EXECUTIVE SUMMARY

Consumers Energy Regulatory Compliance Testing Section (RCTS) personnel conducted filterable particulate matter (FPM), condensable PM (CPM), volatile organic compounds (VOCs) and formaldehyde (HCHO) testing for flexible group FGLMDB1-6 and emission unit EUEADB7 in operation at the Jackson Generating Station located in Jackson, Michigan. The approximately 75 megawatt gross (MWg) output LM Units and 148 MWg output Unit 7EA Unit are natural gas fired combustion turbines that also generate steam to turn a turbine connected to an electricity producing generator. The electricity is routed to the electrical transmission system.

The test program performed June 9 through 11, 2020, was conducted to satisfy testing requirements in renewable operating permit (ROP) MI-ROP-B6626-2019 and Permit to Install (PTI) No. 118-18 and reestablish lb/mmBtu emission factors to be used with heat input determinations to calculate mass emission rates for PM_{10}, VOCs and formaldehyde. Please note that the unit nomenclature and permit limits described in this test report are consistent with PTI No. 118-18, as the plant began operating under said permit in May of 2020 and had submitted a ROP modification request for purposes of incorporating the PTI into the ROP. As proposed in the test protocol, the test results obtained for FGLMDB3 (LM3) will be applied to each unit in the flexible group for purposes of deriving emission factors and calculating mass emissions based upon measured natural gas usage rates and fuel heating values.

Triplicate 120-minute FPM and CPM test runs, and 60-minute VOC and HCHO test runs were conducted following the procedures in USEPA Reference Methods (RM) 1, 2, 3A, 4, 5, and 19 in 40 CFR 60, Appendix A, RM 320 in 40 CFR 63, Appendix A and RM 202 in 40 CFR 51, Appendix M. Testing consisted of a three 60-minute sample runs at each unit for two different load scenarios representative of the upper (full load with duct-burner operation) and lower (part load without duct-burner operation) nominal operating loads for formaldehyde, three 60-minute sample runs at a representative load at each unit for VOCs, and three 120-minute sample runs at a representative load at each unit for FPM and CPM. The sum of the FPM and CPM components was assumed to equal PM_{10} during this test program. Use of RM320 (with a StarBoost FTIR for lower detection levels) to measure formaldehyde as opposed to RM 18 of 40 CFR Part 60, Appendix A represents a deviation from the approved test protocol. The LM3 and 7EA units PM_{10}, VOCs and HCHO results are summarized in the following table.

Table E-1
Executive Summary of Test Results

Parameter	Units	Run			Average	Emission Limit*
		1	2	3		ROP
Unit LM3 – Representative Normal Load (Emission Limits are for FGLMBD1-6, Unless Noted)						
PM_{10}	lb/hr	1.37	1.71	1.42	**1.50**	**4.9**
	ton/yr	6.00	7.50	6.21	**6.57**	**128.0**
	lb/mmBtu	0.0033	0.0045	0.0036	**0.0038**	**N/A***
VOCs	lb/hr	1.60	0.89	0.76	**1.08**	**2.1**
	ton/yr	6.99	3.91	3.35	**4.75**	**46.0**
	lb/mmBtu	0.0038	0.0021	0.0018	**0.00257**	**N/A***
Unit LM3 – Full with Duct Burners in Operation						
HCHO‡	ton/yr	0.39	0.37	0.39	**0.38**	**1.41‡**
	lb/mmBtu	0.00014	0.00014	0.00014	**0.00014**	**N/A***

Table E-1
Executive Summary of Test Results

Parameter	Units	Run 1	Run 2	Run 3	Average	Emission Limit* ROP
Unit LM3 – Partial Load without Duct Burners						
HCHO‡	ton/yr	0.20	0.22	0.19	**0.20**	**1.41‡**
	lb/mmBtu	0.00011	0.00012	0.00010	**0.00011**	**N/A***
Unit 7EA – Representative Normal Load†						
PM_{10}	lb/hr	3.09	2.58	3.89	**3.49**	**9.2**
	ton/yr	13.53	11.29	17.05	**15.29**	**N/A**
	lb/mmBtu	0.0038	0.0029	0.0042	**0.0040**	**N/A***
VOCs	lb/hr	1.77	1.76	1.85	**1.83**	**4.2**
	ton/yr	7.75	7.72	8.11	**7.99**	**N/A**
	lb/mmBtu	0.0018	0.0019	0.0020	**0.0019**	**N/A***
Unit 7EA – Full with Duct Burners in Operation						
HCHO‡	ton/yr	0.49	0.45	0.53	**0.49**	**1.41‡**
	lb/mmBtu	0.00010	0.00009	0.00011	**0.00010**	**N/A***
Unit 7EA – Partial Load without Duct Burners						
HCHO‡	ton/yr	0.28	0.26	0.28	**0.27**	**1.41‡**
	lb/mmBtu	0.00007	0.00006	0.00007	**0.00007**	**N/A***

* : lb/mmBtu results are used in mass emission calculations with continuous heat input to evaluate compliance with the mass emission limits

† : 7EA Run 2 CPM Filter was not received by laboratory, Run 2 not included in average calculations

‡ : A HCHO limit of 9.9 tons per 12-month rolling time period is applicable to the entire site; the presented limit is the permit limit divided by seven for illustrative purposes

Although not consistent with the prescribed compliance methodology in the ROP, the LM3 and 7EA units PM_{10}, VOC and HCHO emission results indicate compliance with the mass emission limits in the permit. The preceding tons per year values are extrapolated assuming continuous operation at the pounds per hour emission rates observed during the testing. The facility uses lb/mmBtu emission factors in conjunction with continuous heat input determinations to calculate 24-operating hour rolling and/or 12-month rolling mass emission rates, as applicable.

Detailed test results are presented in Appendix Tables 1 through 6. Sample calculations, field data sheets, and laboratory data are presented in Appendices A, B, and C. Operating data and supporting documentation are provided in Appendices D and E.

1.0 INTRODUCTION

This report summarizes the results of compliance particulate matter (PM), PM less than 10 microns in diameter (PM_{10}), volatile organic compounds (VOCs), and formaldehyde (HCHO) testing conducted June 9 through 11, 2020 on EULMDB3 (Unit LM3) and EUEADB7 (Unit 7EA) operating at the Consumers Energy Jackson Generating Station in Jackson, Michigan.

This document follows the EGLE format described in the November 2019 publication, 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.

1.1.1 IDENTIFICATION, LOCATION, AND DATES OF TESTS

Consumers Energy Regulatory Compliance Testing Section (RCTS) personnel conducted PM_{10} (as the sum of filterable and condensable PM), VOCs, and HCHO tests at the dedicated exhausts of natural gas-fired combustion turbines Unit LM3 and Unit 7EA operating at the Jackson Generating Station in Jackson, Michigan June 9 through 11, 2020. In order to satisfy the testing requirement for FGLMDB1-6, RCTS proposed to test one of the six identical units as allowed in FGLMDB1-6, Condition V.1. The test results obtained for LM3 will be applied to each unit in the flexible group for purposes of deriving emission factors and calculating mass emissions based upon measured natural gas usage rates and fuel heating values.

A test protocol was submitted to EGLE on April 30, 2020 and subsequently approved by Mr. David Patterson, Environmental Quality Analyst, in his letter dated May 7, 2020.

1.1.2 PURPOSE OF TESTING

The purpose of the testing is to satisfy testing requirements in renewable operating permit MI-ROP-N6626-2019 and Permit to Install (PTI) No. 118-18 and reestablish lb/mmBtu emission factors to be used with heat input determinations to calculate mass emission rates for PM_{10}, VOCs and formaldehyde. Please note that the unit nomenclature and permit limits described in this test report are consistent with PTI No. 118-18, as the plant began operating under said permit in May of 2020 and had submitted a ROP modification request for purposes of incorporating the PTI into the ROP. The applicable emission limits are presented in Table 1-1.

