

REPORT ON COMPLIANCE
TESTING

Detroit Refinery
Coker Heater Stack

Marathon Petroleum Company LP
1300 South Fort Street
Detroit, MI 48217
Client Reference No. 4101379616

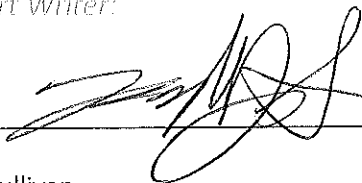
CleanAir Project No. 13714-2
A2LA ISO 17025 Certificate No. 4342.01
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Revision 0, Final Report
January 31, 2019

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COMMITMENT TO QUALITY

To the best of our knowledge, the data presented in this report are accurate, complete, error free and representative of the actual emissions during the test program. Clean Air Engineering operates in conformance with the requirements of ASTM D7036-04 Standard Practice for Competence of Air Emission Testing Bodies.

Report Writer:



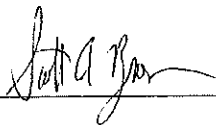
January 31, 2019

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I hereby certify that the information contained within the final test report has been reviewed and, to the best of my ability, verified as accurate.

Independent Report and Appendix Reviewer:



January 31, 2019

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REPORT REVISION HISTORY

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Final	0	01/31/19	All	Final version of original document.

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ACRONYMS &
ABBREVIATIONS

AAS (atomic absorption spectrometry)	ft ³ (cubic feet)	MW (megawatt(s))
acfm (actual cubic feet per minute)	ft/sec (feet per second)	NCASI (National Council for Air and Stream Improvement)
ACI (activated carbon injection)	FTIR (Fourier Transform Infrared Spectroscopy)	ND (non-detect)
ADL (above detection limit)	FTRB (field train reagent blank)	NDIR (non-dispersive infrared)
AIG (ammonia injection grid)	g (gram(s))	NDO (natural draft opening)
APC (air pollution control)	GC (gas chromatography)	NESHAP (National Emission Standards for Hazardous Air Pollutants)
AQCS (air quality control system(s))	GFAAS (graphite furnace atomic absorption spectroscopy)	ng (nanogram(s))
ASME (American Society of Mechanical Engineers)	GFC (gas filter correlation)	Nm ³ (Normal cubic meter)
ASTM (American Society for Testing and Materials)	gr/dscf (grains per dry standard cubic feet)	% (percent)
BDL (below detection limit)	> (greater than)/ ≥ (greater than or equal to)	PEMS (predictive emissions monitoring systems)
Btu (British thermal units)	g/s (grams per second)	PFGC (pneumatic focusing gas chromatography)
CAM (compliance assurance monitoring)	H ₂ O (water)	pg (picogram(s))
CARB (California Air Resources Board)	HAP(s) (hazardous air pollutant(s))	PJFF (pulse jet fabric filter)
CCM (Controlled Condensation Method)	HI (heat input)	ppb (parts per billion)
CE (capture efficiency)	hr (hour(s))	PPE (personal protective equipment)
°C (degrees Celsius)	HR GC/MS (high-resolution gas chromatography and mass spectrometry)	ppm (parts per million)
CEMS (continuous emissions monitoring system(s))	HRVOC (highly reactive volatile organic compounds)	ppmdv (parts per million, dry volume)
CFB (circulating fluidized bed)	HSRG(s) (heat recovery steam generator(s))	ppmwv (parts per million, wet volume)
CFR (Code of Federal Regulations)	HVT (high velocity thermocouple)	PSD (particle size distribution)
cm (centimeter(s))	IC (ion chromatography)	psi (pound(s) per square inch)
COMS (continuous opacity monitoring system(s))	IC/PCR (ion chromatography with post column reactor)	PTE (permanent total enclosure)
CT (combustion turbine)	ICP/MS (inductively coupled argon plasma mass spectroscopy)	PTFE (polytetrafluoroethylene)
CTI (Cooling Technology Institute)	ID (induced draft)	QA/QC (quality assurance/quality control)
CTM (Conditional Test Method)	in. (inch(es))	QI (qualified individual)
CVAAS (cold vapor atomic absorption spectroscopy)	in. H ₂ O (inches water)	QSTI (qualified source testing individual)
CVAFS (cold vapor atomic fluorescence spectrometry)	in. Hg (inches mercury)	QSTO (qualified source testing observer)
DI H ₂ O (de-ionized water)	IPA (isopropyl alcohol)	RA (relative accuracy)
%dv (percent, dry volume)	ISE (ion-specific electrode)	RATA (relative accuracy test audit)
DLL (detection level limited)	kg (kilogram(s))	RB (reagent blank)
DE (destruction efficiency)	kg/hr (kilogram(s) per hour)	RE (removal or reduction efficiency)
DCI (dry carbon injection)	< (less than)/ ≤ (less than or equal to)	RM (reference method)
DGM (dry gas meter)	L (liter(s))	scf (standard cubic feet)
dscf (dry standard cubic feet)	lb (pound(s))	scfm (standard cubic feet per minute)
dscfm (dry standard cubic feet per minute)	lb/hr (pound per hour)	SCR (selective catalytic reduction)
dscm (dry standard cubic meter)	lb/MMBtu (pound per million British thermal units)	SDA (spray dryer absorber)
ESP (electrostatic precipitator)	lb/TBtu (pound per trillion British thermal units)	SNCR (selective non-catalytic reduction)
FAMS (flue gas adsorbent mercury speciation)	lb/lb-mole (pound per pound mole)	STD (standard)
°F (degrees Fahrenheit)	LR GC/MS (low-resolution gas chromatography and mass spectrometry)	STMS (sorbent trap monitoring system)
FB (field blank)	m (meter)	TBtu (trillion British thermal units)
FCC (fluidized catalytic cracking)	m ³ (cubic meter)	TEOM (Tapered Element Oscillating Microbalance)
FCCU (fluidized catalytic cracking unit)	MACT (maximum achievable control technology)	TEQ (toxic equivalency quotient)
FEGT (furnace exit gas temperatures)	MASS [®] (Multi-Point Automated Sampling System)	ton/hr (ton per hour)
FF (fabric filter)	MATS (Mercury and Air Toxics Standards)	ton/yr (ton per year)
FGD (flue gas desulfurization)	MDL (method detection limit)	TSS (third stage separator)
FIA (flame ionization analyzer)	μg (microgram(s))	USEPA or EPA (United States Environmental Protection Agency)
FID (flame ionization detector)	min. (minute(s))	UVA (ultraviolet absorption)
FPD (flame photometric detection)	mg (milligram(s))	WFGD (wet flue gas desulfurization)
FRB (field reagent blank)	ml (milliliter(s))	%wv (percent, wet volume)
FSTM (flue gas sorbent total mercury)	MMBtu (million British thermal units)	
ft (feet or foot)		
ft ² (square feet)		

