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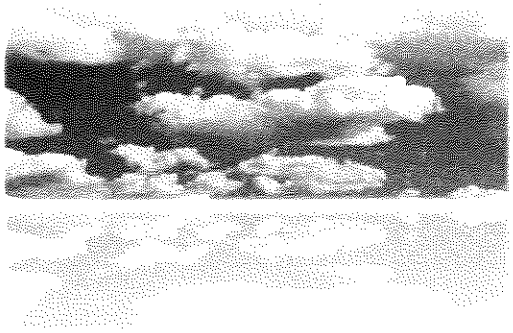

REPORT ON COMPLIANCE TESTING

Detroit Refinery

Crude/Vacuum Heater Stack

Marathon Petroleum Company LP

1300 South Fort Street

Detroit, MI 48217

Client Reference No. 4101379616

CleanAir Project No. 13714-3

A2LA ISO 17025 Certificate No. 4342.01

A2LA / STAC Certificate No. 4342.02

Revision 0, Final Report

February 13, 2019

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:

February 13, 2019

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Date

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:

February 13, 2019

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REPORT REVISION HISTORY

Version	Revision	Date	Pages	Comments
Draft	D0a	02/12/19	All	Draft version of original document.
Final	0	02/13/19	All	Final version of original document.

PROJECT PERSONNEL

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ACRONYMS & ABBREVIATIONS

AAS (atomic absorption spectrometry)
acfm (actual cubic feet per minute)
ACI (activated carbon injection)
ADL (above detection limit)
AIG (ammonia injection grid)
APC (air pollution control)
AQCS (air quality control system(s))
ASME (American Society of Mechanical Engineers)
ASTM (American Society for Testing and Materials)
BDL (below detection limit)
Btu (British thermal units)
CAM (compliance assurance monitoring)
CARB (California Air Resources Board)
CCM (Controlled Condensation Method)
CE (capture efficiency)
°C (degrees Celsius)
CEMS (continuous emissions monitoring system(s))
CFB (circulating fluidized bed)
CFR (Code of Federal Regulations)
cm (centimeter(s))
COMS (continuous opacity monitoring system(s))
CT (combustion turbine)
CTI (Cooling Technology Institute)
CTM (Conditional Test Method)
CVAAS (cold vapor atomic absorption spectroscopy)
CVAFS (cold vapor atomic fluorescence spectrometry)
DI H_2O (de-ionized water)
%dv (percent, dry volume)
DLL (detection level limited)
DE (destruction efficiency)
DCI (dry carbon injection)
DGM (dry gas meter)
dscf (dry standard cubic feet)
dscfm (dry standard cubic feet per minute)
dscm (dry standard cubic meter)
ESP (electrostatic precipitator)
FAMS (flue gas adsorbent mercury speciation)
°F (degrees Fahrenheit)
FB (field blank)
FCC (fluidized catalytic cracking)
FCCU (fluidized catalytic cracking unit)
FEGT (furnace exit gas temperatures)
FF (fabric filter)
FGD (flue gas desulfurization)
FIA (flame ionization analyzer)
FID (flame ionization detector)
FPD (flame photometric detection)
FRB (field reagent blank)
FSTM (flue gas sorbent total mercury)
ft (feet or foot)
ft^2 (square feet)
ft^3 (cubic feet)
ft/sec (feet per second)
FTIR (Fourier Transform Infrared Spectroscopy)
FTRB (field train reagent blank)
g (gram(s))
GC (gas chromatography)
GFAAS (graphite furnace atomic absorption spectroscopy)
GFC (gas filter correlation)
gr/dscf (grains per dry standard cubic feet)
> (greater than)/ ≥ (greater than or equal to)
g/s (grams per second)
H_2O (water)
HAP(s) (hazardous air pollutant(s))
HI (heat input)
hr (hour(s))
HR GC/MS (high-resolution gas chromatography and mass spectrometry)
HRVOC (highly reactive volatile organic compounds)
HSRG(s) (heat recovery steam generator(s))
HVT (high velocity thermocouple)
IC (ion chromatography)
IC/PCR (ion chromatography with post column reactor)
ICP/MS (inductively coupled argon plasma mass spectroscopy)
ID (induced draft)
in. (inch(es))
in. H_2O (inches water)
in. Hg (inches mercury)
IPA (isopropyl alcohol)
ISE (ion-specific electrode)
kg (kilogram(s))
kg/hr (kilogram(s) per hour)
< (less than)/ ≤ (less than or equal to)
L (liter(s))
lb (pound(s))
lb/hr (pound per hour)
lb/MMBtu (pound per million British thermal units)
lb/TBtu (pound per trillion British thermal units)
lb/lb-mole (pound per pound mole)
LR GC/MS (low-resolution gas chromatography and mass spectrometry)
m (meter)
m^3 (cubic meter)
MACT (maximum achievable control technology)
MASS® (Multi-Point Automated Sampling System)
MATS (Mercury and Air Toxics Standards)
MDL (method detection limit)
µg (microgram(s))
min. (minute(s))
mg (milligram(s))
ml (milliliter(s))
MMBtu (million British thermal units)
MW (megawatt(s))
NCASI (National Council for Air and Stream Improvement)
ND (non-detect)
NDIR (non-dispersive infrared)
NDO (natural draft opening)
NESHAP (National Emission Standards for Hazardous Air Pollutants)
ng (nanogram(s))
Nm^3 (Normal cubic meter)
% (percent)
PEMS (predictive emissions monitoring systems)
PFGC (pneumatic focusing gas chromatography)
pg (picogram(s))
PJFF (pulse jet fabric filter)
ppb (parts per billion)
PPE (personal protective equipment)
ppm (parts per million)
ppmdv (parts per million, dry volume)
ppmwv (parts per million, wet volume)
PSD (particle size distribution)
psi (pound(s) per square inch)
PTE (permanent total enclosure)
PTFE (polytetrafluoroethylene)
QA/QC (quality assurance/quality control)
QI (qualified individual)
QSTI (qualified source testing individual)
QSTO (qualified source testing observer)
RA (relative accuracy)
RATA (relative accuracy test audit)
RB (reagent blank)
RE (removal or reduction efficiency)
RM (reference method)
scf (standard cubic feet)
scfm (standard cubic feet per minute)
SCR (selective catalytic reduction)
SDA (spray dryer absorber)
SNCR (selective non-catalytic reduction)
STD (standard)
STMS (sorbent trap monitoring system)
TBtu (trillion British thermal units)
TEOM (Tapered Element Oscillating Microbalance)
TEQ (toxic equivalency quotient)
ton/hr (ton per hour)
ton/yr (ton per year)
TSS (third stage separator)
USEPA or EPA (United States Environmental Protection Agency)
UVA (ultraviolet absorption)
WFGD (wet flue gas desulfurization)
%wv (percent, wet volume)