Table 1-1
Emission Limits

Parameter	Emission Limit	Units	Applicable Requirement
LM3 (FGLMDB1-6)			
$PM_{10}/PM_{2.5}$	4.9	lb/hr	PTI No. 118-18, FGLMDB1-6, Conditions I.5/7 (per unit)
	128.0	ton/yr	PTI No. 118-18, FGLMDB1-6, Conditions I.6/8 (all units combined)
VOC	2.1	lb/hr	PTI No. 118-18, FGLMDB1-6, Condition I.11 (per unit)
	46.0	ton/yr	PTI No. 118-18, FGLMDB1-6, Condition I.12 (all units combined)

Table 1-1
Emission Limits

Parameter	Emission Limit	Units	Applicable Requirement
7EA (EUEADB7)			
$PM_{10}/PM_{2.5}$	9.2	lb/hr	PTI No. 118-18, EUEADB7, Conditions I.4/5
VOC	4.2	lb/hr	PTI No. 118-18, EUEADB7, Condition I.8
Site-Wide (FGFACILITY)			
HCHO	9.9	ton/yr	PTI No. 118-18, FGFACILITY, Condition I.1

In order to satisfy the testing requirement for FGLMDB1-6, RCTS tested one of the six identical units (FGLMDB3) as allowed in FGLMDB1-6, Condition V.1 to be representative of all six combined cycle units in this flexible group. Also, note that the facility attempts to test a different unit during each test cycle, with each of FGLMDB1, FGLMDB4, FGLMDB5 and FGLMDB6 having been previously tested. The test results obtained for FGLMDB3 will be applied to each unit in the flexible group for purposes of deriving emission factors and calculating mass emissions based upon measured natural gas usages rates and fuel heating values.

1.1.3 Brief Description of Source

The Jackson Generating Station consists of seven (7) combined-cycle natural gas fired combustion turbines, designated as Units LM1, LM2, LM3, LM4, LM5, LM6 and 7EA. A heat recovery steam generator (HRSG) equipped with natural gas-fired duct burners is installed on each turbine with flexible group/emission unit ROP/PTI designations of FGLMDB1–6 and EUEADB7, respectively.

1.1.4 Contact Information

Table 1-2 presents the names, addresses, and telephone numbers for contacts involved in this test program.

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 Environment, Great Lakes & Energy (EGLE) Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
Test Facility	Mr. Jason L. Ricketts Plant Business Manager 517-841-5710 jason.l.ricketts@cmsenergy.com	Consumers Energy Company Jackson Generating Station 2219 Chapin Street Jackson, Michigan 49203
Test Facility	Mr. Doug Mallory EHS/NERC Compliance Coordinator 517-841-5723 doug.mallory@cmsenergy.com	Consumers Energy Company Jackson Generating Station 2219 Chapin Street Jackson, Michigan 49203

Table 1-2
Contact Information

Program Role	Contact	Address
Corporate Air Quality Contact	Mr. Jason Prentice Senior Engineer III 517-788-1467 jason.prentice@cmsenergy.com	Consumers Energy Company 1945 W Parnall Road Jackson, Michigan 49201
Test Team Representative	Mr. Dillon King, QSTI Sr. Engineering Technical Analyst 989-891-5585 dillon.king@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Plant 2742 North Weadock Highway, ESD Trailer #4 Essexville, Michigan 48732
Test Team Representative	Mr. Joe Mason, QSTI Sr. Engineering Technical Analyst 616-738-3385 joe.mason@cmsenergy.com	Consumers Energy Company L&D Training Center 17010 Croswell Street West Olive, Michigan 49460

2.0 SUMMARY OF RESULTS

2.1.1 OPERATING DATA

The combined cycle combustion turbines fired natural gas during the test event. As noted in the test protocol, the achievable load for a combustion turbine varies with ambient conditions. Based upon weather conditions at the time of testing, the upper load condition for formaldehyde was run at the full load condition for the combustion turbines with duct burners in operation and corresponded to approximately 145 gross megawatts (MWg) for Unit 7EA and approximately 72 MWg for Unit LM3. The reduced load testing (which overlapped with the representative load ranges used for PM_{10} and VOC testing) was run at average loads from 126-131 MWg for Unit 7EA and 54-56 MWg for LM3.

Refer to Attachment D for detailed operating data, which was recorded in Eastern Standard Time (EST).

2.1.2 APPLICABLE PERMIT INFORMATION

The Jackson Generating Station has the State of Michigan Registration Number (SRN) N6626 and operates in accordance with air permit MI-ROP-N6626-2019 and PTI No. 118-18. The air permits incorporate federal regulations and reports under Federal Registry System (FRS) identification number 110015804511. EULMDB1, EULMDB2, EULMDB3, EULMDB4, EULMDB5, EULMDB6 and EUEADB7 are the emission units identified in the permit. EULMDB1 through EULMDB6 are also included in the FGLMDB1-6 flexible group.

2.1.3 RESULTS

The PM less than 10 microns in diameter (PM_{10}), VOCs and HCHO results are summarized in Table 2-1 below.

Table 2-1
Summary of Test Results

Parameter	Units	Run			Average	Emission Limit*
		1	2	3		ROP
Unit LM3 – Representative Normal Load (Emission Limits are for FGLMBD1-6, Unless Noted)						
PM_{10}	lb/hr	1.37	1.71	1.42	**1.50**	**4.9**
	ton/yr	6.00	7.50	6.21	**6.57**	**128.0**
	lb/mmBtu	0.0033	0.0045	0.0036	**0.0038**	**N/A***
VOCs	lb/hr	1.60	0.89	0.76	**1.08**	**2.1**
	ton/yr	6.99	3.91	3.35	**4.75**	**46.0**
	lb/mmBtu	0.0038	0.0021	0.0018	**0.00257**	**N/A***
Unit LM3 – Full with Duct Burners in Operation						
HCHO‡	ton/yr	0.39	0.37	0.39	**0.38**	**1.41‡**
	lb/mmBtu	0.00014	0.00014	0.00014	**0.00014**	**N/A***
Unit LM3 – Partial Load without Duct Burners						
HCHO‡	ton/yr	0.20	0.22	0.19	**0.20**	**1.41‡**
	lb/mmBtu	0.00011	0.00012	0.00010	**0.00011**	**N/A***
Unit 7EA – Representative Normal Load†						
PM_{10}	lb/hr	3.09	2.58	3.89	**3.49**	**9.2**
	ton/yr	13.53	11.29	17.05	**15.29**	**N/A**
	lb/mmBtu	0.0038	0.0029	0.0042	**0.0040**	**N/A***
VOCs	lb/hr	1.77	1.76	1.85	**1.83**	**4.2**
	ton/yr	7.75	7.72	8.11	**7.99**	**N/A**
	lb/mmBtu	0.0018	0.0019	0.0020	**0.0019**	**N/A***
Unit 7EA – Full with Duct Burners in Operation						
HCHO‡	ton/yr	0.49	0.45	0.53	**0.49**	**1.41‡**
	lb/mmBtu	0.00010	0.00009	0.00011	**0.00010**	**N/A***
Unit 7EA – Partial Load without Duct Burners						
HCHO‡	ton/yr	0.28	0.26	0.28	**0.27**	**1.41‡**
	lb/mmBtu	0.00007	0.00006	0.00007	**0.00007**	**N/A***

* : lb/mmBtu results are used in mass emission calculations with continuous heat input to evaluate compliance with the mass emission limits

† : 7EA Run 2 CPM Filter was not received by laboratory, Run 2 not included in average calculations

‡ : A HCHO limit of 9.9 tons per 12-month rolling time period is applicable to the entire site; the presented limit is the permit limit divided by seven for illustrative purposes

Although not consistent with the prescribed compliance methodology in the ROP, the LM3 and 7EA units PM_{10}, VOC and HCHO emission results indicate compliance with the mass emission limits in the permit. The preceding tons per year values are extrapolated assuming continuous operation at the pounds per hour emission rates observed during the testing. The facility uses lb/mmBtu emission factors in conjunction with continuous heat input determinations to calculate 24-operating hour rolling and/or 12-month rolling mass emission rates, as applicable.

Detailed test results are presented in Appendix Tables 1 through 6. Sample calculations, field data sheets, and laboratory data are presented in Appendices A, B, and C. Operating data and supporting documentation are provided in Appendices D and E.

