.42	512.82
Mass of Filterable and Condensable PM	mg	152.3	174.3	162.6	163.1
Filterable and Condensable PM Concentration	gr/dscf	0.02255	0.02585	0.02421	0.02420
Filterable and Condensable PM Mass Emission Rate	lb/hr	112.74	128.31	119.17	120.08
Filterable and Condensable PM Mass Emission Rate	lb/mmBtu	0.0446	0.0547	0.0464	0.0486
Filterable and Condensable PM Mass Emission Rate [Assumes 8,760 Hrs/Yr Op.]	tpy	493.80	562.02	521.97	525.93

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DEK2 FPM and CPM Test Results

Facility and Source Information	Units	Run 1	Run 2	Run 3	Average
Customer:		D.E. Karn			
Source:		DEK2 Stack			
Work Order:		26815610			
Date:		9/10/2018	9/10/2018	9/10/2018	
Unit Load:	MWg	241.5	241.5	241.5	241.5
Stack Diameter	inches	216.0	216.0	216.0	
Cross-sectional Area of Stack, A	ft^2	254.47	254.47	254.47	
Source Pollutant Test Data	**Units**	**Run 1**	**Run 2**	**Run 3**	**Average**
Barometric Pressure, P_{bar}	inches of Hg	29.40	29.20	29.18	29.26
Dry Gas Meter Calibration Factor, Y	dimensionless	0.999	0.999	0.999	0.999
Pitot Tube Coefficient, C_p	dimensionless	0.84	0.84	0.84	0.84
Stack Static Pressure, P_g	inches of H_2O	-1.00	-1.00	-1.00	-1.00
Nozzle Diameter, D_n	inches	0.240	0.240	0.240	0.240
Run Start Time	hr:mm	9:00	11:45	14:35	
Run Stop Time	hr:mm	11:19	14:05	16:52	
Duration of Sample, θ	minutes	120	120	120	120
Dry Gas Meter Leak Rate, L_p	cfm	0.000	0.000	0.000	0.000
Dry Gas Meter Start Volume	ft^3	280.19	373.39	467.11	373.57
Dry Gas Meter Final Volume	ft^3	372.97	466.55	561.17	466.89
Average Pressure Difference across the Orifice Meter, ΔH	inches of H_2O	1.94	1.97	1.98	1.96
Average Dry Gas Meter Temperature, T_m	°F	79.3	79.2	81.1	79.9
Average Square Root Velocity Head, √Δp	√inches H_2O	0.9166	0.9225	0.9174	0.9188
Stack Gas Temperature, $T_{s(abavg)}$	°F	202.5	204.5	203.6	203.5
Source Moisture Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Volume of Water Vapor Condensed in Silica Gel, $V_{wsg(std)}$	scf	1.4	1.6	1.8	1.6
Total Volume of Water Vapor Condensed, $V_{w(std)}$	scf	16.090	16.755	16.792	16.546
Volume of Gas Sample as Measured by the Dry Gas Meter, V_m	dcf	92,772	93,157	94,055	93,328
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscf	89,554	89,342	89,827	89,574
Volume of Gas Sample Measured by the Dry Gas Meter corrected to STP, $V_{m(std)}$	dscm	2,536	2,530	2,544	2,54
Moisture Content of Stack Gas, B_{ws}	% H_2O	15.23	15.79	15.75	15.59
Gas Analysis Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Carbon Dioxide, %CO_2	%, dry	12.3	11.8	12.7	12.2
Oxygen, %O_2	%, dry	7.3	7.8	6.8	7.3
Nitrogen, %N	%, dry	80.4	80.4	80.5	80.4
Dry Molecular Weight, M_d	lb/lb-mole	30.26	30.20	30.30	30.25
Wet Molecular Weight, M_s	lb/lb-mole	28.39	28.27	28.36	28.34
