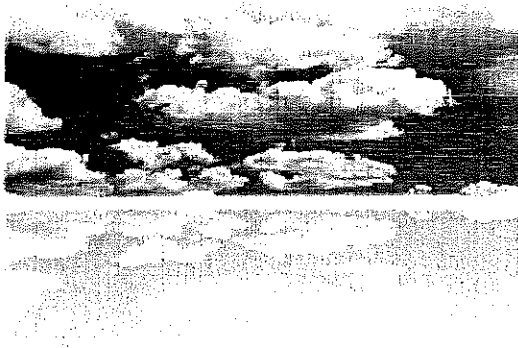




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AIR QUALITY DIVISION



REPORT ON COMPLIANCE &  
RATA TESTING

Detroit Refinery  
Vacuum 2 Heater Stack

Marathon Petroleum Company LP  
1300 South Fort Street  
Detroit, MI 48217  
Client Reference No. 4101004604

CleanAir Project No. 13276-1  
STAC Certificate No. 2007.002.0113.1217  
Revision 0, Final Report  
August 1, 2017

## AIR QUALITY DIVISION

## 1. PROJECT OVERVIEW

## Test Program Summary

Marathon Petroleum Company LP (MPC) contracted CleanAir Engineering (CleanAir) to successfully complete testing on the Vacuum 2 Heater (EU04-VAC2HTR-S1) at the Detroit Refinery, located in Detroit, Michigan. The test program included the following objectives:

- Perform particulate matter (PM) and sulfuric acid mist (H<sub>2</sub>SO<sub>4</sub>) testing to demonstrate compliance with the Michigan Department of Environmental Quality (DEQ) Permit No. MI-ROP-A9831-2012c.
- Perform a relative accuracy test audit (RATA) on the facility's continuous emissions monitoring system (CEMS) for oxygen (O<sub>2</sub>) and nitrogen oxide (NO<sub>x</sub>).

A summary of the test program results is presented below. Section 2 Results provides a more detailed account of the test conditions and data analysis. Test program information, including the test parameters, on-site schedule and a project discussion, begins on page 2.

**Table 1-1:  
Summary of Compliance Results**

Source	Constituent (Units)	Sampling Method	Average Emission	Permit Limit <sup>1</sup>
<i>Vacuum 2 Heater</i>				
	PM (lb/MMBtu)	USEPA M5	0.0006	0.0019
	PM <sub>10</sub> (lb/MMBtu)	USEPA M5 / 202	0.0021	0.0076
	H <sub>2</sub> SO <sub>4</sub> (lb/MMBtu)	Draft ASTM CCM	6.2E-04	N/A

<sup>1</sup> Permit limits obtained from MDEQ Permit No. MI-ROP-A9831-2012c.

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

Source	Reference Method	Relative Accuracy (%) <sup>1</sup>	Applicable Specification	Standard Used	Specification Limit
<i>Vacuum 2 Heater</i>					
	USEPA M-3A	0.09	PS3	abs. diff.	± 1.0%
	USEPA M-7E	6.2	PS2	% of appl. std. <sup>2</sup>	10%

<sup>1</sup> Relative Accuracy is expressed in terms of comparison to the reference method (% RM), applicable standard (% appl. std.) or avg. absolute difference. The specific expression used depends on the specification limit cited.

<sup>2</sup> Applicable standard = 40 ppm @ 0%O<sub>2</sub>.

## Test Program Details

### Parameters

The test program included the following emissions measurements:

- particulate matter (PM), assumed equivalent to filterable particulate matter (FPM) only
- total particulate matter less than 10 microns in diameter (PM<sub>10</sub>), assumed equivalent to the sum of the following constituents:
  - filterable particulate matter (FPM)
  - condensable particulate matter (CPM)
- nitrogen oxides (NO<sub>x</sub>)
- sulfuric acid mist (H<sub>2</sub>SO<sub>4</sub>)
- flue gas composition (e.g., O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>O)
- flue gas temperature
- flue gas flow rate

### Schedule

Testing was performed on June 5 and 6, 2017. The on-site schedule followed during the test program is outlined in Table 1-3.