3.0 SOURCE DESCRIPTION

3.1.1 PROCESS

The Jackson Generating Station consists of seven (7) combined-cycle natural gas fired combustion turbines, designated as Units LM1, LM2, LM3, LM4, LM5, LM6 and 7EA. A heat recovery steam generator (HRSG) equipped with natural gas-fired duct burners is installed on each turbine with flexible group/emission unit ROP designations of FGLMDB1–6 and EUEADB7, respectively.

3.1.2 PROCESS FLOW

NOx control is achieved on the LM1-LM6 combustion turbines through the use of Steam Injection, while Dry Low NOx Burners are used on the 7EA combustion turbine to control NOx. The process data in Appendix D includes the steam injection rates during the LM3 testing.

3.1.3 MATERIALS PROCESSED

Natural gas is combusted in the turbines and duct burners, producing heat and steam that is used for electricity generation.

3.1.4 RATED CAPACITY

Units LM1 – LM6 are each rated at 650 mmBtu/hour maximum heat input, and these units each have a Lower Operating Boundary of 15 megawatts (MW) and an Upper Operating Boundary of 75 MW. The 7EA Unit is rated at 1,300 mmBtu/hour maximum heat input, with Lower and Upper Operating Boundaries of 75 MW and 152 MW, respectively.

As proposed in the test protocol, testing was performed on the LM3 unit (one representative LM unit that hasn't been tested yet) and the 7EA unit.

3.1.5 PROCESS INSTRUMENTATION

Operators, environmental technicians, and data acquisition systems continuously monitored the process during testing. One-minute data for the following parameters were collected during each FPM, CPM, VOCs, and HCHO test run:

- total heat input (mmBtu/hr)
- gross electricity output (MWg) [combustion turbine plus a share of the steam turbine electrical generators output]
- for LM3 only, steam injection rate (lbs/hour)
- Natural gas heating value (Btu/scf)
- turbine and duct burner gas flow (hundred scfh)

Due to the various instrumentation systems, the sampling times were correlated to data acquisition and handling systems time. Refer to Appendix D for operating data.

Note that in a few instances, there were pauses in test runs due to weather conditions or temporary loss of duct firing. In such cases, the run averages for the process data are presented based upon overall run start and stop times, as well as only those minutes when sampling was being conducted.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

RCTS personnel tested for FPM, CPM, VOCs and HCHO 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)
Oxygen and Carbon Dioxide (VOC/HCOH testing)	3A	Oxygen and Carbon Dioxide Concentrations – Instrumental
Oxygen and Carbon Dioxide (FPM/CPM testing)	ALT-123	Alternative Test Method for Diluent Measurement to Support Particulate Testing under 40 CFR 63, Subpart UUUUU
Moisture (FPM/CPM testing)	4	Determination of Moisture Content in Stack Gases
Moisture (7EA VOC testing)	ALT-008	Alternative Moisture Measurement Method Impingers
Filterable Particulate Matter*	5	Determination of Particulate Matter Emissions from Stationary Sources
Formaldehyde	18	Measurement of Gaseous Organic Compound Emissions by Gas Chromatography (FTIR)
Emission Rate	19	Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates
Volatile Organic Compounds	25A	Determination of Total Gaseous Phase Organic Concentration Using a Flame Ionization Analyzer
Condensable Particulate Matter*	202	Dry Impinger Method for Determining Condensable Particulate Emissions From Stationary Sources
Moisture (VOC/HCOH testing)	320	Vapor Phase Organic and Inorganic Emissions by Extractive FTIR
Formaldehyde		

*: Methods 5 and 202 were conducted in conjunction to measure PM_{10}

4.1.1 DESCRIPTION OF SAMPLING TRAIN AND FIELD PROCEDURES

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

Table 4-2
Test Matrix

Date (2020)	Run	Sample Type	Unit	Load Condition	Start Time (EST)	Stop Time (EST)	Test Duration (min)
June 9	1	VOCs and HCHO	LM3	Representative/Lower Load	9:20	10:20	60
	1	PM_{10}	7EA	Representative Load	9:28	11:58	120
	2	VOCs and HCHO	LM3	Representative/Lower Load	10:46	11:45	60
	3	VOCs and HCHO	LM3	Representative/Lower Load	12:14	13:14	60
	2	PM_{10}	7EA	Representative Load	13:22	16:38	120
	1	HCHO	LM3	Upper Load	14:56	15:56	60
	2	HCHO	LM3	Upper Load	16:08	17:08	60
	3	PM_{10}	7EA	Representative Load	17:10	19:16	120
	3	HCHO	LM3	Upper Load	17:16	18:16	60
June 10	1	PM_{10}	LM3	Representative Load	10:00	13:40	120
	1	VOCs	7EA	Representative Load	15:40	16:39	60
	2	VOCs	7EA	Representative Load	16:53	17:52	60
	3	VOCs	7EA	Representative Load	18:06	19:06	60
June 11	2	PM_{10}	LM3	Representative Load	7:46	10:14	120
	1	HCHO	7EA	Upper Load	8:22	9:22	60
	2	HCHO	7EA	Upper Load	9:34	11:27	60
	3	PM_{10}	LM3	Representative Load	10:38	12:55	120
	3	HCHO	7EA	Upper Load	11:34	13:02	60
	1	HCHO	7EA	Lower Load	13:37	14:37	60
	2	HCHO	7EA	Lower Load	14:45	15:45	60
	3	HCHO	7EA	Lower Load	15:53	16:53	60

4.1.2 SAMPLE LOCATION AND TRAVERSE POINTS (USEPA METHOD 1)

The number and location of traverse points for measuring exhaust gas velocity and volumetric airflow were determined in accordance with USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources.* Four test ports for the LM units (1 through 6) are in the horizontal plane of the 9.5 feet diameter stack situated:

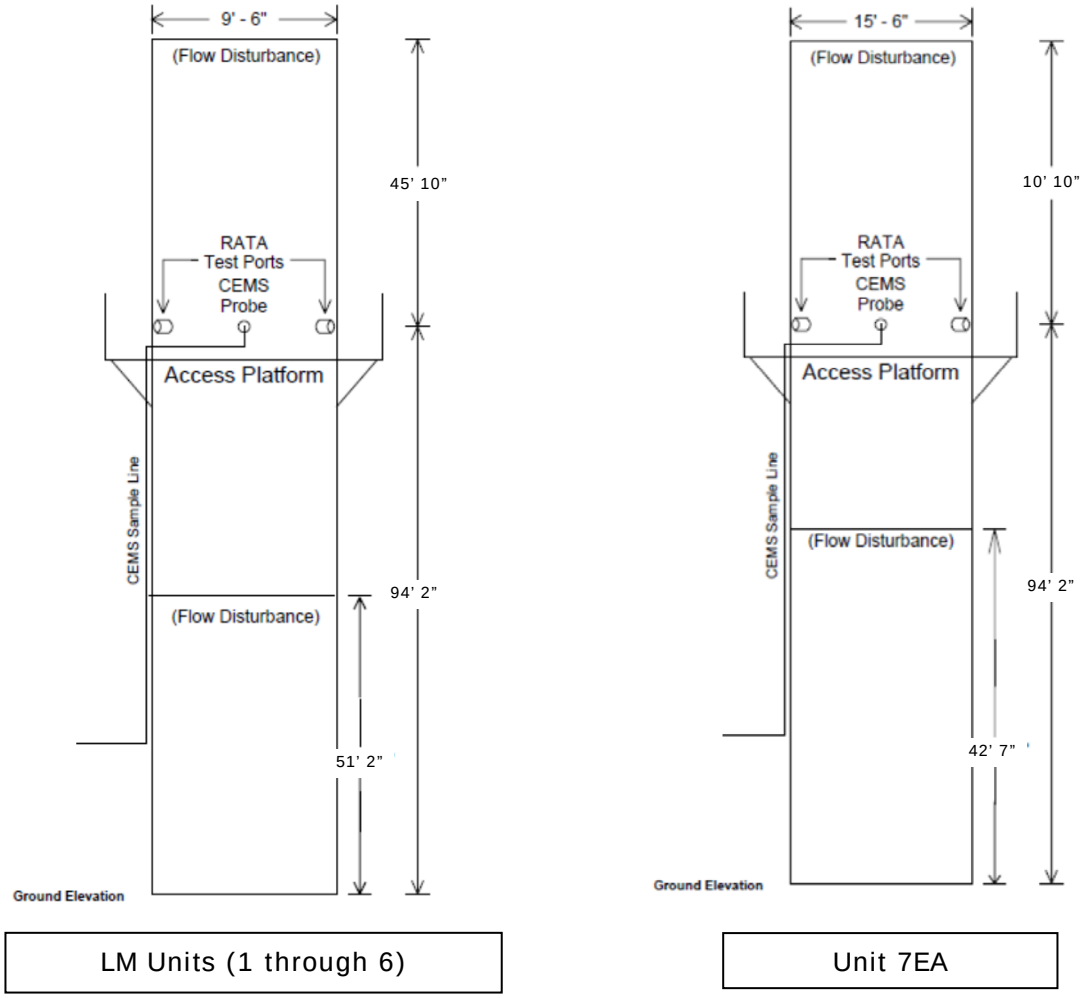
- Approximately 50 feet or 5.3 duct diameters downstream of a flow disturbance, and
- Approximately 46 feet or 4.8 duct diameters upstream of the stack exit.

