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REPORT ON COMPLIANCE TESTING

Performed for:
MARATHON PETROLEUM COMPANY LP
DETROIT REFINERY

FCCU REGENERATOR STACK (SVFCCU)

Client Reference No: 4100048779
CleanAir Project No: 12605-2
Revision 0: January 16, 2015

To the best of our knowledge, the data presented in this report are accurate, complete, error free, legible 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.

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REVISION HISTORY

REPORT ON COMPLIANCE TESTING

DRAFT REPORT REVISION HISTORY

Revision:	Date	Pages	Comments
D0a	01/15/15	All	Draft version of original document.

FINAL REPORT REVISION HISTORY

Revision:	Date	Pages	Comments
0	01/16/15	All	Final version of original document.

CONTENTS

PROJECT OVERVIEW

INTRODUCTION

Marathon Petroleum Company LP (MPC) contracted Clean Air Engineering (CleanAir) to perform emission measurements at the Detroit Refinery for compliance purposes.

All testing was conducted in accordance with the regulations set-forth by the United States Environmental Protection Agency (USEPA) and the Michigan Department of Environmental Quality (MDEQ). The permit limits are referenced in Michigan Department of Environmental Quality, Air Quality Division Permit to Install No. 63-08D, issued May 12, 2014.

Key Project Participants

Individuals responsible for coordinating and conducting the test program were:

Crystal Davis – MPC
Joe Reidy – MPC
Thomas Gasloli – MDEQ
Jaci Amundsen – CleanAir

Test Program Parameters

The testing was performed at the FCCU Regenerator Stack (Emission Unit ID No. EU11-FCCU; Stack ID No. SVFCCU) on November 18-20, 2014, and included the following emissions measurements:

- particulate matter (PM), assumed equivalent to non-sulfate filterable particulate matter (NSFPM)
- total particulate matter less than or equal to 10 microns (μm) in diameter (Total PM_{10}), assumed equivalent to the sum of the following constituents:
  - non-sulfate filterable particulate matter (NSFPM)
  - condensable particulate matter (CPM)
- ammonia (NH_3)
- flue gas composition (e.g., O_2, CO_2, H_2O)
- flue gas flow rate
- flue gas velocity decay (wall effects)

PROJECT OVERVIEW

Testing was also performed at the FCCU Regenerator ESP Inlet per the request of MPC. Diagnostic O_2 and CO_2 measurements were made at the ESP Inlet concurrently with the testing outlined above. ESP Inlet data can be found in Appendix H of the report.

Target Coke burn rates, FCC charge rates, NH_3 injection into the ESP, and ESP operation were varied in the following manner during the test program.

- Target Condition 1, 11/18/14: High Coke burn rate, FCC charge rate ~ 41,000 barrels per day (bpd), NH_3 injection ~ 32 ppm, full ESP in operation with low power reduction (LPR)
- Target Condition 2, 11/19-20/14: High Coke burn rate, FCC charge rate ~ 41,000 barrels per day (bpd), NH_3 injection ~ 29 ppm, full ESP in operation with low power reduction (LPR)

PROJECT OVERVIEW

TEST PROGRAM SYNOPSIS

Test Schedule

The on-site schedule followed during the test program is outlined in Table 1-1.