**Table 1-3:  
Test Schedule**

Run Number	Location	Method	Analyte	Date	Start Time	End Time
1	Vac 2 Heater Stack	USEPA Method 5/202	FPM/CPM	06/05/17	09:34	11:36
2	Vac 2 Heater Stack	USEPA Method 5/202	FPM/CPM	06/05/17	12:23	14:28
3	Vac 2 Heater Stack	USEPA Method 5/202	FPM/CPM	06/05/17	15:15	17:18
1	Vac 2 Heater Stack	USEPA Method 3A/7E	O <sub>2</sub> /CO <sub>2</sub> /NO <sub>x</sub>	06/05/17	07:48	08:09
2	Vac 2 Heater Stack	USEPA Method 3A/7E	O <sub>2</sub> /CO <sub>2</sub> /NO <sub>x</sub>	06/05/17	08:18	08:39
3	Vac 2 Heater Stack	USEPA Method 3A/7E	O <sub>2</sub> /CO <sub>2</sub> /NO <sub>x</sub>	06/05/17	08:52	09:13
4	Vac 2 Heater Stack	USEPA Method 3A/7E	O <sub>2</sub> /CO <sub>2</sub> /NO <sub>x</sub>	06/05/17	09:25	09:46
5	Vac 2 Heater Stack	USEPA Method 3A/7E	O <sub>2</sub> /CO <sub>2</sub> /NO <sub>x</sub>	06/05/17	09:55	10:16
6	Vac 2 Heater Stack	USEPA Method 3A/7E	O <sub>2</sub> /CO <sub>2</sub> /NO <sub>x</sub>	06/05/17	10:25	10:46
7	Vac 2 Heater Stack	USEPA Method 3A/7E	O <sub>2</sub> /CO <sub>2</sub> /NO <sub>x</sub>	06/05/17	10:56	11:17
8	Vac 2 Heater Stack	USEPA Method 3A/7E	O <sub>2</sub> /CO <sub>2</sub> /NO <sub>x</sub>	06/05/17	11:27	11:48
9	Vac 2 Heater Stack	USEPA Method 3A/7E	O <sub>2</sub> /CO <sub>2</sub> /NO <sub>x</sub>	06/05/17	11:57	12:18
10	Vac 2 Heater Stack	USEPA Method 3A/7E	O <sub>2</sub> /CO <sub>2</sub> /NO <sub>x</sub>	06/05/17	12:31	12:52
0	Vac 2 Heater Stack	Draft ASTM CCM	Sulfuric Acid	06/06/17	08:12	09:12
1	Vac 2 Heater Stack	Draft ASTM CCM	Sulfuric Acid	06/06/17	09:36	10:36
2	Vac 2 Heater Stack	Draft ASTM CCM	Sulfuric Acid	06/06/17	10:48	11:48
3	Vac 2 Heater Stack	Draft ASTM CCM	Sulfuric Acid	06/06/17	12:07	13:07

## Discussion

### *Test Scope Synopsis*

#### FPM & PM<sub>10</sub> Testing

A total of three (3) 120-minute EPA Method 5/202 test runs were performed. FPM/CPM emission results were calculated in units of pounds per million Btu (lb/MMBtu). The final result was expressed as the average of the three (3) valid runs.

For this test program, PM emission rate is assumed equivalent to FPM. PM<sub>10</sub> is assumed equivalent to the sum of FPM less than 10 micrometers ( $\mu\text{m}$ ) in diameter (FPM<sub>10</sub>) and CPM. The Method 5/202 sample train yields a front-half (FPM) result and a back-half (CPM) result. The total PM result (FPM plus CPM) from Method 5/202 can be used as a worst-case estimation of total PM<sub>10</sub> since Method 5 collects all FPM present in the flue gas (regardless of particle size).

#### O<sub>2</sub> & NO<sub>x</sub> RATA Testing

Minute-average data points for O<sub>2</sub> and NO<sub>x</sub> (dry basis) were collected over a period of 21 minutes for each run utilizing EPA Methods 3A and 7E. Relative accuracy was determined based on nine (9) of ten (10) total runs conducted per procedures outlined in PS 2, Section 8.4.4.

Sampling occurred at the three (3) points specified in Section 8.1.3.2 of PS 2 during each run. The average result for each run was converted to identical units of measurement as the facility CEMs and compared for relative accuracy.

#### H<sub>2</sub>SO<sub>4</sub> Testing

H<sub>2</sub>SO<sub>4</sub> emissions were determined referencing the Draft ASTM Controlled Condensation Method (CCM). Three (3) 60-minute Draft ASTM CCM test runs were performed. H<sub>2</sub>SO<sub>4</sub> emission results were calculated in units of lb/MMBtu. The final results were expressed as the average of three (3) valid runs.

Prior to the first official test run, a 60-minute sample conditioning run (Run 0) was performed in order to minimize the absorption capacity of the front-half components of the sample train (upstream of the H<sub>2</sub>SO<sub>4</sub>-collecting portion of the sample train). The conditioning run was recovered in the same manner as the official test runs, but the condenser rinse and SAM filter were not analyzed.