Four test ports for the 7EA unit are in the horizontal plane of the 15.5 feet diameter stack situated:

- Approximately 51.6 feet or 3.3 duct diameters downstream of a flow disturbance, and
- Approximately 11 feet or 0.7 duct diameters upstream of the stack exit.

The area of the exhaust stacks was calculated, and the cross-sections divided into a number of equal areas based on distances to air flow disturbances. For the FPM and CPM testing (including the ALT-123 samples for determination of O_2 and CO_2), flue gas was sampled for five minutes at each of the six traverse points from the four sample ports for a total of 24 sample points and 120 minutes. For VOCs, HCHO, and associated O_2/CO_2 measurements, each run included 20-minutes of data at each of three traverse points located 15.7, 47.2 and 78.7 inches from the duct wall. A stack schematic including sample port locations is presented in Figure 5-1 below. A schematic showing traverse point detail is shown in Figure 5-2.

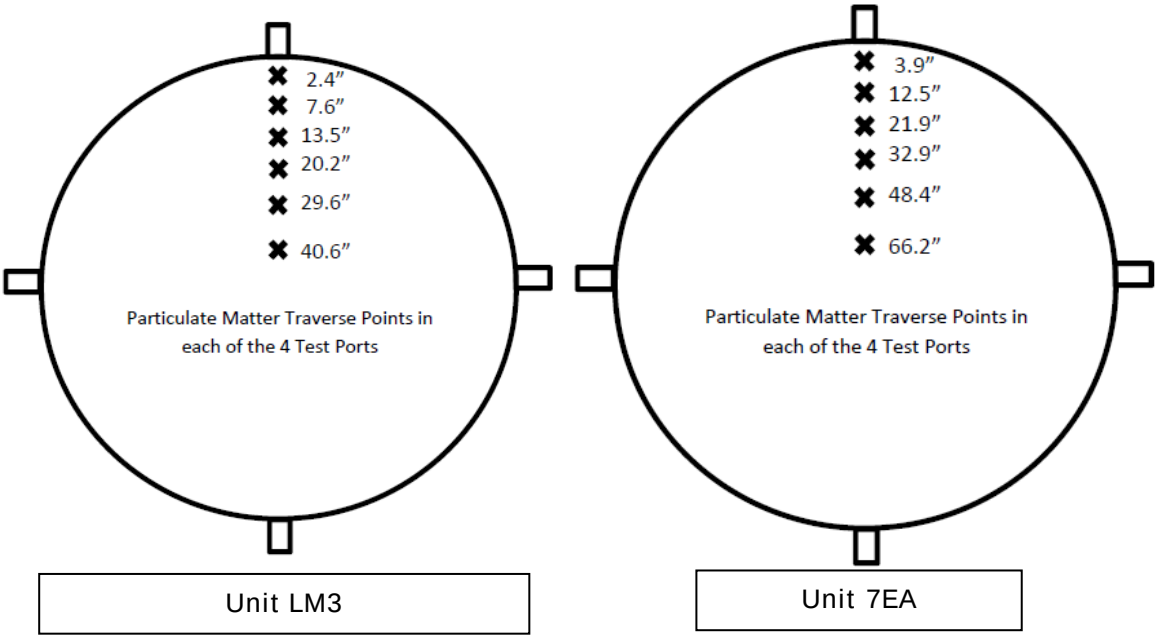
Figure 4-1. Jackson Generating Station LM and EA Unit Sampling Locations



LM Units (1 through 6)

Unit 7EA

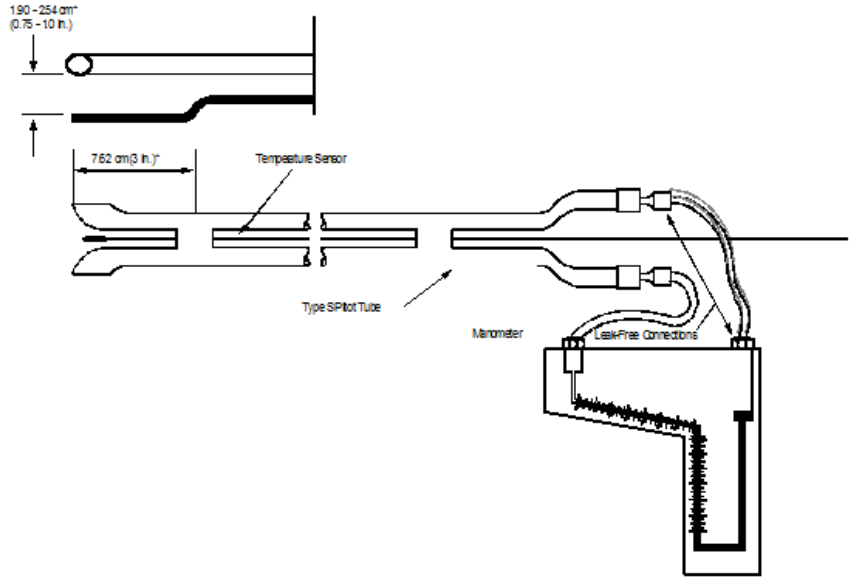
Figure 4-2. Jackson Generating Station LM3 and 7EA Unit Traverse Point Detail



4.1.3 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 4-3 for the Method 2 Pitot tube, thermocouple, and inclined oil-filled manometer configuration.