1. PROJECT OVERVIEW

Test Program Summary

Marathon Petroleum Company LP (MPC) contracted CleanAir Engineering (CleanAir) to complete testing on the Coker Heater (EU70-COKERHTR-S1) at the Detroit Refinery.

This test program is a re-test of an invalid test conducted on August 15, 2018. The testing produced only two valid test runs. Of the three test runs conducted, the first run was invalidated due to contamination in the sample. Refer to CleanAir Report No. 13647-3 for further details.

This test program included the following objective:

- Perform filterable particulate matter (FPM), condensable particulate matter (CPM), and sulfuric acid mist (H₂SO₄) testing to demonstrate compliance with regard to particulate matter (PM) and total particulate matter less than 10 microns in diameter (PM₁₀) regulations outlined in the Michigan Department of Environmental Quality (MDEQ) Permit No. MI-ROP-A9831-2012c

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	Sampling Method (USEPA)	Average Emission	Permit Limit ¹
<u>Coker Heater Stack</u>			
FPM (lb/MMBtu)	5	0.0006	N/A
PM ₁₀ (lb/MMBtu)	5 / 202	0.0023	0.0076
H ₂ SO ₄ (lb/MMBtu)	ASTM Draft CCM	0.0006	N/A
PM (lb/MMBtu) ^{2,3}	5 / ASTM Draft CCM	0.00002	0.0019
NSFPM (lb/MMBtu) ⁴	5B	0.0004	N/A

¹ Permit limits obtained from MDEQ Renewable Operating Permit No. MI-ROP-A9831-2012c.

² Expressed as the average of the three (3) highest valid runs.

³ PM assumed equivalent to FPM less H₂SO₄. See page 2 for further description.

⁴ NSFPM measured for supplemental purposes.