#### *Fuel Analysis*

Emission results in units of dry volume-based concentration (lb/dscf, ppm<sub>dv</sub>) were converted into units of pound per million BTU (lb/MMBtu) by calculating an oxygen-based fuel factor (F<sub>d</sub>) for refinery gas per EPA Method 19 specifications. The F<sub>d</sub> factor was calculated from percent volume composition analytical data provided by MPC and tabulated heating values for each of the measured constituents.

#### *Test Conditions*

The unit was operated at the maximum normal operating capacity during each of the emissions compliance test runs and no less than 50% of the maximum normal operating capacity during RATA test runs. MPC was responsible for logging any relevant process-related data and providing it to CleanAir for inclusion in the test reports.

## 2. RESULTS

This section summarizes the test program results. Additional results are available in the report appendices, specifically Appendix C Parameters.

**Table 2-1:  
Vacuum 2 Heater Stack – FPM & PM<sub>10</sub> Emissions**

Run No.		1	2	3	Average
Date (2017)		Jun 5	Jun 5	Jun 5	
Start Time (approx.)		09:34	12:23	15:15	
Stop Time (approx.)		11:36	14:28	17:18	
<b>Process Conditions</b>					
P <sub>1</sub>	Fuel gas flow rate (Mscf/day)	1,044	1,043	1,066	1,051
F <sub>d</sub>	Oxygen-based F-factor (dscf/MMBtu)	8,233	8,233	8,233	8,233
<b>Gas Conditions</b>					
O <sub>2</sub>	Oxygen (dry volume %)	5.1	5.1	5.2	5.1
CO <sub>2</sub>	Carbon dioxide (dry volume %)	9.2	9.1	9.0	9.1
T <sub>s</sub>	Sample temperature (°F)	611	611	612	612
B <sub>w</sub>	Actual water vapor in gas (% by volume)	15.2	15.1	14.2	14.8
<b>Gas Flow Rate</b>					
Q <sub>a</sub>	Volumetric flow rate, actual (acfm)	22,700	23,000	22,800	22,800
Q <sub>s</sub>	Volumetric flow rate, standard (scfm)	10,900	11,000	10,900	10,900
Q <sub>std</sub>	Volumetric flow rate, dry standard (dscfm)	9,230	9,340	9,390	9,320
<b>Sampling Data</b>					
V <sub>msld</sub>	Volume metered, standard (dscf)	92.83	92.74	92.34	92.64
%I	Isokinetic sampling (%)	101.4	100.2	99.2	100.3
<b>Laboratory Data</b>					
m <sub>FPM</sub>	Total FPM (g)	0.00247	0.00201	0.00262	
m <sub>CPM</sub>	Total CPM (g)	0.00661	0.00559	0.00520	
m <sub>Part</sub>	Total particulate matter (as PM <sub>10</sub> ) (g)	0.00908	0.00760	0.00782	
<b>FPM Results</b>					
C <sub>sd</sub>	Particulate Concentration (lb/dscf)	5.87E-08	4.78E-08	6.26E-08	5.63E-08
E <sub>lb/hr</sub>	Particulate Rate (lb/hr)	0.0325	0.0268	0.0352	0.0315
E <sub>Fd</sub>	Particulate Rate - F <sub>d</sub> -based (lb/MMBtu)	0.000639	0.000520	0.000686	0.000615
<b>CPM Results</b>					
C <sub>sd</sub>	Particulate Concentration (lb/dscf)	1.57E-07	1.33E-07	1.24E-07	1.38E-07
E <sub>lb/hr</sub>	Particulate Rate (lb/hr)	0.0870	0.0745	0.0699	0.0771
E <sub>Fd</sub>	Particulate Rate - F <sub>d</sub> -based (lb/MMBtu)	0.00171	0.00145	0.00136	0.00151
<b>Total Particulate Matter (as PM<sub>10</sub>) Results</b>					
C <sub>sd</sub>	Particulate Concentration (lb/dscf)	2.16E-07	1.81E-07	1.87E-07	1.94E-07
E <sub>lb/hr</sub>	Particulate Rate (lb/hr)	0.120	0.101	0.105	0.109
E <sub>Fd</sub>	Particulate Rate - F <sub>d</sub> -based (lb/MMBtu)	0.00235	0.00197	0.00205	0.00212