Figure 4-3. Method 2 Sample Apparatus

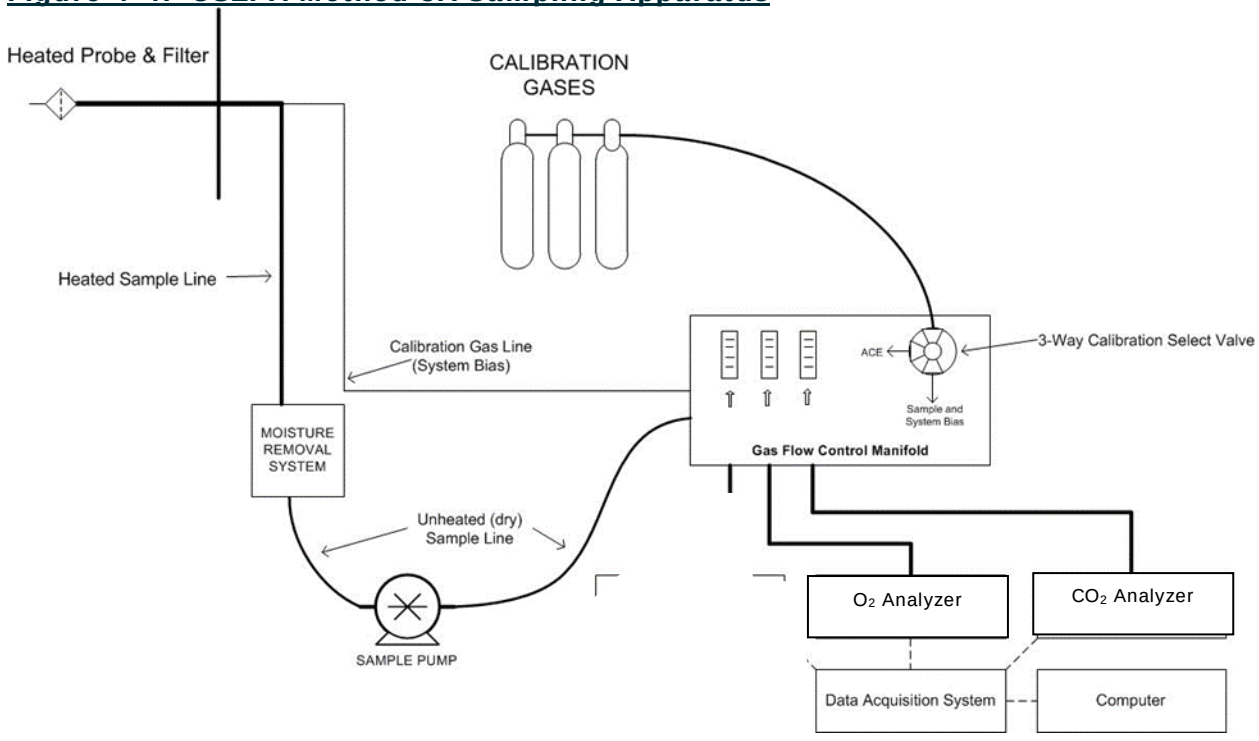


Method 1, § 11.4.2 states "if the average (null angle) is greater than 20°, the overall flow condition in the stack is unacceptable, and alternative methodology…must be used." The average null yaw angle measured at the Unit 7EA exhaust on June 8, 2020 was 6.3°, the average null yaw angle measured at the Unit LM3 exhaust on June 10, 2020 was 2.9° thus meeting the less than 20° requirement. The cyclonic flow testing data is presented in Appendix B.

4.1.4 MOLECULAR WEIGHT (US EPA METHOD 3A AND ALT-123)

Oxygen (O2) and carbon dioxide (CO2) concentrations were measured using a non-dispersive infrared (NDIR) analyzer equipped with paramagnetic O2 analysis capacity, following the guidelines of USEPA Method 3A, *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from a Stationary Source (Instrumental Analyzer Procedure)* during VOCs and HCHO tests and USEPA ALT-123, *Alternative Test Method for Diluent Measurement to Support Particulate Matter Testing Under 40 CFR 63, Subpart UUUUU* during FPM and CPM testing. The sampling and analytical procedures of the methods are similar except ALT-123 is a composite sample taken over the course of a test run in a tedlar bag and analyzed after the run completion while Method 3A directly measures O2 and CO2 during a test run. Exhaust gas was extracted from the duct through a steel tube probe, Teflon® tubing, and a gas conditioning system to remove water and dry the sample before entering a tedlar bag (ALT-123) or pump, manifold, and the gas analyzers for Method 3A. The output signal from each analyzer was connected to a data acquisition system (DAS). The RM analyzers were calibrated with USEPA Protocol calibration gases and operated to ensure that zero drift, calibration gas drift, bias and calibration error met the specified method requirements. Refer to Figure 4-4 for a drawing of the reference method 3A sample apparatus.

Figure 4-4. USEPA Method 3A Sampling Apparatus



4.1.5 MOISTURE CONTENT (USEPA METHODS 4, 320, AND ALT-008)

The exhaust gas moisture content was measured using USEPA Method 4, *Determination of Moisture in Stack Gases* in conjunction with the Method 5 and 202 sample apparatus for FPM/CPM testing. Flue gas was drawn through a series of impingers immersed in an ice bath to condense and remove water from the sample. The amount of water condensed and collected in the impingers was measured gravimetrically and used to calculate the exhaust gas moisture content.

Moisture content for VOC testing on LM3 and all HCHO testing was determined using USEPA Method 320, *Vapor Phase Organic and Inorganic Emissions by Extractive FTIR.* Refer to Section 4.1.8 for a summary of the sampling and analytical techniques for the method.

Moisture content for VOC testing on 7EA was determined using USEPA ALT-008, *Alternative Moisture Measurement Method Midget Impingers*. The sample apparatus follows the general guidelines contained in § 8.2 of USEPA Method 4. Exhaust gas was drawn at a constant rate through a series of midget impingers immersed in an ice bath to remove moisture, which was subsequently measured gravimetrically to calculate moisture content.

4.1.6 FILTERABLE PARTICULATE MATTER (USEPA METHOD 5)

Filterable particulate matter samples were collected isokinetically in conjunction with RM 202 following USEPA Method 5, *Determination of Particulate Matter Emissions from Stationary Sources* procedures.

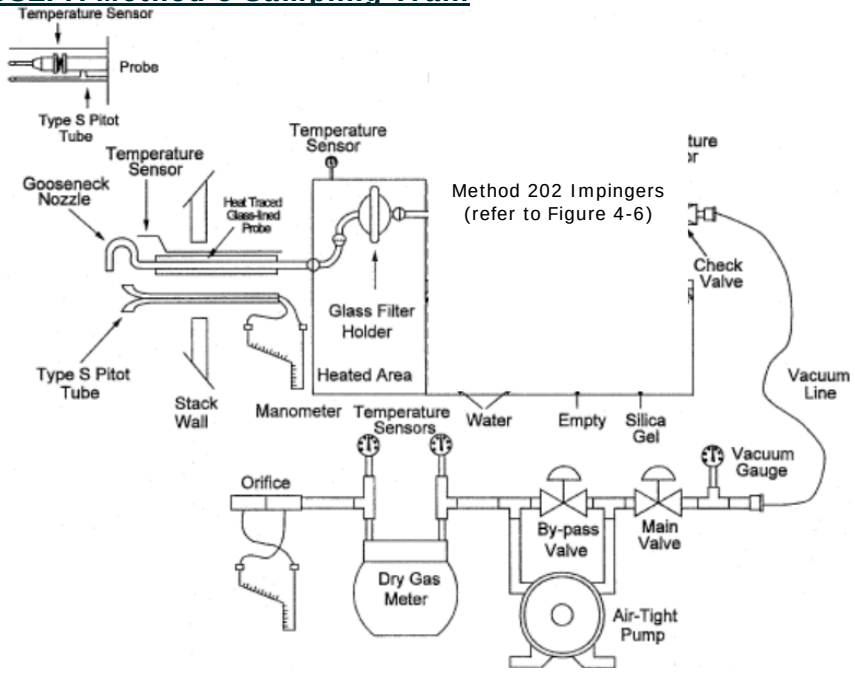
The flue gas is collected using a specifically sized nozzle, probe, quartz-fiber filter, and a series of impingers configured as shown in Table 4-3. The FPM is collected on the filter and water vapor and/or CPM is collected in the impingers. Figure 4-5 depicts the USEPA Method 5 sample apparatus.

Before testing, a preliminary velocity traverse was performed and/or representative flow data from previous measurements was reviewed to calculate an ideal nozzle size that allowed isokinetic sampling to be performed. A pre-cleaned nozzle that had an inner diameter approximating 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 PM sample 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 a sample apparatus leak rate of less than 0.02 cubic feet per minute (cfm). The sample probe was 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 sample apparatus parameters (e.g., flue velocity, temperature) were monitored to ensure isokinetic sample rates were within 100±10% for the duration of the test.

Figure 4-5. USEPA Method 5 Sampling Train



At the conclusion of a test run and the post-test leak check, the sample train was disassembled and the impingers and FPM filter housing were transported to the recovery area.