Table 1-1:
Schedule of Activities

Run Number	Location	Method	Analyte	Date	Start Time	End Time
1	FCCU Regenerator Stack	USEPA Method 5F/202	FPM/CPM	11/18/14	12:51	14:33
2	FCCU Regenerator Stack	USEPA Method 5F/202	FPM/CPM	11/18/14	17:26	18:38
3	FCCU Regenerator Stack	USEPA Method 5F/202	FPM/CPM	11/18/14	20:28	21:38
4	FCCU Regenerator Stack	USEPA Method 5F/202	FPM/CPM	11/19/14	14:34	15:43
5	FCCU Regenerator Stack	USEPA Method 5F/202	FPM/CPM	11/20/14	09:51	10:58
6	FCCU Regenerator Stack	USEPA Method 5F/202	FPM/CPM	11/20/14	12:33	13:41
1	FCCU Regenerator Stack	USEPA CTM-027	NH_3	11/18/14	12:51	14:33
2	FCCU Regenerator Stack	USEPA CTM-027	NH_3	11/18/14	17:26	18:38
3	FCCU Regenerator Stack	USEPA CTM-027	NH_3	11/18/14	20:28	21:38
4	FCCU Regenerator Stack	USEPA CTM-027	NH_3	11/19/14	11:28	12:33
5	FCCU Regenerator Stack	USEPA CTM-027	NH_3	11/19/14	14:34	15:43
6	FCCU Regenerator Stack	USEPA CTM-027	NH_3	11/20/14	09:51	10:58
7	FCCU Regenerator Stack	USEPA CTM-027	NH_3	11/20/14	12:33	13:41
1	FCCU Regenerator Stack	USEPA Method 2H	Velocity Decay	11/18/14	10:06	10:25
2	FCCU Regenerator Stack	USEPA Method 2H	Velocity Decay	11/19/14	10:36	10:52
3	FCCU Regenerator Stack	USEPA Method 2H	Velocity Decay	11/20/14	09:04	09:19
1	FCCU Regenerator Stack	USEPA Method 2F	3-D Velocity	11/18/14	11:07	11:23
2	FCCU Regenerator Stack	USEPA Method 2F	3-D Velocity	11/18/14	15:21	15:39
3	FCCU Regenerator Stack	USEPA Method 2F	3-D Velocity	11/18/14	19:26	19:41
4	FCCU Regenerator Stack	USEPA Method 2F	3-D Velocity	11/18/14	21:47	21:59
5	FCCU Regenerator Stack	USEPA Method 2F	3-D Velocity	11/19/14	10:51	11:04
6	FCCU Regenerator Stack	USEPA Method 2F	3-D Velocity	11/19/14	12:49	13:03
7	FCCU Regenerator Stack	USEPA Method 2F	3-D Velocity	11/19/14	16:14	16:29
8	FCCU Regenerator Stack	USEPA Method 2F	3-D Velocity	11/20/14	09:06	09:16
9	FCCU Regenerator Stack	USEPA Method 2F	3-D Velocity	11/20/14	11:27	11:44
10	FCCU Regenerator Stack	USEPA Method 2F	3-D Velocity	11/20/14	14:12	14:23
1	FCCU Regenerator ESP Inlet	USEPA Method 3A	O_2/CO_2	11/18/14	12:51	14:32
2	FCCU Regenerator ESP Inlet	USEPA Method 3A	O_2/CO_3	11/18/14	17:26	18:37
3	FCCU Regenerator ESP Inlet	USEPA Method 3A	O_2/CO_4	11/18/14	20:28	21:38
4	FCCU Regenerator ESP Inlet	USEPA Method 3A	O_2/CO_5	11/19/14	11:28	12:33
5	FCCU Regenerator ESP Inlet	USEPA Method 3A	O_2/CO_6	11/19/14	15:20	15:59
6	FCCU Regenerator ESP Inlet	USEPA Method 3A	O_2/CO_7	11/20/14	09:50	10:57
7	FCCU Regenerator ESP Inlet	USEPA Method 3A	O_2/CO_8	11/20/14	12:32	13:40

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PROJECT OVERVIEW

Results Summary

Table 1-2 and Table 1-3 summarize the results of the test program. A more detailed presentation of the test conditions and results of analysis are shown on pages 2-1 through 2-5.

Table 1-2:
Summary of NSFPM, CPM and Total PM_{10} Results (USEPA 5F/202)

FCCU Regenerator Stack			NSFPM Rate	CPM Rate (all in lb/Mlb coke)	Total PM_{10} Rate
Condition 1 - 11/18/14					
Coke Burn Rate (Mlb coke/hr)	22.7	Run 1	0.148	0.385	0.534
FCC Rate (bpd)	40,979	Run 2	0.128	0.461	0.589
Aqueous NH_3 Injection (lb/hr)	27.8	Run 3	0.120	0.314	0.434
ESP Operation	Both/LPR	Average	**0.132**	**0.387**	**0.519**
		Limit	**0.8**		**1.1**
Condition 2 - 11/19-20/14					
Coke Burn Rate (Mlb coke/hr)	22.7	Run 4	0.292	0.349	0.640
FCC Rate (bpd)	41,009	Run 5	0.298	0.292	0.590
Aqueous NH_3 Injection (lb/hr)	26.7				
ESP Operation	Both/LPR	Average	**0.295**	**0.320**	**0.615**
		Limit	**0.8**		**1.1**

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Table 1-3:
Summary of NH_3 Results (USEPA CTM-027)

FCCU Regenerator Stack			NH_3 Conc. (ppmdv)	NH_3 Slip (lb/hr)	NH_3 Slip (lb/Mlb coke)
Condition 1 - 11/18/14					
Coke Burn Rate (Mlb coke/hr)	22.7	Run 1	16.5	3.18	0.141
FCC Rate (bpd)	40,979	Run 2	14.0	2.67	0.117
Aqueous NH_3 Injection (lb/hr)	27.8	Run 3	13.9	2.57	0.113
ESP Operation	Both/LPR	Average	**14.8**	**2.81**	**0.124**
Condition 2 - 11/19-20/14					
Coke Burn Rate (Mlb coke/hr)	22.7	Run 4	9.4	1.85	0.082
FCC Rate (bpd)	41,009	Run 5	10.5	2.04	0.090
Aqueous NH_3 Injection (lb/hr)	26.7	Run 6	11.1	2.16	0.095
ESP Operation	Both/LPR	Average	**10.3**	**2.02**	**0.089**