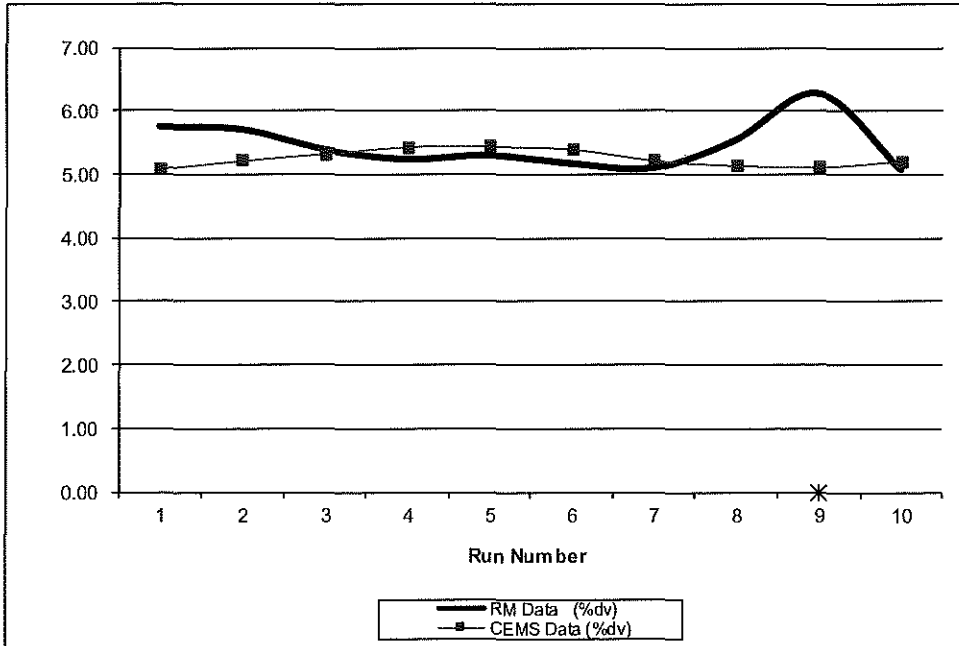
**Table 2-2:  
 Vacuum 2 Heater Stack – O<sub>2</sub> (% dv) RATA**

Run No.	Start Time	Date (2017)	RM Data (%dv)	CEMS Data (%dv)	Difference (%dv)	Difference Percent
1	07:48	Jun 5	5.74	5.08	0.66	11.5%
2	08:18	Jun 5	5.70	5.21	0.49	8.6%
3	08:52	Jun 5	5.38	5.32	0.06	1.1%
4	09:25	Jun 5	5.23	5.43	-0.20	-3.8%
5	09:55	Jun 5	5.29	5.44	-0.15	-2.8%
6	10:25	Jun 5	5.16	5.39	-0.23	-4.5%
7	10:56	Jun 5	5.09	5.21	-0.12	-2.4%
8	11:27	Jun 5	5.54	5.13	0.41	7.4%
9 *	11:57	Jun 5	6.27	5.11	1.16	18.5%
10	12:31	Jun 5	5.06	5.20	-0.14	-2.8%
<b>Average</b>			<b>5.35</b>	<b>5.27</b>	<b>0.09</b>	<b>1.6%</b>

**Relative Accuracy Test Audit Results**

Standard Deviation of Differences	0.341	
Confidence Coefficient (CC)	0.262	
t-Value for 9 Data Sets	2.306	
<b>Avg. Abs. Diff. (%dv)</b>	<b>0.09</b>	<b>Limit 1.0</b>

RM = Reference Method (CleanAir Data) 070617 182300  
 CEMS = Continuous Emissions Monitoring System (MPC Data)  
 RATA calculations are based on 9 of 10 runs. \* indicates the excluded run.



**Table 2-3:  
 Vacuum 2 Heater Stack – NO<sub>x</sub> (ppm @ 0% O<sub>2</sub>) RATA**

Run No.	Start Time	Date (2017)	RM Data (ppm@0%O <sub>2</sub> )	CEMS Data (ppm@0%O <sub>2</sub> )	Difference (ppm@0%O <sub>2</sub> )	Difference Percent
1	07:48	Jun 5	25.8	23.1	2.7	10.5%
2	08:18	Jun 5	26.3	24.0	2.3	8.7%
3	08:52	Jun 5	26.7	24.1	2.6	9.7%
4	09:25	Jun 5	26.9	24.9	2.0	7.4%
5 *	09:55	Jun 5	27.6	24.7	2.9	10.5%
6	10:25	Jun 5	26.7	24.3	2.4	9.0%
7	10:56	Jun 5	26.6	24.5	2.1	7.9%
8	11:27	Jun 5	25.5	23.8	1.7	6.7%
9	11:57	Jun 5	25.8	23.6	2.2	8.5%
10	12:31	Jun 5	26.4	24.1	2.3	8.7%
<b>Average</b>			<b>26.3</b>	<b>24.0</b>	<b>2.3</b>	<b>8.6%</b>