1. PROJECT OVERVIEW

Test Program Summary

Marathon Petroleum Company LP (MPC) contracted CleanAir Engineering (CleanAir) to complete testing on the Crude/Vacuum Heater (EU05-CRUDEHTR-S1 & EU04-VACHTR-S-1) at the Detroit Refinery. The test program included the following objective:

- Perform particulate matter (PM) and sulfuric acid mist (H_2SO_4) quarterly testing to demonstrate compliance with the Michigan Department of Environmental Quality (DEQ) 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.

Table 1-1:
Summary of Results

Source Constituent	Sampling Method	Average Emission	Permit Limit[1]
Crude/Vacuum Heater			
FPM (lb/MMBtu)	EPA M5	0.0004	NA
H_2SO_4 (lb/MMBtu	Draft ASTM CCM	0.0003	NA
PM (lb/MMBtu)[2,3]	EPA M5 / Draft ASTM CCM	0.0001	0.0019
NSFPM (lb/MMBtu)[4]	EPA M5B	0.0003	0.0019

[1] Permit limits obtained from MDEQ Renew able Operating Permit No. MI-ROP-A9831-2012c.
[2] PM assumed equivalent to FPM minus H_2SO_4. The letter from the MDEQ referenced in Appendix K further outlines the correction of particulate emissions for H_2SO_4 bias.
[3] Expressed as the average of the three (3) highest valid runs.
[4] NSFPM measured for supplemental purposes.