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Test Program Details

Parameters

The test program included the following emissions measurements:

- filterable particulate matter (FPM)
- total particulate matter less than 10 microns in diameter (PM₁₀), assumed equivalent to the sum of the following constituents:
 - FPM
 - condensable particulate matter (CPM)
- sulfuric acid mist (H₂SO₄)
- PM assumed equivalent to FPM minus H₂SO₄
- nonsulfuric acid particulate matter (NSFPM)
- flue gas composition (e.g., O₂, CO₂, H₂O)
- flue gas temperature
- flue gas flow rate

Schedule

Testing was performed on December 4 and 5, 2018. The on-site schedule followed during the test program is outlined in Table 1-2.

**Table 1-2:
Test Schedule**

Run Number	Location	Method	Analyte	Date	Start Time	End Time
1	Coker Heater Stack	USEPA Method 5 / 202	FPM / CPM	12/04/18	13:18	16:46
2	Coker Heater Stack	USEPA Method 5 / 202	FPM / CPM	12/05/18	09:49	11:55
3	Coker Heater Stack	USEPA Method 5 / 202	FPM / CPM	12/05/18	13:08	15:18
4	Coker Heater Stack	USEPA Method 5 / 202	FPM / CPM	12/05/18	16:30	19:05
1	Coker Heater Stack	USEPA Method 5B	NSFPM	12/04/18	13:18	16:46
2	Coker Heater Stack	USEPA Method 5B	NSFPM	12/05/18	09:44	11:55
3	Coker Heater Stack	USEPA Method 5B	NSFPM	12/05/18	13:08	15:18
4	Coker Heater Stack	USEPA Method 5B	NSFPM	12/05/18	16:29	19:05
0	Coker Heater Stack	Draft ASTM CCM	Sulfuric Acid	12/04/18	09:07	10:07
1	Coker Heater Stack	Draft ASTM CCM	Sulfuric Acid	12/04/18	13:18	16:46
2	Coker Heater Stack	Draft ASTM CCM	Sulfuric Acid	12/05/18	09:44	11:55
3	Coker Heater Stack	Draft ASTM CCM	Sulfuric Acid	12/05/18	13:08	15:18
4	Coker Heater Stack	Draft ASTM CCM	Sulfuric Acid	12/05/18	16:30	19:05

Discussion

Project Synopsis

PM and PM₁₀ Testing

A total of four (4) 120-minute EPA Method 5/202 test runs were performed. PM and PM₁₀ emission results were calculated in units of pounds per million Btu (lb/MMBtu). All runs were deemed valid.

PM is assumed equivalent to the difference of FPM and H₂SO₄ emissions. H₂SO₄ emissions were determined concurrently with FPM emissions, converted to units of lb/MMBtu, and subtracted from total FPM emissions from each respective run. The final result was expressed as the average of the three (3) highest valid runs.

PM₁₀ is assumed equivalent to the sum of FPM 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 PM₁₀ since Method 5 collects all FPM present in the flue gas (regardless of particle size). The final result was expressed as the average of four (4) valid runs.

H₂SO₄ Testing – Draft ASTM Controlled Condensation Method

H₂SO₄ emissions were determined referencing the Draft ASTM Controlled Condensation Method (CCM). Four (4) 120-minute Draft ASTM CCM test runs were performed concurrently with all Method 5/202 runs. H₂SO₄ emission results were calculated in units of lb/MMBtu. The H₂SO₄ final results were expressed as the average of four (4) valid runs.

Diluent concentrations (%O₂, %CO₂) from concurrent Method 5/202 runs were utilized to convert H₂SO₄ concentrations to units of lb/MMBtu. There was no diluent concentration data collected during H₂SO₄ runs because, due to sufficiently low ambient temperature, there was insufficient sample flow to create pressure drop to collect a slip stream of the sample gas. This measure was approved on-site by Tom Gasoli of MDEQ.

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 H₂SO₄-collecting portion of the sample train). The conditioning run was recovered in the same manner as the official test runs.

NSFPM Testing – USEPA Method 5B

A total of four (4) 120-minute EPA Method 5B test runs were performed concurrently with Method 5/202 and Draft ASTM CCM test runs. NSFPM emission results were calculated in units of pounds per million Btu (lb/MMBtu). The NSFPM final results were expressed as the average of four (4) valid runs. NSFPM emissions were determined for supplemental purposes.