**Relative Accuracy Test Audit Results**

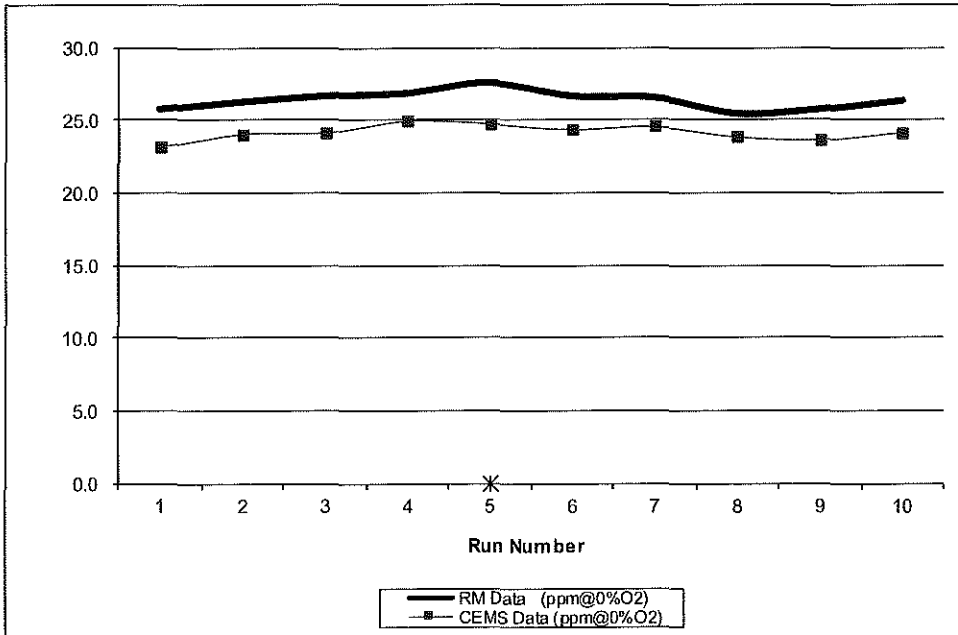
Standard Deviation of Differences	0.305	
Confidence Coefficient (CC)	0.234	
t-Value for 9 Data Sets	2.306	
		Limit
Relative Accuracy (as % of RM)	9.5%	20.0%
Relative Accuracy (as % of Appl. Std.)	6.2%	10.0%
Appl. Std. = 40 ppm@0%O <sub>2</sub>		

RM = Reference Method (CleanAir Data)

070617 182534

CEMS = Continuous Emissions Monitoring System (MPC Data)

RATA calculations are based on 9 of 10 runs. \* indicates the excluded run.



**Table 2-4:  
 Vacuum 2 Heater Stack – H<sub>2</sub>SO<sub>4</sub> Emissions**

Run No.		1	2	3	Average
Date (2017)		Jun 6	Jun 6	Jun 6	
Start Time (approx.)		09:36	10:48	12:07	
Stop Time (approx.)		10:36	11:48	13:07	
<b>Process Conditions</b>					
P <sub>1</sub>	Fuel gas flow rate (Mscf/day)	1,068	1,052	1,085	1,068
F <sub>d</sub>	Oxygen-based F-factor (dscf/MMBtu)	8,284	8,284	8,284	8,284
<b>Gas Conditions</b>					
O <sub>2</sub>	Oxygen (dry volume %)	8.3	8.8	6.1	7.7
CO <sub>2</sub>	Carbon dioxide (dry volume %)	6.1	7.0	8.6	7.2
T <sub>s</sub>	Sample temperature (°F)	621	625	625	624
B <sub>w</sub>	Actual water vapor in gas (% by volume)	13.8	13.1	14.8	13.9
<b>Sampling Data</b>					
V <sub>mstd</sub>	Volume metered, standard (dscf)	28.06	28.59	28.49	28.38
<b>Laboratory Data (Ion Chromatography)</b>					
m <sub>n</sub>	Total H <sub>2</sub> SO <sub>4</sub> collected (mg)	0.5705	0.5975	0.6429	
<b>Sulfuric Acid Vapor (H<sub>2</sub>SO<sub>4</sub>) Results</b>					
C <sub>sd</sub>	H <sub>2</sub> SO <sub>4</sub> Concentration (lb/dscf)	4.48E-08	4.61E-08	4.98E-08	4.69E-08
C <sub>sd</sub>	H <sub>2</sub> SO <sub>4</sub> Concentration (ppmdv)	0.176	0.181	0.196	0.184
E <sub>Fd</sub>	H <sub>2</sub> SO <sub>4</sub> Rate - Fd-based (lb/MMBtu)	0.000616	0.000659	0.000582	0.000619

End of Section



### 3. DESCRIPTION OF INSTALLATION

#### Process Description

MPC's facility in Detroit, Michigan, produces refined petroleum products from crude oil. MPC must continue to demonstrate that select process units are in compliance with permitted emission limits.