Test Program Details

Parameters

The test program included the following measurements:

- filterable particulate matter (FPM)
- particulate matter (PM) – defined as FPM minus sulfuric acid (H_2SO_4)
- nonsulfuric acid filterable particulate matter (NSFPM)
- H_2SO_4 – conducted concurrently with FPM measurements
- flue gas composition (e.g., O_2, CO_2, H_2O)
- flue gas temperature
- flue gas flow rate

Schedule

Testing was performed on January 9 and 10, 2019. 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	Crude/Vacuum Heater	USEPA Method 5	FPM	01/09/19	10:25	13:13
2	Crude/Vacuum Heater	USEPA Method 5	FPM	01/09/19	14:42	16:50
3	Crude/Vacuum Heater	USEPA Method 5	FPM	01/10/19	08:36	10:47
4	Crude/Vacuum Heater	USEPA Method 5	FPM	01/10/19	11:50	13:58
1	Crude/Vacuum Heater	Draft ASTM CCM	H_2SO_4	01/09/19	10:25	13:13
2	Crude/Vacuum Heater	Draft ASTM CCM	H_2SO_4	01/09/19	14:42	16:50
3	Crude/Vacuum Heater	Draft ASTM CCM	H_2SO_4	01/10/19	08:36	10:47
4	Crude/Vacuum Heater	Draft ASTM CCM	H_2SO_4	01/10/19	11:50	13:58
1	Crude/Vacuum Heater	USEPA Method 5B	NSFPM	01/09/19	10:25	13:13
2	Crude/Vacuum Heater	USEPA Method 5B	NSFPM	01/09/19	14:42	16:50
3	Crude/Vacuum Heater	USEPA Method 5B	NSFPM	01/10/19	08:36	10:47
4	Crude/Vacuum Heater	USEPA Method 5B	NSFPM	01/10/19	11:50	13:58

Discussion

Project Synopsis

PM Testing

A total of four (4) 120-minute EPA Method 5 test runs were performed. PM 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 H_2SO_4 emissions. H_2SO_4 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.

H_2SO_4 Testing – Draft ASTM Controlled Condensation Method

H_2SO_4 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 runs. H_2SO_4 emission results were calculated in units of lb/MMBtu. The H_2SO_4 final results were expressed as the average of four (4) valid runs.

Run 1 exhibited an elevated oxygen concentration; however, the moisture content and H_2SO_4 concentration were consistent with subsequent runs. There is no overt explanation for this occurrence.

On January 8, prior to performing official test runs, 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_2SO_4-collecting portion of the sample train). The conditioning run was recovered in the same manner as the official test runs. Samples from Run 0 are archived.

NSFPM Testing – USEPA Method 5B

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

Fuel Analysis

Emission results in units of dry volume-based concentration (lb/dscf, ppmdv) were converted into units of lb/MMBtu by calculating an oxygen-based fuel factor (Fd) 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 and RATA 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:
Crude/Vacuum Heater – FPM Emissions

Run No.		1	2	3	4	Average
Date (2019)		Jan 9	Jan 9	Jan 10	Jan 10	
Start Time (approx.)		10:25	14:42	08:36	11:50	
Stop Time (approx.)		13:13	16:50	10:47	13:58	
Process Conditions						
P_1	Charge Rate (BPD)	129,336	130,048	129,868	130,176	**129,857**
F_d	Oxygen-based F-factor (dscf/MMBtu)	8,348	8,348	8,282	8,282	**8,315**
H_i	Actual heat input (MMBtu/hr)	276	275	282	285	**280**
Gas Conditions						
O_2	Oxygen (dry volume %)	7.6	7.5	7.9	7.9	**7.7**
CO_2	Carbon dioxide (dry volume %)	7.9	8.0	7.6	7.5	**7.8**
T_s	Sample temperature (°F)	287	289	289	290	**289**
B_w	Actual water vapor in gas (% by volume)	13.4	12.6	12.5	12.1	**12.7**
Gas Flow Rate						
Q_a	Volumetric flow rate, actual (acfm)	111,000	121,000	123,000	120,000	**119,000**
Q_s	Volumetric flow rate, standard (scfm)	76,300	82,600	85,900	83,200	**82,000**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	66,100	72,200	75,100	73,100	**71,600**
Sampling Data						
V_{mstd}	Volume metered, standard (dscf)	79.43	89.88	94.73	91.62	**88.91**
%I	Isokinetic sampling (%)	97.8	101.4	102.7	102.0	**101.0**
Laboratory Data						
m_{filter}	Matter collected on filter(s) (g)	0.00053	0.00083	0.00058	0.00056	
m_s	Matter collected in solvent rinse(s) (g)	0.00069	0.00068	0.00092	0.00051	
m_n	Total FPM (g)	0.00122	0.00151	0.00150	0.00107	
FPM Results						
C_{sd}	Particulate Concentration (lb/dscf)	3.39E-08	3.70E-08	3.49E-08	2.58E-08	**3.29E-08**
$E_{lb/hr}$	Particulate Rate (lb/hr)	0.134	0.160	0.157	0.113	**0.141**
E_{Fd}	Particulate Rate - F_d-based (lb/MMBtu)	0.000444	0.000482	0.000465	0.000343	**0.000434**