Percent Excess Air, %EA	%	52.64	58.26	47.49	52.80
Fuel F-Factor, F_o:	dimensionless	1.107	1.109	1.109	1.108
Fuel F-Factor, F_c:	scf/mmBtu	1,840.0	1,840.0	1,840.0	1,840.0
Gas Volumetric Flow Rate Data		**Run 1**	**Run 2**	**Run 3**	**Average**
Average Stack Gas Velocity, v_s	ft/s	58.7	59.5	59.1	59.1
Stack Gas Volumetric Flow Rate, Q	acfm	896,496	908,603	901,801	902,300
Stack Gas Standard Volumetric Flow Rate, Q_s	scfm	700,317	702,812	698,035	700,388
Stack Gas Dry Standard Volumetric Flow Rate, Q_{sd}	dscfm	593,656	591,825	588,095	591,192
Percent of Isokinetic Sampling, I	%	101.9	102.0	103.2	102.3
Gas Concentrations and Emission Rates		**Run 1**	**Run 2**	**Run 3**	**Average**
Mass of Filterable PM Collected, m_n	mg	1.00	3.20	1.10	1.77
Filterable PM Concentration, c_s	gr/dscf	0.00017	0.00055	0.00019	0.00030
Filterable PM Concentration at Stack Conditions, $c_{s@stack\ conditions}$	mg/wacm	0.281	0.824	0.282	0.456
Filterable PM Mass Emission Rate, E	lb/hr	0.88	2.80	0.95	1.54
Filterable PM, lb/mmBtu, E	lb/mmBtu	0.0004	0.0012	0.0004	0.0007
Filterable PM, tpy [Assumes 8,760 Hrs/Yr Operation]	tpy	3.83	12.26	4.16	6.75
Mass of Organic CPM, m_o	mg	1.0	1.0	1.2	1.1
Organic Condensable PM Concentration	gr/dscf	0.00017	0.00017	0.00021	0.00018
Organic Condensable PM, Mass Emission Rate	lb/hr	0.88	0.87	1.04	0.93
Organic Condensable PM, Mass Emission Rate	lb/mmBtu	0.0004	0.0004	0.0004	0.0004
Organic Condensable PM, Mass Emission Rate	tpy	3.83	3.83	4.54	4.1
Mass of Inorganic Condensable PM, m_i	mg	89.0	100.0	93.0	94.0
Inorganic Condensable PM Concentration	gr/dscf	0.01530	0.01724	0.01594	0.01616
Inorganic Condensable PM Mass Emission Rate	lb/hr	77.88	87.44	80.37	81.90
Inorganic Condensable PM Mass Emission Rate	lb/mmBtu	0.0328	0.0384	0.0331	0.0348
Inorganic Condensable PM Mass Emission Rate [Assumes 8,760 Hrs/Yr Operation]	tpy	341.11	382.99	352.02	358.71
Mass of Total CPM in Field Train Recovery Blank Correction, m_{fb}	mg	2.0	2.0	2.0	2.0
Mass of Total Condensable PM, m_{cpm}	mg	88.0	99.0	92.2	93.1
Condensable PM Concentration	gr/dscf	0.01513	0.01706	0.01581	0.01600
Condensable PM Mass Emission Rate	lb/hr	77.00	86.57	79.68	81.08
Condensable PM Mass Emission Rate	lb/mmBtu	0.0324	0.0380	0.0328	0.0344
Condensable PM Mass Emission Rate [Assumes 8,760 Hrs/Yr Operation]	tpy	337.27	379.16	349.00	355.14
Mass of Filterable and Condensable PM	mg	89.0	102.2	93.3	94.8
Filterable and Condensable PM Concentration	gr/dscf	0.01530	0.01762	0.01600	0.01631
Filterable and Condensable PM Mass Emission Rate	lb/hr	77.88	89.36	80.63	82.62
Filterable and Condensable PM Mass Emission Rate	lb/mmBtu	0.0328	0.0392	0.0332	0.0351
Filterable and Condensable PM Mass Emission Rate [Assumes 8,760 Hrs/Yr Op.]	tpy	341.11	391.41	353.16	361.89