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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. 4101004604

CleanAir Project No. 13276-4
STAC Certificate No. 2007.002.0113.1217
Revision 0, Final Report
September 28, 2017

1. PROJECT OVERVIEW

Test Program Summary

Marathon Petroleum Company LP (MPC) contracted CleanAir Engineering (CleanAir) to successfully complete testing on the Crude/Vacuum Heater (EU05-CRUDEHTR-S1) at the Detroit Refinery, located in Detroit, Michigan. The test program included the following objective:

- Perform particulate matter (PM) and nonsulfuric acid particulate matter 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. Test program information, including the test parameters, on-site schedule and a project discussion, begins below Table 1-1.

Table 1-1:
Summary of Compliance Results

Source Constituent	Sampling Method	Average Emission	Permit Limit[1]
Crude/Vacuum Heater Stack			
PM (lb/MMBtu)	USEPA M5	0.0018	0.0019
PM_{10} (lb/MMBtu)	USEPA M5 / 202	0.0033	0.0076
NSFPM (lb/MMBtu	USEPA M5B	0.0006	N/A

[1] Permit limits obtained from MDEQ Renew able Operation Permit No. MI-ROP-A9831-2012c.

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_{10}), assumed equivalent to the sum of the following constituents:
  - filterable particulate matter (FPM)
  - condensable particulate matter (CPM)
- nonsulfuric acid particulate matter (NSFPM)

Schedule

Testing was performed from August 22 and 23, 2017. 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 Stack	USEPA Method 5/202	FPM/CPM	08/22/17	10:36	13:07
2[1]	Crude/Vacuum Heater Stack	USEPA Method 5/202	FPM/CPM	08/22/17	14:57	20:01
3	Crude/Vacuum Heater Stack	USEPA Method 5/202	FPM/CPM	08/23/17	09:17	11:34
4	Crude/Vacuum Heater Stack	USEPA Method 5/202	FPM/CPM	08/23/17	12:48	15:27
5	Crude/Vacuum Heater Stack	USEPA Method 5/202	FPM/CPM	08/23/17	17:04	19:16
1	Crude/Vacuum Heater Stack	USEPA Method 5B	NSFPM	08/22/17	10:36	13:06
2[1]	Crude/Vacuum Heater Stack	USEPA Method 5B	NSFPM	08/22/17	14:52	20:01
3	Crude/Vacuum Heater Stack	USEPA Method 5B	NSFPM	08/23/17	09:17	11:34
4	Crude/Vacuum Heater Stack	USEPA Method 5B	NSFPM	08/23/17	12:48	15:27
5	Crude/Vacuum Heater Stack	USEPA Method 5B	NSFPM	08/23/17	17:04	19:16

[1] Run 2 deemed invalid due to process disruption.

Discussion

Test Scope Synopsis

FPM & PM_{10} Testing

A total of five (5) 120-minute 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 four (4) valid runs. The Crude/Vacuum Heater tripped during Run 2, resulting in an extended delay. Consequently, Run 2 emissions are not included in the final results.

For this test program, PM emission rate is assumed equivalent to FPM. PM_{10} is assumed equivalent to the sum of FPM less than 10 micrometers (µm) in diameter (FPM_{10}) 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_{10} since Method 5 collects all FPM present in the flue gas (regardless of particle size).

NSFPM Testing

A total of five (5) 120-minute Method 5B test runs were performed. NSFPM emission results were calculated in units of pounds per million Btu (lb/MMBtu). The final result was expressed as the average of the four (4) valid runs. The Crude/Vacuum Heater tripped during Run 2, resulting in an extended delay. Consequently, Run 2 emissions are not included in the final results.

Fuel Analysis

Emission results in units of dry volume-based concentration (lb/dscf, ppmdv) were converted into units of pound per million Btu (lb/MMBtu) by calculating an oxygen-based fuel factor (F_d) for refinery gas per EPA Method 19 specifications. The F_d 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. 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 Stack – FPM & PM_{10} Emissions