Run 1 moisture content was comparatively low. There was no overt explanation for this occurrence. NSFPM results were consistent with the other runs so the results from Run 1 were included in the final results.

Fuel Analysis

Emission results in units of dry volume-based concentration (lb/dscf, ppm_{dv}) were converted into units of pounds per million Btu (lb/MMBtu) by calculating an oxygen-based fuel factor (F_d) for refinery gas per EPA Method 19 specifications. The heat content and F_d factor were 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. MPC was responsible for logging any relevant process-related data and providing it to CleanAir for inclusion in the test report.

End of Section

2. RESULTS

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

**Table 2-1:
Coker Heater – FPM & PM₁₀ Emissions**

Run No.		1	2	3	4	Average
Date (2018)		Dec 4	Dec 5	Dec 5	Dec 5	
Start Time (approx.)		13:18	09:49	13:08	16:30	
Stop Time (approx.)		16:46	11:55	15:18	19:05	
Process Conditions						
P ₁	Charge rate (BPD)	42,570	42,600	42,570	42,570	42,600
P ₂	Heater duty (MMBtu/hr)	250	247	248	250	249
F _d	Oxygen-based F-factor (dscf/MMBtu)	8,350	8,356	8,356	8,356	
Gas Conditions						
O ₂	Oxygen (dry volume %)	7.6	7.9	7.7	7.9	7.8
CO ₂	Carbon dioxide (dry volume %)	7.8	7.7	7.5	7.6	7.7
T _s	Sample temperature (°F)	393	395	395	394	394
Sampling Data						
V _{mstd}	Volume metered, standard (dscf)	86.79	78.56	81.53	79.60	81.62
%I	Isokinetic sampling (%)	101.1	101.4	102.8	99.9	101.3
Laboratory Data						
m _n	Total FPM (g)	0.00192	0.00133	0.00167	0.00138	
m _{CPM}	Total CPM (g)	0.00552	0.00363	0.00509	0.00510	
m _{Part}	Total particulate matter (as PM ₁₀) (g)	0.00744	0.00496	0.00676	0.00648	
FPM Results						
C _{sd}	Particulate Concentration (lb/dscf)	4.88E-08	3.73E-08	4.52E-08	3.82E-08	4.24E-08
E _{lb/hr}	Particulate Rate (lb/hr)	0.170	0.118	0.146	0.124	0.139
E _{Fd}	Particulate Rate - F _d -based (lb/MMBtu)	0.000640	0.000502	0.000598	0.000514	0.000563
CPM Results						
C _{sd}	Particulate Concentration (lb/dscf)	1.40E-07	1.02E-07	1.38E-07	1.41E-07	1.30E-07
E _{lb/hr}	Particulate Rate (lb/hr)	0.490	0.321	0.444	0.458	0.428
E _{Fd}	Particulate Rate - F _d -based (lb/MMBtu)	0.00184	0.00137	0.00182	0.00190	0.00173
Total Particulate Matter (as PM₁₀) Results						
C _{sd}	Particulate Concentration (lb/dscf)	1.89E-07	1.39E-07	1.83E-07	1.80E-07	1.73E-07
E _{lb/hr}	Particulate Rate (lb/hr)	0.660	0.439	0.590	0.582	0.568
E _{Fd}	Particulate Rate - F _d -based (lb/MMBtu)	0.00248	0.00187	0.00242	0.00241	0.00229

**Table 2-2:
Coker Heater – H₂SO₄ Emissions**

Run No.		1	2	3	4	Average
Date (2018)		Dec 4	Dec 5	Dec 5	Dec 5	
Start Time (approx.)		13:18	09:44	13:08	16:30	
Stop Time (approx.)		16:46	11:55	15:18	19:05	
Process Conditions						
P ₁	Charge rate (BPD)	42,570	42,570	42,570	42,570	42,570
P ₂	Heater duty (MMBtu/hr)	250	247	248	250	249
F _d	Oxygen-based F-factor (ds cf/MMBtu)	8,350	8,356	8,356	8,356	
Gas Conditions¹						
O ₂	Oxygen (dry volume %)	7.6	7.9	7.7	7.4	7.7
CO ₂	Carbon dioxide (dry volume %)	7.8	7.7	7.5	8.0	7.8
T _s	Sample temperature (°F)	394	397	396	395	395
B _w	Actual water vapor in gas (% by volume)	12.9	13.4	13.3	13.1	13.2
Sampling Data						
V _{rsld}	Volume metered, standard (ds cf)	54.76	54.67	54.36	53.65	54.36
Laboratory Data (Ion Chromatography)						
m _n	Total H ₂ SO ₄ collected (mg)	1.1421	0.8781	1.1513	1.2457	
Sulfuric Acid Vapor (H₂SO₄) Results						
C _{sd}	H ₂ SO ₄ Concentration (lb/ds cf)	4.60E-08	3.54E-08	4.67E-08	5.12E-08	4.48E-08
C _{sd}	H ₂ SO ₄ Concentration (ppmdv)	0.181	0.139	0.184	0.201	0.176
E _{Fd}	H ₂ SO ₄ Rate - F _d -based (lb/MMBtu)	0.000603	0.000476	0.000618	0.000662	0.000590