Table 2-2:
Crude/Vacuum Heater – H_2SO_4 Emissions

Run No.		1	2	3	4	Average
Date (2019)		Jan 9	Jan 9	Jan 10	Jan 10	
Start Time (approx.)		10:25	14:42	08:36	11:50	
Stop Time (approx.)		13:13	16:50	10:47	13:58	
Process Conditions						
P_1	Charge rate (BPD)	129,336	130,048	129,868	130,176	**130,176**
F_d	Oxygen-based F-factor (dscf/MMBtu)	8,348	8,348	8,282	8,282	**8,282**
H_i	Actual heat input (MMBtu/hr)	276	275	282	285	**285**
Gas Conditions						
O_2	Oxygen (dry volume %)	10.2	7.7	8.1	8.1	**8.5**
CO_2	Carbon dioxide (dry volume %)	6.6	7.9	7.6	7.5	**7.4**
T_s	Sample temperature (°F)	287	286	287	287	**287**
B_w	Actual water vapor in gas (% by volume)	12.9	13.4	13.0	12.8	**13.0**
Gas Flow Rate						
Q_a	Volumetric flow rate, actual (acfm)	111,000	121,000	123,000	120,000	**119,000**
Q_s	Volumetric flow rate, standard (scfm)	76,300	82,600	85,900	83,200	**82,000**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	66,100	72,200	75,100	73,100	**71,600**
Sampling Data						
V_{mstd}	Volume metered, standard (dscf)	55.01	55.32	56.51	56.24	**55.77**
Laboratory Data (Ion Chromatography)						
m_n	Total H_2SO_4 collected (mg)	0.5673	0.6509	0.5100	0.5212	
Sulfuric Acid Vapor (H_2SO_4) Results						
C_{sd}	H_2SO_4 Concentration (lb/dscf)	2.274E-08	2.595E-08	1.990E-08	2.044E-08	**2.226E-08**
C_{sd}	H_2SO_4 Concentration (ppmdv)	0.0894	0.102	0.0782	0.0803	**0.0875**
E_{Fd}	H_2SO_4 Rate - Fd-based (lb/MMBtu)	0.000371	0.000343	0.000269	0.000276	**0.000315**

Table 2-3:
Crude/Vacuum Heater – PM Emissions

Run No.		1	2	3	4	Average
Date (2019)		Jan 9	Jan 9	Jan 10	Jan 10	
Start Time (approx.)		10:25	14:42	08:36	11:50	
Stop Time (approx.)		13:13	16:50	10:47	13:58	
Process Conditions						
P_1	Charge Rate (BPD)	129,336	130,048	129,868	130,176	**129,857**
F_d	Oxygen-based F-factor (dscf/MMBtu)	8,348	8,348	8,282	8,282	**8,315**
H_i	Actual heat input (MMBtu/hr)	276	275	282	285	**280**
Gas Conditions						
O_2	Oxygen (dry volume %)	7.6	7.5	7.9	7.9	**7.7**
CO_2	Carbon dioxide (dry volume %)	7.9	8.0	7.6	7.5	**7.8**
T_s	Sample temperature (°F)	287	289	289	290	**289**
B_w	Actual water vapor in gas (% by volume)	13.4	12.6	12.5	12.1	**12.7**
FPM Results						
E_{Fd}	Particulate Rate - F_d-based (lb/MMBtu)	0.000444	0.000482	0.000465	0.000343	**0.000434**
Sulfuric Acid Vapor (H_2SO_4) Results						
E_{Fd}	H_2SO_4 Rate - F_d-based (lb/MMBtu)	0.000326	0.000409	0.000319	0.000314	**0.000342**
Particulate Matter (as PM_{10}) Results[1]						
E_{Fd}	Particulate Rate - F_d-based (lb/MMBtu)	0.000118	0.000074	0.000146	0.000029	**0.000113**