The filter was recovered from the filter housing, placed in a Petri dish, sealed with Teflon tape, and labeled as "FPM Container 1." The nozzle, probe liner, and the front half of the filter housing was triple rinsed with acetone and collected in pre-cleaned sample containers, sealed with Teflon tape, and labeled as "FPM Container 2." The flue gas moisture condensed in the impingers was weighed on an electronic scale to determine flue gas moisture content, after which the impingers were recovered following Method 202 CPM requirements (see Section 4.1.7). Refer to Figure 4-6 for the USEPA Method 5 sample recovery scheme.

The sample containers, including blanks, were transported to the RCTS laboratory for analysis. The sample analysis followed USEPA Method 5 procedures as summarized in the sample recovery scheme presented in Figure 4-7.

Figure 4-6. USEPA Method 5 Sample Recovery Scheme

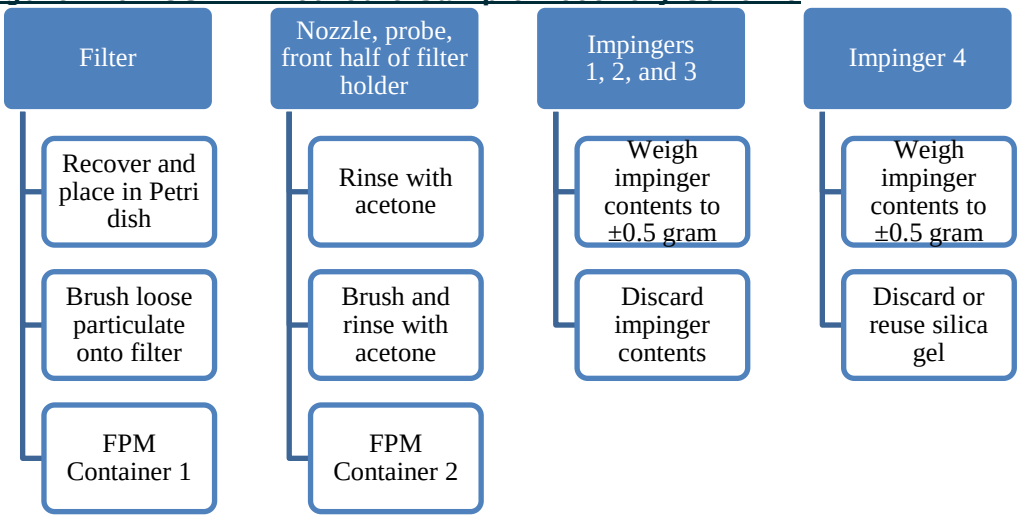
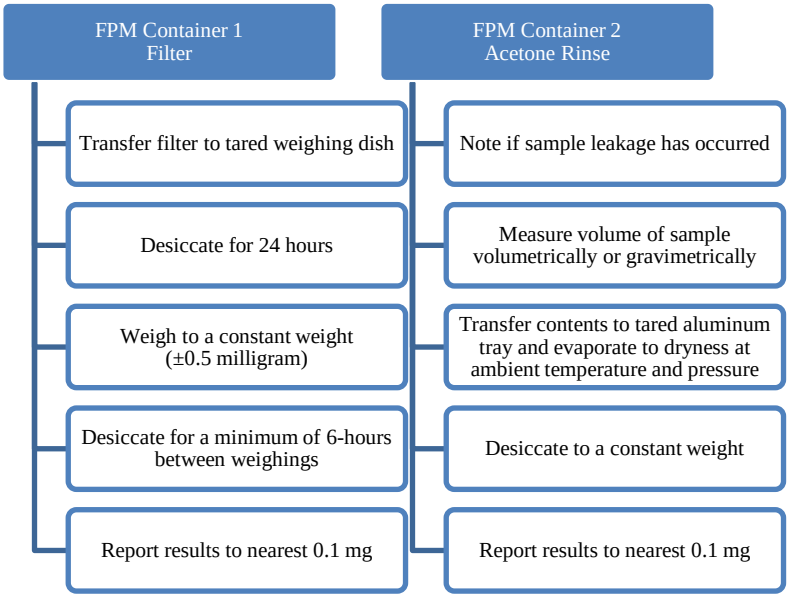


Figure 4-7. USEPA Method 5 Analytical Scheme



4.1.7 CONDENSABLE PARTICULATE MATTER (USEPA METHOD 202)

Condensable particulate matter was collected isokinetically 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.* The Method 202 sample apparatus uses clean, baked glassware comprised 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 approximately 100 milliliters of water and one impinger containing silica gel. During each CPM run, temperature controlled water recirculated in the coil condenser jacket maintained the CPM filter temperature below 85°F. Refer to Figure 4-8 for a drawing of the Method 202 sample apparatus and Table 4-3 which describes the Method 5/202 impinger configuration.

Figure 4-8. USEPA Method 202 Sampling Train

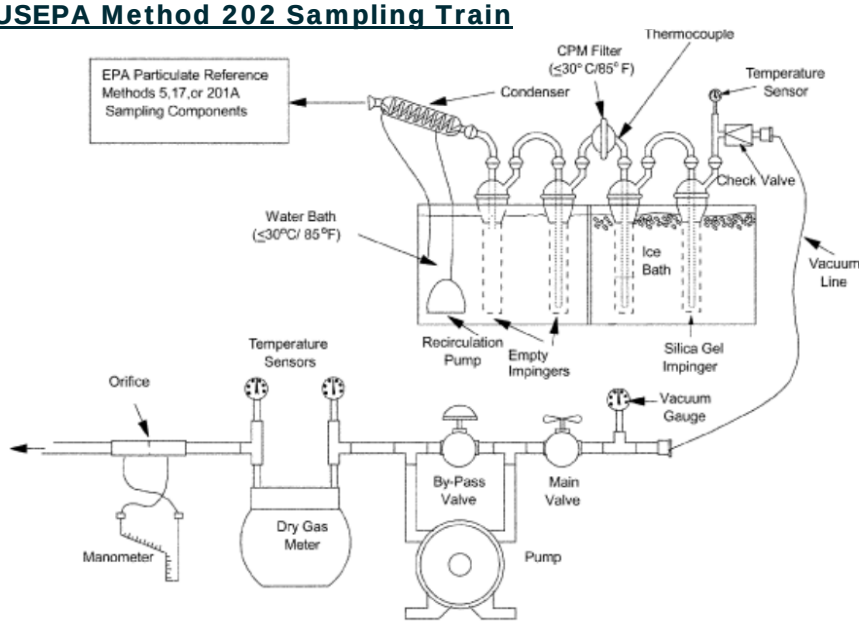


Table 4-3 Method 5/202 Impinger Configuration

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

Upon test completion, each impinger was weighed to determine flue gas moisture content. The condenser, dropout and back-up impingers, and the CPM filter housing were then re-assembled and purged with Ultra-high purity nitrogen at a rate of approximately 14 liters per minute for a minimum of one hour to remove dissolved sulfur dioxide (SO_2) gases from the impinger water. During the purge, water continued to recirculate in the condenser jacket to maintain the CPM filter exit temperature and the impingers were observed to ensure the contents did not evaporate.

After the nitrogen purge, the condensate collected in the dropout and back-up impingers were 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 were 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 rinses). 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 the samples were sealed and transported to the Bureau Veritas laboratory in Mississauga, Ontario for analysis.

4.1.8 FORMALDEHYDE (USEPA METHOD 320)

Formaldehyde and moisture content during formaldehyde and concurrent VOC test runs were measured using the sampling and analytical procedures of USEPA Method 320, *Vapor Phase Organic and Inorganic Emissions by Extractive FTIR*. Exhaust gas was extracted through a heated stainless steel probe and heated Teflon® sample line prior to being introduced to the FTIR. The stainless steel probe and Teflon® sample line were maintained at approximately 375°F.

Prior to testing, a calibration transfer standard (CTS) was used to ensure suitable agreement between the sample and reference spectra. Following the CTS, a spike gas and tracer gas was introduced to the sample line at a constant flowrate of ≤10% of the total sample flow. The system passed the QA spike when the average spike concentration was within 0.7 to 1.3 times the expected concentration.

Data was validated and corrected per specifications outlined in USEPA Method 301. A total of 60 minutes of reference spectra data was collected for each run. Following each run, another CTS spectrum was recorded and compared to the pre-test CTS. The pre-test and post-test CTS are required to be within ±5% of the mean value for the run to be valid.