¹ Diluent concentrations from concurrent EPA Method 5/202 runs.

**Table 2-3:
Coker Heater – PM Emissions**

Run No.		1	2	3	4	Average
Date (2018)		Dec 4	Dec 5	Dec 5	Dec 5	
Start Time (approx.)		13:18	09:49	13:08	16:30	
Stop Time (approx.)		16:46	11:55	15:18	19:05	
Process Conditions						
P ₁	Charge rate (BPD)	42,570	42,600	42,570	42,570	42,600
P ₂	Heater duty (MMBtu/hr)	250	247	248	250	249
F _d	Oxygen-based F-factor (dscf/MMBtu)	8,350	8,356	8,356	8,356	
Gas Conditions						
O ₂	Oxygen (dry volume %)	7.6	7.9	7.7	7.9	7.8
CO ₂	Carbon dioxide (dry volume %)	7.8	7.7	7.5	7.6	7.7
T _s	Sample temperature (°F)	393	395	395	394	394
FPM Results						
E _{Fd}	Particulate Rate - F _d -based (lb/MMBtu)	0.00064	0.00050	0.00060	0.00051	0.00056
Sulfuric Acid Vapor (H₂SO₄) Results						
E _{Fd}	H ₂ SO ₄ Rate - F _d -based (lb/MMBtu)	0.00060	0.00048	0.00062	0.00066	0.00059
Particulate Matter (as PM₁₀) Results¹						
E _{Fd}	Particulate Rate - F _d -based (lb/MMBtu) ²	3.66E-05	2.57E-05	-2.03E-05	-1.49E-04	2.08E-05

¹ Final PM results average of three (3) highest valid runs.² Negative values considered zero in final average.

**Table 2-4:
Coker Heater – NSFPM Emissions**

Run No.		1	2	3	4	Average
Date (2018)		Dec 4	Dec 5	Dec 5	Dec 5	
Start Time (approx.)		13:18	09:44	13:08	16:29	
Stop Time (approx.)		16:46	11:55	15:18	19:05	
Process Conditions						
P ₁	Charge rate (BPD)	42,570	42,570	42,570	42,570	42,570
P ₂	Heater duty (MMBtu/hr)	250	247	248	250	248
F _d	Oxygen-based F-factor (dscf/MMBtu)	8,350	8,356	8,356	8,356	
Gas Conditions						
O ₂	Oxygen (dry volume %)	8.0	7.4	7.9	7.8	7.8
CO ₂	Carbon dioxide (dry volume %)	7.2	8.0	7.6	7.7	7.6
T _s	Sample temperature (°F)	393	396	397	397	396
B _w	Actual water vapor in gas (% by volume)	7.7	13.5	13.7	13.7	12.1
Sampling Data						
V _{mstd}	Volume metered, standard (dscf)	74.83	76.58	76.57	77.75	76.43
%I	Isokinetic sampling (%)	93.2	100.5	101.0	101.3	99.0
Laboratory Data						
m _{FPM}	Total FPM (g)	0.00120	0.00120	0.00089	0.00109	
NSFPM Results						
C _{sd}	Particulate Concentration (lb/dscf)	3.54E-08	3.46E-08	2.56E-08	3.09E-08	3.16E-08
E _{lb/hr}	Particulate Rate (lb/hr)	0.115	0.107	0.079	0.097	0.100
E _{Fd}	Particulate Rate - F _d -based (lb/MMBtu)	0.000478	0.000447	0.000344	0.000412	0.000420