The Vacuum Unit (EU04-VACUUM) separates the reduced crude from the Crude Unit through the use of a vacuum column. The reduced crude is separated into light vacuum gas oil, medium vacuum gas oil, heavy vacuum gas oil and a bottoms product called flux. The various fractions are sent to other units in the refinery for further processing. The Vacuum Unit consists of process vessels (including heat exchangers and vacuum column), two process heaters, tanks, containers, two cooling towers, flare, compressors, pumps, piping drains and various components (pumps and compressor seals, process valves, pressure relief valves, flanges, connectors, etc.).

The Vacuum 2 Heater (EU04-VAC2HTR-S1) is fired by refinery fuel gas. Emissions are vented to the atmosphere via the Vacuum 2 Heater Stack (SV04-H2), where testing was performed.

#### Test Location

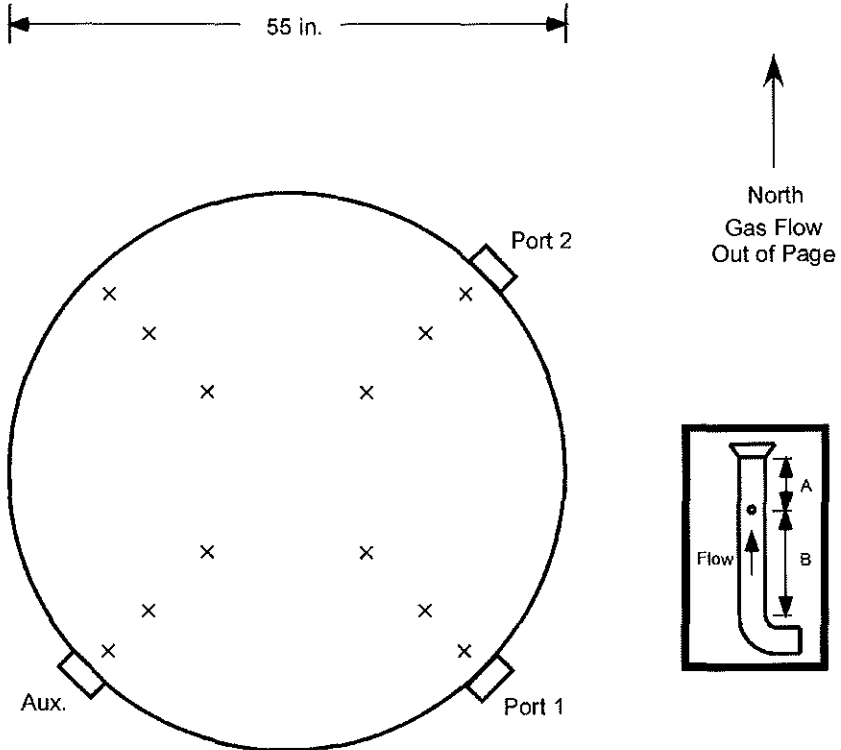
The sample point locations were determined by EPA Methods 1 and 7E specifications. Table 3-1 presents the sampling information for the test location described in this report. The figures shown on pages 9 and 10 represent the layout of the test location.

**Table 3-1:  
Sampling Point Information**

Source Constituent	Method	Run No.	Ports	Points per Port	Minutes per Point	Total Minutes	Figure
<i>Vacuum 2 Heater</i>							
FPM/CPM (PM <sub>10</sub> )	EPAM5/202	1-3	2	6	10	120	3-1
H <sub>2</sub> SO <sub>4</sub>	Draft ASTM CCM	1-3	1	1	60	60	N/A <sup>1</sup>
O <sub>2</sub> / NO <sub>x</sub> (RATA)	EPAM3A/7E	1-10	1	3	7	21	3-2

<sup>1</sup> Sampling occurred at a single point near the center of duct.