Run No.		1	3	4	5	Average
Date (2017)		Aug 22	Aug 23	Aug 23	Aug 23	
Start Time (approx.)		10:36	09:17	12:48	17:04	
Stop Time (approx.)		13:07	11:34	15:27	19:16	
Process Conditions						
P_2	Charge rate (bpd)	151,362	151,043	149,998	150,005	**150,091**
F_d	Oxygen-based F-factor (dscf/MMBtu)	8,203	8,180	8,180	8,180	
H_i	Actual heat input (MMBtu/hr)	203	191	193	203	**196**
Gas Conditions						
O_2	Oxygen (dry volume %)	7.6	7.5	7.4	7.1	**7.4**
CO_2	Carbon dioxide (dry volume %)	7.4	7.4	7.4	7.7	**7.5**
T_s	Sample temperature (°F)	315	309	310	310	**311**
B_w	Actual water vapor in gas (% by volume)	14.7	13.4	13.6	13.5	**13.8**
Gas Flow Rate						
Q_a	Volumetric flow rate, actual (acfm)	116,000	122,000	115,000	114,000	**116,750**
Q_s	Volumetric flow rate, standard (scfm)	78,000	82,900	78,500	77,700	**79,275**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	66,500	71,900	67,900	67,200	**68,375**
Sampling Data						
V_{mstd}	Volume metered, standard (dscf)	84.68	93.21	87.72	86.53	**88.03**
%I	Isokinetic sampling (%)	101.9	103.8	103.5	103.1	**103.1**
Laboratory Data						
m_{FPM}	Total FPM (g)	0.00525	0.00633	0.00631	0.00472	
m_{CPM}	Total CPM (g)	0.00604	0.00475	0.00331	0.00528	
m_{Part}	Total particulate matter (as PM_{10}) (g)	0.01129	0.01108	0.00962	0.01000	
FPM Results						
C_{sd}	Particulate Concentration (lb/dscf)	1.37E-07	1.50E-07	1.59E-07	1.20E-07	**1.41E-07**
$E_{lb/hr}$	Particulate Rate (lb/hr)	0.546	0.646	0.646	0.485	**0.581**
E_{Fd}	Particulate Rate - F_d-based (lb/MMBtu)	0.00176	0.00191	0.00201	0.00149	**0.00179**
CPM Results						
C_{sd}	Particulate Concentration (lb/dscf)	1.57E-07	1.12E-07	8.31E-08	1.35E-07	**1.22E-07**
$E_{lb/hr}$	Particulate Rate (lb/hr)	0.628	0.485	0.338	0.542	**0.498**
E_{Fd}	Particulate Rate - F_d-based (lb/MMBtu)	0.00203	0.00143	0.00105	0.00167	**0.00154**
Total Particulate Matter (as PM_{10}) Results						
C_{sd}	Particulate Concentration (lb/dscf)	2.94E-07	2.62E-07	2.42E-07	2.55E-07	**2.63E-07**
$E_{lb/hr}$	Particulate Rate (lb/hr)	1.17	1.13	0.98	1.03	**1.08**
E_{Fd}	Particulate Rate - F_d-based (lb/MMBtu)	0.00379	0.00335	0.00306	0.00316	**0.00334**

Note: Run 2 deemed invalid due to process disruption.

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

Run No.		1	3	4	5	Average
Date (2017)		Aug 22	Aug 23	Aug 23	Aug 23	
Start Time (approx.)		10:36	09:17	12:48	17:04	
Stop Time (approx.)		13:06	11:34	15:27	19:16	
Process Conditions						
P_2	Charge rate (bpd)	151,359	151,043	149,998	150,005	**150,088**
F_d	Oxygen-based F-factor (dscf/MMBtu)	8,203	8,180	8,180	8,180	
H_i	Actual heat input (MMBtu/hr)	203	191	193	203	**196**
Gas Conditions						
O_2	Oxygen (dry volume %)	7.6	7.1	7.5	6.9	**7.3**
CO_2	Carbon dioxide (dry volume %)	7.4	7.7	7.4	7.8	**7.6**
T_s	Sample temperature (°F)	318	311	312	312	**314**
B_w	Actual water vapor in gas (% by volume)	15.8	14.9	13.0	13.4	**14.3**
Gas Flow Rate						
Q_a	Volumetric flow rate, actual (acfm)	128,000	127,000	126,000	127,000	**127,000**
Q_s	Volumetric flow rate, standard (scfm)	86,100	86,200	85,600	86,400	**86,075**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	72,500	73,400	74,400	74,800	**73,775**
Sampling Data						
V_{mstd}	Volume metered, standard (dscf)	93.55	94.36	93.80	94.68	**94.10**
%I	Isokinetic sampling (%)	103.3	103.0	100.9	101.4	**102.1**
Laboratory Data						
m_{FPM}	Total NSFPM (g)	0.00215	0.00132	0.00182	0.00222	
NSFPM Results						
C_{sd}	Particulate Concentration (lb/dscf)	5.08E-08	3.08E-08	4.29E-08	5.17E-08	**4.40E-08**
$E_{lb/hr}$	Particulate Rate (lb/hr)	0.221	0.135	0.192	0.232	**0.195**
E_{Fd}	Particulate Rate - F_d-based (lb/MMBtu)	0.000654	0.000381	0.000547	0.000631	**0.000554**

Note: Run 2 deemed invalid due to process disruption.