[1] Final PM results average of three (3) highest valid runs.

Table 2-4:
Crude/Vacuum Heater – NSFPM Emissions

Run No.		1	2	3	4	Average
Date (2019)		Jan 9	Jan 9	Jan 10	Jan 10	
Start Time (approx.)		10:25	14:42	08:36	11:50	
Stop Time (approx.)		13:13	16:50	10:47	13:58	
Process Conditions						
P_1	Charge Rate (BPD)	129,336	130,048	129,868	130,176	**129,857**
F_d	Oxygen-based F-factor (dscf/MMBtu)	8,348	8,348	8,282	8,282	**8,315**
H_i	Actual heat input (MMBtu/hr)	276	275	282	285	**280**
Gas Conditions						
O_2	Oxygen (dry volume %)	7.6	7.6	7.9	8.8	**8.0**
CO_2	Carbon dioxide (dry volume %)	7.9	8.0	7.6	7.1	**7.7**
T_s	Sample temperature (°F)	288	287	288	284	**287**
B_w	Actual water vapor in gas (% by volume)	12.1	12.7	12.7	13.2	**12.6**
Gas Flow Rate						
Q_a	Volumetric flow rate, actual (acfm)	115,000	111,000	114,000	113,000	**113,000**
Q_s	Volumetric flow rate, standard (scfm)	78,800	76,100	79,100	79,200	**78,300**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	69,300	66,400	69,100	68,700	**68,400**
Sampling Data						
V_{mstd}	Volume metered, standard (dscf)	85.27	79.86	84.66	84.42	**83.55**
%I	Isokinetic sampling (%)	100.2	97.9	99.8	100.0	**99.5**
Laboratory Data						
m_{filter}	Matter collected on filter(s) (g)	0.00029	0.00029	0.00055	0.00034	
m_s	Matter collected in solvent rinse(s) (g)	0.00040	0.00056	0.00032	0.00032	
m_n	Total NSFPM (g)	0.00069	0.00085	0.00087	0.00066	
NSFPM Results						
C_{sd}	Particulate Concentration (lb/dscf)	1.78E-08	2.35E-08	2.27E-08	1.72E-08	**2.03E-08**
$E_{lb/hr}$	Particulate Rate (lb/hr)	0.0742	0.0936	0.0939	0.0711	**0.0832**
E_{Fd}	Particulate Rate - F_d-based (lb/MMBtu)	0.000234	0.000308	0.000302	0.000247	**0.000273**

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 Crude Unit (EU05-CRUDE) separates crude oil into various fractions through the use of distillation processes. These fractions are sent to other units in the refinery for further processing. The Crude Unit consists of process vessels (including heat exchangers and fractionation columns), the Alcorn Heater (EU05-CRUDEHTR-S1), tanks, containers, compressors, pumps, piping drains, and various components (pump and compressor seals, process valves, pressure relief valves, flanges, connectors, etc.).

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.).

Both the Crude Heater (EU05-CRUDEHTR-S1) and the Vacuum Heater (EU04-VACHTR-S1) are fired by refinery fuel gas. Emissions are vented to the atmosphere via a common stack known as the Crude/Vacuum Heater Stack (SV04-H1-05-H1), where testing was performed.