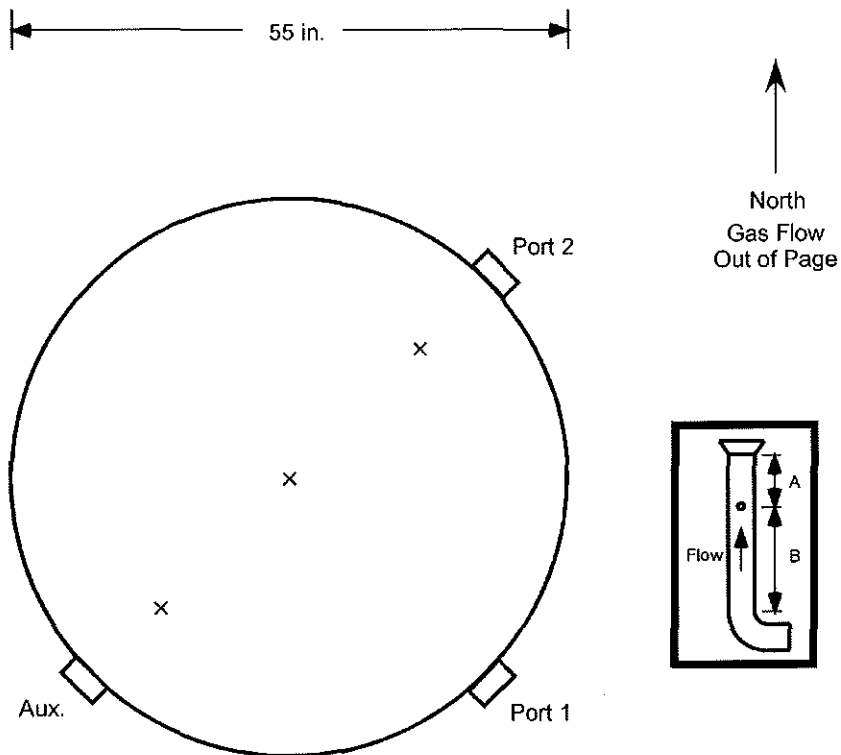
**Figure 3-1:  
 FPM & PM<sub>10</sub> Sample Point Layout (EPA Method 1)**



Sampling Point	% of Stack Diameter	Port to Point Distance (inches)
1	95.6	52.6
2	85.4	47.0
3	70.4	38.7
4	29.6	16.3
5	14.6	8.0
6	4.4	2.4

Duct diameters upstream from flow disturbance (A): 9.2      Limit: 0.5  
 Duct diameters downstream from flow disturbance (B): 12.0      Limit: 2.0

**Figure 3-2:  
 O<sub>2</sub> & NO<sub>x</sub> Sample Point Layout (EPA Method 7E)**



Sampling Point	% of Stack Diameter	Port to Point Distance (inches)
1	83.3	45.8
2	50.0	27.5
3	16.7	9.2

Duct diameters upstream from flow disturbance (A): 9.2                      Limit: 0.5  
 Duct diameters downstream from flow disturbance (B): 12.0              Limit: 2.0

End of Section

## 4. METHODOLOGY

### Procedures and Regulations

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The test program sampling measurements followed procedures and regulations outlined by the U.S. Environmental Protection Agency (USEPA) and the Michigan Department of Environmental Quality (DEQ). These methods appear in detail in Title 40 of the CFR and at <https://www.epa.gov/emc>. Appendix A includes diagrams of the sampling apparatus, as well as specifications for sampling, recovery and analytical procedures.

CleanAir follows specific QA/QC procedures outlined in the individual methods and in USEPA "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III Stationary Source-Specific Methods," EPA/600/R-94/038C. Appendix D contains additional QA/QC measures, as outlined in CleanAir's internal Quality Manual.

#### Title 40 CFR Part 60, Appendix A

Method 1	"Sample and Velocity Traverses for Stationary Sources"
Method 2	"Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)"
Method 3	"Gas Analysis for the Determination of Dry Molecular Weight"
Method 3A	"Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)"
Method 3B	"Gas Analysis for the Determination of Emission Rate Correction Factor or Excess Air"
Method 4	"Determination of Moisture Content in Stack Gases"
Method 5	"Determination of Particulate Matter Emissions from Stationary Sources"
Method 7E	"Determination of Nitrogen Oxide Emissions from Stationary Sources (Instrumental Analyzer"
Method 19	"Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide and Nitrogen Oxide Emission Rates"

#### Title 40 CFR Part 60, Appendix B Performance Specifications

PS2	"Specifications and Test Procedures for SO <sub>2</sub> and NO <sub>x</sub> Continuous Emission Monitoring Systems in Stationary Sources"
PS3	"Specifications and Test Procedures for O <sub>2</sub> and CO <sub>2</sub> Continuous Emission Monitoring Systems in Stationary Sources"

#### Title 40 CFR Part 51, Appendix M

Method 202	"Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources"
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#### CTM-013 (Mod.)/Draft ASTM Controlled Condensation Method (Draft ASTM CCM)

"Determination of Sulfur Oxides Including Sulfur Dioxide, Sulfur Trioxide and Sulfuric Acid Vapor and Mist from Stationary Sources Using a Controlled Condensation Sampling Apparatus"

## Methodology Discussion

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### FPM and PM<sub>10</sub> Testing – USEPA Method 5/202

The front-half (EPA Method 5 portion) of the sampling train consisted of a glass nozzle, glass liner and filter holder heated to 248°F ± 25°F and a quartz fiber filter. Flue gas samples were extracted isokinetically per Method 5 requirements.