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 Coker unit (EU70-COKER) converts Vacuum Resid (Crude Vacuum Tower Bottoms), a product normally sold as asphalt or blended into residual fuel oil, into lighter, more valuable products. The Vacuum Resid feedstock is heated before it enters the main fractionator, where lighter material vaporizes. The fractionator bottoms are routed through a fired heater and then into a coke drum. This emission unit consists of process vessels (fractionators), coke drums, heater (EU70-COKERHTR-S1), cooling tower, compressors, pumps, piping, drains and various components (pumps and compressor seals, process valves, pressure relief valves, flanges, connectors, etc.). This emission group includes the Coke Handling System, which collects, sizes and transports the petroleum coke created during the coking process. The system consists of a coke pit, storage pad, enclosed crusher, enclosed conveyors and surge bins.

The Coker Heater is fired by refinery fuel gas. Emissions are vented to the atmosphere via the Coker Heater Stack (SV70-H1) where testing was performed.

Test Location

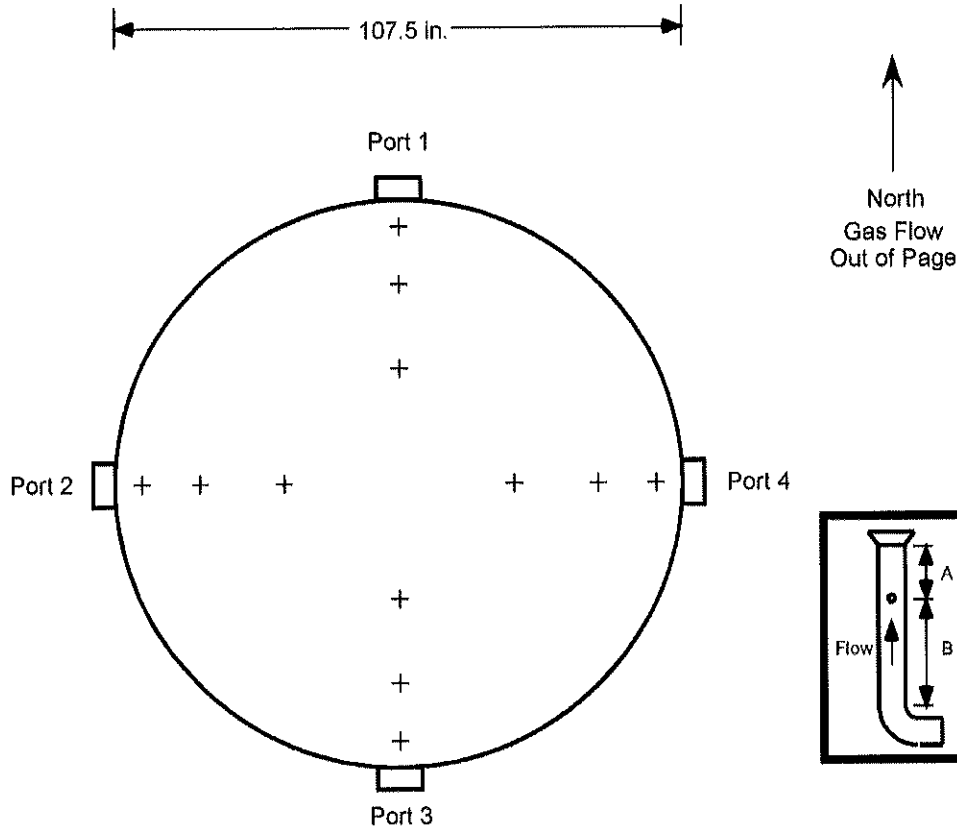
The sample point locations were determined by EPA Method 1. Table 3-1 presents the sampling information for the test location described in this report. The figure shown on page 10 represents the layout of the test location.

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

Source		Method (USEPA)	Run No.	Ports	Points per Port	Minutes per Point	Total Minutes	Figure
Constituent								
<u>Coker Heater Stack</u>								
FPM / CPM		5 / 202	1-4	4	3	10	120	3-1
H ₂ SO ₄		Draft ASTM CCM	1-4	1	1	120	120	N/A ¹
NSFPM		5B	1-4	4	3	10	120	3-1

¹ Draft ASTM CCM sampling occurred at a single point near the center of the duct.