Test Location

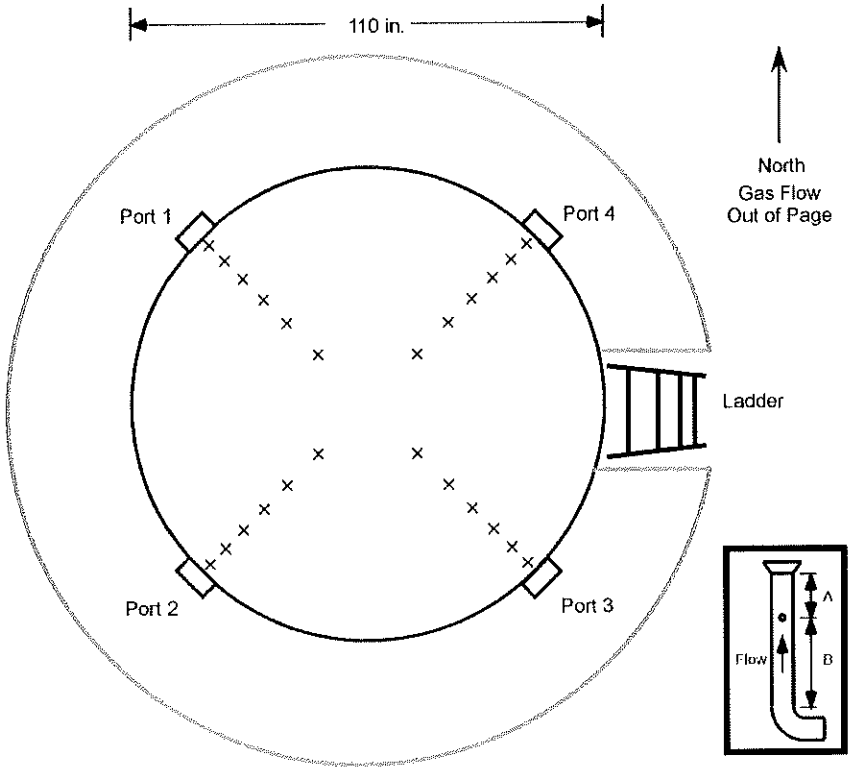
The sample point locations were determined by EPA Method 1. Table 3-1 presents the sampling information for the test location described in this report. The figure shown on page 9 represents the layout of the test location.

Table 3-1:
Sampling Information

Source Constituent	Method (USEPA)	Run No.	Ports	Points per Port	Minutes per Point	Total Minutes	Figure
Crude/Vac Heater Stack							
FPM	5	1-4	4	6	5	120	3-1
H_2SO_4	Draft ASTM CCM	1-4	1	1	120	120	N/A[1]
NSFPM	5B	1-4	4	6	5	120	3-1

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

Figure 3-1:
Particulate Sample Point Layout



Sampling Point	% of Stack Diameter	Port to Point Distance (inches)
1	35.6	39.2
2	25.0	27.5
3	17.7	19.5
4	11.8	13.0
5	6.7	7.4
6	2.1	2.3

Duct diameters upstream from flow disturbance (A): 5.3 Limit: 0.5
Duct diameters downstream from flow disturbance (B): 2.4 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 3A	"Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)"
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"
Method 19	"Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide and Nitrogen Oxide Emission Rates"

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

Filterable Particulate Matter – USEPA Methods 5

FPM emissions were determined using EPA Method 5.

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.

After exiting the front-half filter, the flue gas passed through a series of knock-out jars. Condensate in the knock-out jars were 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.

All samples and blanks were returned to CleanAir Analytical Services in Palatine, Illinois, for gravimetric analysis. Upon receipt, the filters dessicated 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.

Nonsulfuric Acid Filterable Particulate Matter – USEPA Method 5B

EPA Method 5B, "Determination of Nonsulfuric Acid Particulate Matter Emissions from Stationary Sources", was utilized for the nonsulfuric filterable particulate matter (NSFPM) measurements. This method is contained in Appendix A of 40 CFR 60.

Particulate matter was withdrawn isokinetically from the source and collected on a quartz fiber filter maintained at a temperature of 160°C ± 14°C (320°F ± 25°F). 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 collected samples were prepared according to the method and then heated in an oven at 160°C (320°F) for six hours to volatize any condensed sulfuric acid that may have been collected. The nonsulfuric acid particulate mass was determined gravimetrically by CleanAir Analytical Services.

H_2SO_4 Testing – Draft ASTM CCM

H_2SO_4 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°F ± 25°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) 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 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 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_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, for ion chromatography (IC) analysis.

End of Section