The back-half (EPA Method 202 portion) of the sampling train is designed to mimic ambient conditions and collect only the particles that would truly form CPM in the atmosphere by minimizing the sulfur dioxide (SO<sub>2</sub>) and NO<sub>x</sub> interferences observed with earlier versions of the method, in which flue gas was bubbled through cold water; SO<sub>2</sub> and NO<sub>x</sub> were absorbed and partially oxidized before they could be purged out with nitrogen (N<sub>2</sub>).

Flue gas exiting the front-half heated filter passed through a coiled condenser and dry impinger system jacketed by water continually circulated at ambient temperature. Moisture was removed from the flue gas without bubbling through the condensed water. Flue gas then passed through a tetrafluoroethane (TFE) membrane filter at ambient temperature. The temperature of the flue gas at the exit of the filter was directly measured with an in-line thermocouple and maintained in the temperature range of 65°F to 85°F.

After exiting the ambient filter, the flue gas passed through two (2) additional impingers surrounded by ice in a "cold" section of the impinger bucket. The moisture collected in these impingers were not analyzed for CPM and was only collected to determine the flue gas moisture and thoroughly dry the gas. The sample gas then flowed into a calibrated dry gas meter where the collected sample gas volume was determined.

The front-half portion of the sample train (nozzle, probe and heated filter) was recovered per Method 5 requirements, using acetone as the recovery solvent. The back-half of the sample train (heated filter outlet, condenser, dry impingers and TFE membrane filter) was recovered per Method 202 requirements. The impinger train was purged with N<sub>2</sub> at a rate of 14 liters per minute (lpm) for one (1) hour following each test run and prior to recovery.

A field train blank was assembled, purged and recovered as if it were an actual test sample; analysis of the field train blank was used to blank-correct the test run results. Reagent blanks were also collected to quantify background contamination. All samples and blanks were returned to CleanAir Analytical Services for gravimetric analysis. Method 202 samples were maintained at a temperature < 85°F during transport to the laboratory.

### O<sub>2</sub>, CO<sub>2</sub> & NO<sub>x</sub> Testing – USEPA Methods 3A and 7E

Reference method O<sub>2</sub> and carbon dioxide (CO<sub>2</sub>) emissions were determined using a paramagnetic/NDIR analyzer per EPA Method 3A. Reference method NO<sub>x</sub> emissions were determined using a chemiluminescent analyzer per EPA Method 7E.

Sample gas was extracted at a constant rate, conditioned to remove moisture and delivered to an analyzer bank which measured concentration on a dry basis (units of %dv or ppm<sub>dv</sub>).

Calibration error checks were performed by introducing zero N<sub>2</sub>, high range and mid-range calibration gases to the inlet of each analyzer during calibration error checks. Bias checks were performed before and after each sampling run by introducing calibration gas to the inlet of the sampling system's heated filter. Per Methods 3A and 7E, the average results for each run were drift-corrected.

### H<sub>2</sub>SO<sub>4</sub> Testing – Draft ASTM CCM

A gas sample was extracted from the source at a constant flow rate using a quartz-lined probe maintained at a temperature of 650°F ± 25°F (depending on the required probe length) and a quartz fiber filter maintained at the same temperature as the probe to remove particulate matter.

The sample then passed through a glass coil condenser for collection of sulfuric acid vapor and/or mist. A second quartz fiber filter (referred to as the sulfuric acid mist (SAM) filter) was located at the condenser outlet for the collection of residual SAM not collected by the condenser. The condenser temperature was regulated by a water jacket and the SAM filter was regulated by a closed oven. Both the water jacket and SAM filter oven were maintained at 140°F ± 9°F.

After exiting the SAM filter, the sample gas continued through a series of four (4) glass knock-out jars: two (2) containing water, one (1) empty and one (1) containing silica gel for residual moisture removal. The exit temperature from the knock-out jar set was maintained below 68°F. The sample gas then flowed into a dry gas meter, where the collected sample gas volume was determined by means of a calibrated, dry gas meter or an orifice-based flow meter.

The H<sub>2</sub>SO<sub>4</sub>-collecting portion of the sample train (condenser and SAM filter) was recovered into a single fraction using deionized (DI) H<sub>2</sub>O as the recovery/extraction solvent; any H<sub>2</sub>SO<sub>4</sub> disassociates into sulfate ion (SO<sub>4</sub><sup>2-</sup>) and is stabilized in the H<sub>2</sub>O matrix until analysis.

Samples and blanks were returned to CleanAir Analytical Services for ion chromatography (IC) analysis.

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*End of Section*