**Figure 3-1:
 PM, PM₁₀ & NSFPM Sample Point Layout**



Sampling Point	% of Stack Diameter	Port to Point Distance (inches)
1	29.6	31.8
2	14.6	15.5
3	4.4	4.7

Duct diameters upstream from flow disturbance (A): 5.2 Limit: 0.5
 Duct diameters downstream from flow disturbance (B): 8.3 Limit: 2.0

End of Section

4. *METHODOLOGY*

Procedures and Regulations

The test program sampling measurements followed procedures and regulations outlined by the United States Environmental Protection Agency (USEPA) and the 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. Any modifications to standard test methods are explicitly indicated in this appendix. In accordance with ASTM D7036 requirements, CleanAir included a description of any such modifications along with the full context of the objectives and requirements of the test program in the test protocol submitted prior to the measurement portion of this project. Modifications to standard methods are not covered by the ISO 17025 and TNI portions of CleanAir's A2LA accreditation.

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 4 "Determination of Moisture Content in Stack Gases"
- Method 5 "Determination of Particulate Matter Emissions from Stationary Sources"
- Method 5B "Determination of Nonsulfuric Acid Particulate Matter Emissions from Stationary Sources"

Title 40 CFR Part 51, Appendix M

- Method 202 "Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources"

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

PM & PM₁₀ Testing – USEPA Method 5/202

PM and PM₁₀ emissions were determined using EPA Method 5/202.

The front-half 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 (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 (SO₂) and nitrogen oxide (NO_x) interferences observed with earlier versions of the method, in which flue gas was bubbled through cold water, and SO₂ and NO_x were absorbed and partially oxidized before they could be purged out with nitrogen (N₂).

Flue gas exiting the front-half heated filter passes through a coiled condenser and dry impinger system jacketed by water continually circulated at ambient temperature. Moisture is removed from the flue gas without bubbling through the condensed water. Flue gas then passes through a tetrafluoromethane (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 passes through two (2) additional impingers surrounded by ice in a “cold” section of the impinger bucket. The moisture collected in these impingers will not be analyzed for CPM and is only collected to determine the flue gas moisture and to thoroughly dry the gas. The sample gas then flows into a calibrated dry gas meter where the collected sample gas volume is 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 N₂ 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 collected to quantify background contamination. All samples and blanks were returned to CleanAir Analytical Services in Palatine, Illinois, for gravimetric analysis. Method 202 samples were maintained at a temperature < 85°F during transport to the laboratory.

All samples and blanks were returned to CleanAir Analytical Services in Palatine, Illinois, for gravimetric analysis. Upon receipt, the filters desiccated for 24 hours at ambient temperature. The front-half rinses were evaporated at ambient temperature and pressure. The masses from each fraction were then summed for a total FPM mass.

H₂SO₄ Testing – Draft ASTM CCM

H₂SO₄ emissions were determined referencing the 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 $650^{\circ}\text{F} \pm 25^{\circ}\text{F}$ and a quartz fiber filter (to remove particulate matter) maintained at the same temperature as the probe. The sample was 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) is located at the condenser outlet for the collection of residual SAM not collected by the condenser. The condenser temperature is regulated by a water jacket and the SAM filter is regulated by a closed oven. Both the water jacket and SAM filter oven were maintained at $140^{\circ}\text{F} \pm 9^{\circ}\text{F}$ plus 2°F for each 1% moisture above 16% flue gas moisture (above the water dew point, which eliminates the oxidation of dissolved sulfur dioxide (SO_2) into the H_2SO_4 -collecting fraction of the sample train).

After exiting the SAM filter, the sample gas then 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 is 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_2SO_4 -collecting portion of the sample train (condenser and SAM filter) was recovered into a single fraction using DI H_2O as the recovery/extraction solvent; any H_2SO_4 disassociates into sulfate ion (SO_4^{2-}) and is stabilized in the H_2O matrix until analysis.

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

NSFPM Testing – USEPA Method 5B

NSFPM emissions were determined using EPA Method 5B.

The front-half of the sampling train consisted of a glass nozzle, glass liner and filter holder heated to $320^{\circ}\text{F} \pm 25^{\circ}\text{F}$ and a quartz fiber filter. Flue gas samples were extracted isokinetically per Method 5B requirements. The front-half portion of the sample train (nozzle, probe and heated filter) was recovered per Method 5B requirements, using acetone as the recovery solvent.

All samples and blanks were returned to CleanAir Analytical Services in Palatine, Illinois, for gravimetric analysis.

End of Section