An on-site minimum detectable concentration (MDC) analysis was performed for the target analytes using procedures outlined in ASTM D 6348 A2.3. The MDC was calculated as three times the standard deviation of the concentrations from ten representative background spectra taken during the MDC analysis and was 0.01 ppmv wet for formaldehyde.

4.1.9 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_{10}, VOC and formaldehyde emission rates in units of lb/mmBtu. Measured oxygen concentrations and F factors (ratios of combustion gas volumes to heat inputs) were used to calculate emission rates using equation 19-1 from the method; refer to Appendix A for sample calculations.

4.1.10 VOLATILE ORGANIC COMPOUNDS (USEPA METHOD 25A)

VOC concentrations were measured from the engine using a Thermo Model 55i Direct Methane and Non-methane Analyzer following the guidelines of USEPA Method 25A, *Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer (FIA*). The instrument uses a flame ionization detector (FID) to measure the exhaust gas total hydrocarbon concentration in conjunction with a gas chromatography column that separates methane from other organic compounds.

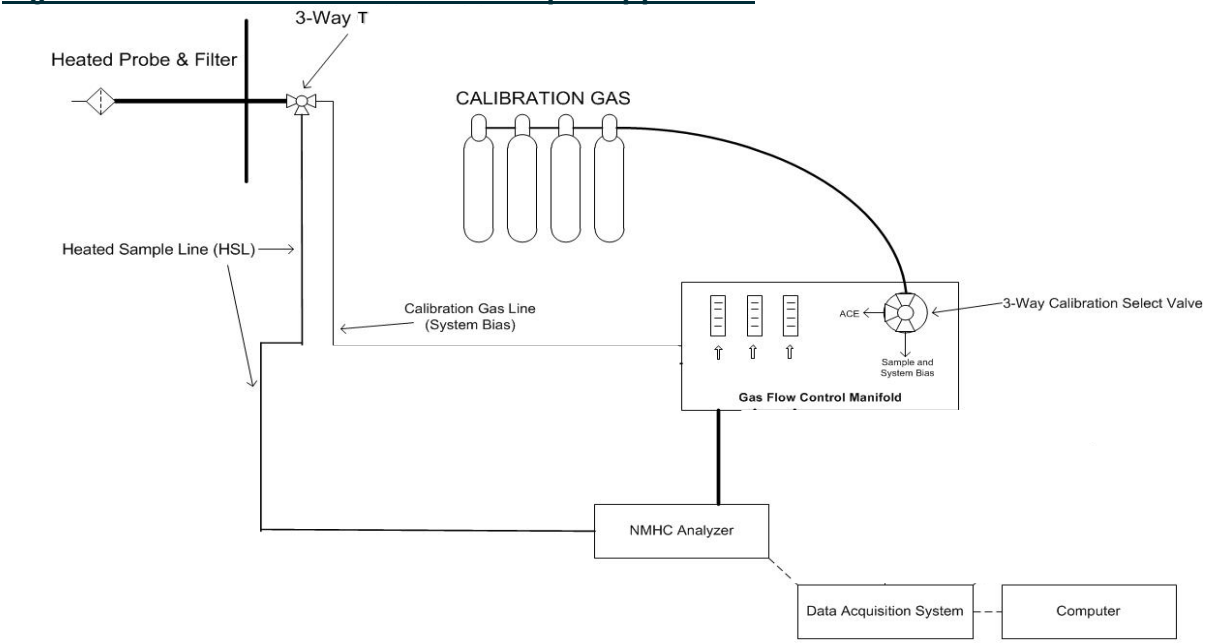
The components of the extractive sample interface apparatus are constructed of stainless steel and Teflon. Flue gas was collected from the stack via a sample probe and heated sample line and into the analyzer, which communicates with the data acquisition handling system (DAHS) via output signal cables. The analyzer uses a rotary valve and gas chromatograph column to separate methane from hydrocarbons in the sample and quantifies these components using a flame ionization detector.

Sample gas is injected into the column and due to methane's low molecular weight and high volatility moves through the column more quickly than other organic compounds that may be present and quantified by the FID. The column is then flushed with inert carrier gas and the remaining non-methane organic compounds are analyzed in the FID. This analytical technique allows separate measurements for methane and non-methane organic compounds via the use of a single FID. Refer to Figure 4-9 for a drawing of the USEPA Method 25A sampling apparatus.

The field VOC instrument was calibrated with a zero air and three propane in air calibration gases following USEPA Method 25A procedures at the zero level, low (25 to 35 percent of calibration span), mid (45 to 55 percent of calibration span) and high (equivalent to 80 to 90 percent of instrument span). Please note that since the field VOC instrument measures on a wet basis, exhaust gas moisture content was determined during each test run to convert wet VOC concentrations to dry basis for calculating VOC mass emission rates.

The Thermo 55i analyzer used measures exhaust gas ethane as part of the NMOC measurement. Therefore, the NMOC concentrations measured may reflect a positive NMOC bias when used as a surrogate for VOCs.

Figure 4-9. USEPA Method 25A Sample Apparatus



5.0 TEST RESULTS AND DISCUSSION

The test results obtained as required by EGLE MI-ROP-N6626-2019 and PTI No. 118-18 on June 9-11, 2020 for Units LM3 and 7EA indicate PM_{10}, VOCs and HCHO measured less than the emission limits at all load conditions (again, stack testing is not the compliance method; the lb/mmBtu emission factors will be used in conjunction with heat input determinations to calculate mass emissions based upon the proper averaging periods). Therefore, Units 7EA and LM1 through 6 (determined by testing of LM3) are in compliance with the mass emission limits in the ROP. Refer to Section 2.3 for a summary of the test results.

5.1.1 TABULATION OF RESULTS

Table 2-1 in Section 2 of this report summarizes the results and Appendix Tables 1 through 6 contain detailed tabulation of results, process operating conditions, and exhaust gas conditions.

5.1.2 SIGNIFICANCE OF RESULTS

The Unit 7EA and LM3 PM_{10}, VOCs and HCHO results indicate ongoing compliance with the mass emission limits present in EGLE MI-ROP-N6626-2019 and PTI No. 118-18.

5.1.3 VARIATIONS FROM SAMPLING OR OPERATING CONDITIONS

RCTS indicated in the test protocol that USEPA Method 18 would be utilized to measure formaldehyde at low concentrations during the test. On June 8, 2020 an equipment issue was discovered during set up and it was decided that Method 320 could be utilized with a specialized FTIR to achieve the desired low detection levels. This was communicated to and approved by EGLE representative David Patterson via Email on June 8, 2020. When possible (during VOC testing on LM3 and all HCHO testing), moisture content of the exhaust gas was determined with the FTIR. VOC testing of Unit 7EA on June 10th occurred after the FTIR analysts departed the site and USEPA ALT-008 was performed to measure moisture content and determine VOC concentrations on a dry basis.

For the PM_{10} test runs, ALT-123 was utilized to measure O_2 and CO_2 for molecular weight determination (vs Method 3A) as the analytical technique is identical and the additional RM3A sampling system was located at the source being tested for VOCs and HCHO. Two samples (CPM filters) were lost in transit between the facility and the laboratory. The samples the laboratory did not receive were the CPM filters for Unit 7EA Run 2 and the field train recovery blank. Though the PM_{10} results are not significantly different between the three runs (0.0035, 0.0022, and 0.0024 lb/mmBtu, respectively), Run 2 for Unit 7EA was excluded from the run average calculations for condensable particulate and PM_{10}. The missing sample from the field train recovery blank had no effect on results as the mass from the organic and inorganic rinse analysis exceeded the maximum allowable blank correction of 2.0 mg.

On June 10, 2020 formaldehyde testing was attempted on Unit 7EA but an issue with the sampling equipment caused a positive bias on the HCHO results and the test was aborted. The positive bias was caused by the sample probe tip position which had receded into the probe sheathe and was exposed to off-gassing of the probe heating element. The probe tip was re-positioned outside of the sheathe once discovered and the test was re-attempted and completed on June 11, 2020. HCHO data from June 10 is available upon request though it is not representative of the HCHO emissions from Unit 7EA.