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 compressors 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

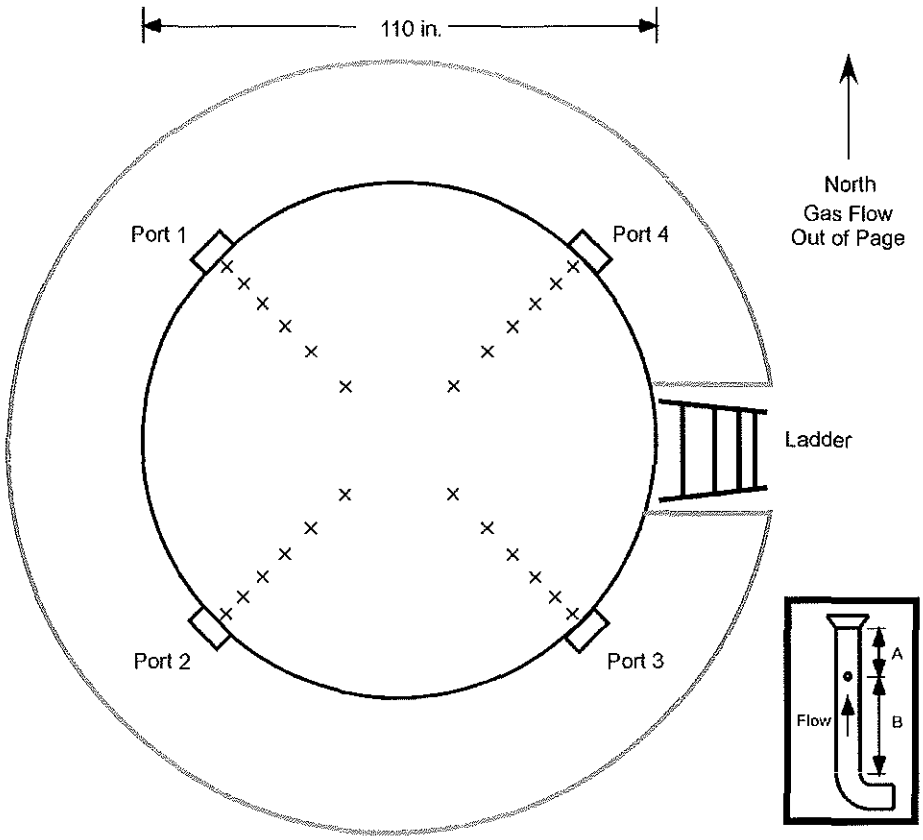
The sample point locations were determined by EPA Methods 1 and 25A (with references to Method 7E specifications). Table 3-1 presents the sampling information for the test location described in this report. The figure shown on page 7 represents the layout of the test location.

Table 3-1:
Sampling Point Information

Source Constituent	Method	Run No.	Ports	Points per Port	Minutes per Point	Total Minutes	Figure
Crude/Vacuum Heater Stack							
FPM / CPM	M5 / 202	1-5[1]	4	6	5	120	3-1
NSFPM	M5B	1-5[1]	4	6	5	120	3-1

[1] Run 2 deemed invalid due to process disruption.

Figure 3-1:
FPM, PM_{10} and NSFPM Sample Point Layout (EPA Method 1)



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 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.

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 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"

Title 40 CFR Part 51, Appendix M

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

Methodology Discussion

FPM and PM_{10} Testing – USEPA Method 5/202

The front-half (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 (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_2) and nitrogen oxide (NO_X) interferences observed with earlier versions of the method, in which flue gas was bubbled through cold water and, SO_2 and NO_X were absorbed and partially oxidized before they could be purged out with nitrogen (N_2).

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 nitrogen (N_2) 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.

NSFPM Testing – USEPA Method 5B

The front-half of the sampling train consisted of a glass nozzle, glass liner and filter holder heated to 320°F ± 25°F and a quartz fiber filter. Flue gas samples were extracted isokinetically per Method 5B requirements.

After exiting the front-half filter, the flue gas passed through a serious of knockout jars. Condensate in these knockout 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 5B requirements, using acetone as the recovery solvent.

All samples and blanks were returned to CleanAir Analytical Services for gravimetric analysis.

End of Section