Due to the NMVOC analyzer's range and corresponding span value (200 ppmv) and the low-level of VOCs measured during Run 1 at LM3, RCTS decided to send an additional calibration gas (cylinder no. CC349505, 10.01 ppmv propane) following the run to verify the multiplication factor was accurate between the zero-gas and the low-level gas. The response indicated a slight positive bias so the low-level (cylinder no. CC22269, 60.04 ppmv propane) was used to correct VOCs for analyzer drift for Unit LM3. The additional low-level calibration gas (10.01 ppmv) was used to correct VOCs for analyzer drift during the Unit 7EA testing as it was introduced prior to Run 1 and responded within 5% of the cylinder value.

The first attempt at Run 2 for Unit 7EA FPM/CPM testing was voided due to an equipment failure that occurred 30 minutes into the test run and prevented calculation of isokinetic sampling rate. Data for this voided run is included in Appendix B1.

There were no other variations from the approved test protocol.

5.1.4 Process or Control Equipment Upset Conditions

The turbine and associated control equipment were operating under routine conditions during testing. On June 9, 2020, during Run 3 of the PM_{10} testing on Unit 7EA, the facility encountered issues with the duct burners that would cause them to go out. Testing continued as the unit was still operating at a representative load. The FPM results appear slightly higher for that run, and it is speculated that this is due to the duct burner issues. On June 11, 2020, during Runs 2 and 3 of the upper load condition formaldehyde testing on Unit 7EA (high load with duct burner on), the operators encountered issues with the duct burners that would cause them to go out. Testing was paused during these times until the issue was resolved.

5.1.5 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 equipment is a continuous process to ensure compliance with regulatory emission limits.

5.1.6 RE-TEST DISCUSSION

Based on the results of this test program, Jackson Generating Station does not believe a re-test is required. While the total PM result for Unit 7EA is based on only two runs (due to the loss of the Run 2 CPM filter), the two-run average for total PM indicates a significant compliance margin relative to the permit limit. Specifically, when the resulting total PM emission factor of 0.0040 is multiplied by the maximum hourly heat input rating of 1,300 mmBtu/hr, the resulting total PM emission rate is only 5.2 lbs/hr as compared to the permit limit of 9.2 lbs/hr. Further, the CPM results for Runs 1 and 3 were fairly similar, at 0.0035 and 0.0024 lb/mmBtu, respectively.

5.1.7 RESULTS OF AUDIT SAMPLES

Audit samples are not required for the reference methods utilized during this test program and are not available from USEPA Stationary Source Audit Sample Program providers. A list of QA/QC Procedures is listed below in Table 5-1.

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria
M1: Sampling Location	Evaluates 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	Verifies 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°
M3A, 25A: Calibration gas standards	Ensure accurate calibration standards	Cal Gas Traceability protocol	Pre-test	Calibration gas uncertainty ≤2.0%
M3A: Calibration Error	Evaluate analyzer operation	Introduce cal gas directly to analyzers	Pre-test	±2.0% of span or ≤0.5 ppmv or ≤0.5% O_2 abs. difference
M3A: System Bias and Analyzer Drift	Evaluate analyzer and sample system integrity and accuracy	Introduce cal gas at sample probe tip	Pre and Post-test	Bias: ±5.0% of span Drift: ±3.0% of span or ≤ 0.5 ppmv, 0.5% O_2/CO_2 abs. difference
M2: Pitot tube calibration and standardization	Verifies construction and alignment of Pitot tube	Inspect Pitot tube, assign coefficient value	Pre-test and after each field use	Method 2 alignment and dimension requirements
M2: Pitot tube leak check	Verify leak free sampling systems	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
M4: Field balance calibration	Verify moisture measurement accuracy	Use Class 6 weight to check balance accuracy	Daily before use	The field balance must measure the weight within ±0.5 gram of the certified mass

Table 5-1
QA/QC Procedures

QA/QC Activity	Purpose	Procedure	Frequency	Acceptance Criteria
M4: Impinger temperature	Ensures collection of condensed water	Maintain last impinger temperature ≤68°F	Throughout test	Last impinger temperature must be ≤68°F
M5: nozzle diameter measurements	Verify nozzle diameter used to calculate sample rate	Measure inner diameter across three cross-sectional chords	Pre-test	3 measurements agree within ±0.004 inch
M5: Apparatus Temperature	Prevents condensation within sample apparatus	Set probe & filter heat controllers to 248±25°F	Verify prior to and during each run	Apparatus temperature must be 248±25°F
M5: Sample rate	Ensure representative sample collection	Calculate isokinetic sample rate	During and post-test	100±10% isokinetic rate
M5/202: Post-test leak check	Evaluate if system leaks biased the sample	Cap sample train; monitor DGM	Post-test	≤0.020 cfm
M5/202: post-test meter audit	Evaluates sample volume accuracy	DGM pre- and post-test; compare calibration factors (Y and Yqa)	Pre-test Post-test	±5%
M5: Apparatus Temperature	Ensures purge of acid gases in glass probe liner and Teflon filter	Set probe & filter heat controllers to ≥248°F	Verify prior to and during each run	Apparatus temperature must be ≥223°F and ≤273°F
M25A: Calibration Error	Evaluate initial analyzer sample system integrity and accuracy	Introduce cal gas at sample probe tip	Pre-test	±5.0% of cal gas value
M25A: Zero and Calibration Drift	Evaluate analyzer sample system integrity and accuracy over test duration	Introduce cal gas through sample system	Pre and Post-test	±3.0% of analyzer calibration span
M202: Impinger temperature	Ensure collection of condensate	Maintain CPM filter temperature below 85°F	Throughout test	CPM filter temperature must be ≥65°F and ≤85°F
M320: Sampling system leak check	Verify leak free sampling system	Cap sampling system, monitor flowrate	Pre-test	≤200 mL/min
M320: Analytical system leak check	Verify leak free analytical system	Cap analytical system, monitor pressure	Pre-test	≤4.0% of the FTIR system volume
M320: QA Spike	Evaluates operation of analyzer	Calibration gases introduced into sampling system at ≤10.0% of sampling rate	Pre-test Post-test	average spiked concentration 0.7 to 1.3 times the expected concentration

5.1.8 CALIBRATION SHEETS

Aside from RM 320, calibration sheets, including dry gas meter, gas protocol sheets, and analyzer quality control and assurance checks are presented in Appendix E. All M320 related calibration sheets are appended to the associated PRISM Analytical Technologies test report in Appendix C.

5.1.9 SAMPLE CALCULATIONS

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

5.1.10 FIELD DATA SHEETS

Field data sheets are presented in Appendix B.

5.1.11 LABORATORY QUALITY ASSURANCE / QUALITY CONTROL PROCEDURES

The method specific quality assurance and quality control procedures in each method employed during this test program were followed, without deviation. Refer to Appendix C for the laboratory data sheets.

5.1.12 QA / QC BLANKS

Reagent and media blanks were analyzed for the parameters of interest. The results of the blanks analysis are presented in the Table 5-2. Laboratory QA/QC and blank results data are contained in Appendix C.

Table 5-2
QA / QC Blanks

Sample Identification	Result	Comment
Method 5 Acetone Blank	0.3 mg	Sample volume was 160 milliliters Acetone blank corrections were applied
Method 5 Filter Blank	0.1 mg	Reporting limit is 0.1 milligrams
Method 202 DI H_2O Blank	0.7 mg	Sample weight was 170 grams Result is for inorganic condensable
Method 202 Acetone Blank	<1.0 mg	Sample weight was 160 grams Result is for organic condensable
Method 202 Hexane Blank	<1.0 mg	Sample weight was 120 grams Result is for organic condensable
Method 202 Field Train Recovery Blank	5.3 mg inorganic <1.0 mg organic	Maximum blank correction of 2.0 mg applied to results, sample weight was 460 grams; CPM filter was missing from sample, but this would have potentially further increased the blank correction above the maximum allowed 2.0 mg