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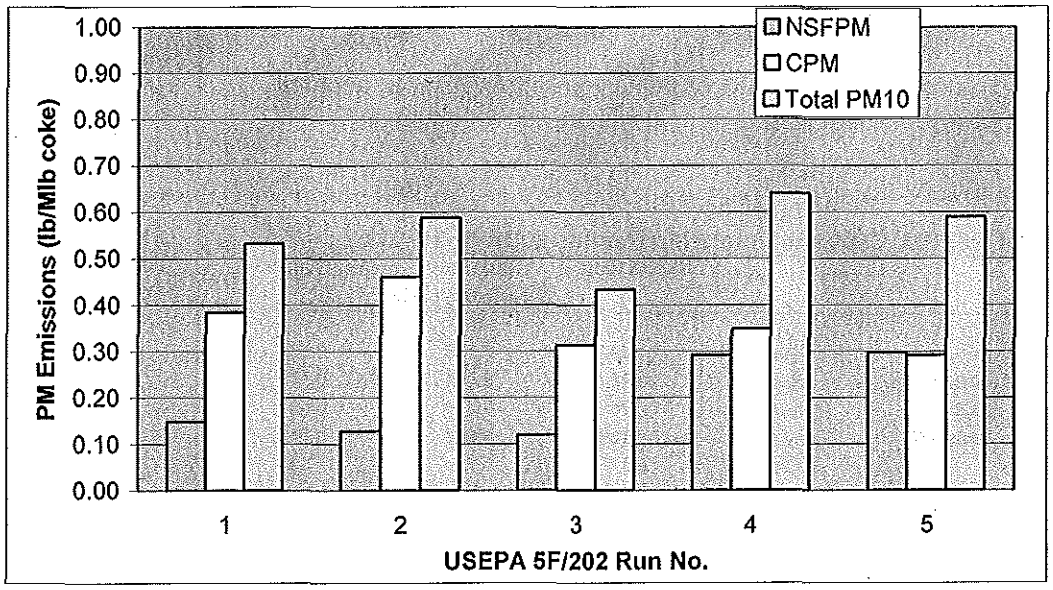

Figure 1-1: NSFPM, CPM and Total PM_{10} Results

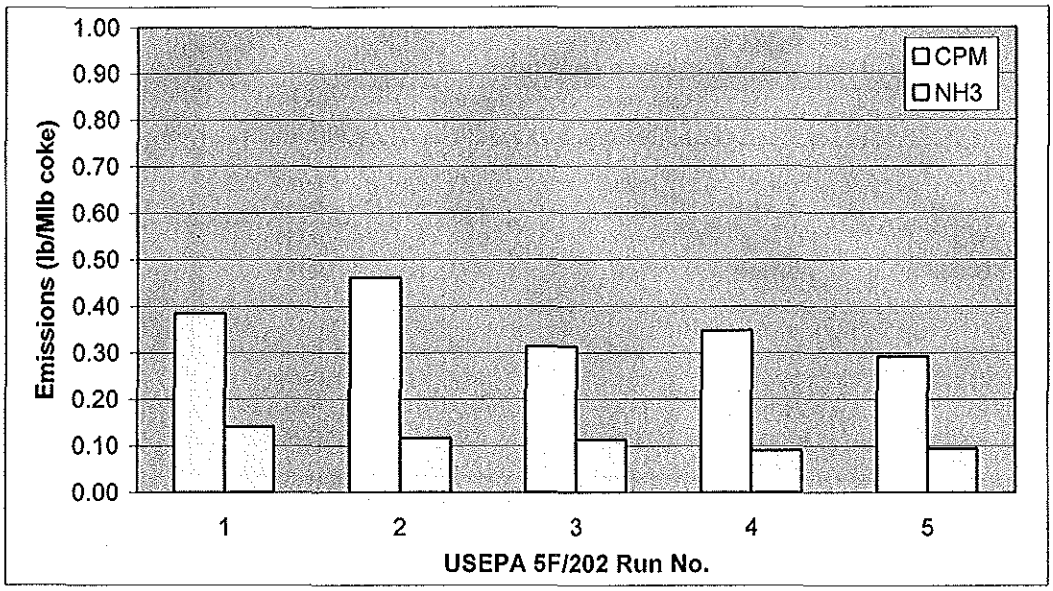

Figure 1-2: CPM and NH_3 Results

PROJECT OVERVIEW

Discussion of Test Program

Flow Rate Measurements – USEPA Method 2F/2H - Stack

A wall-effects adjustment factor (WAF) was determined per Method 2H each test day prior to the start of the first test run.

3-D flow traverses per Method 2F were performed before and after each Method 5F/202 and CTM-027 test run.

Upon reduction of the Method 2F data, it was found that an accurate measurement was not taken at traverse point 2-9 of Run 8. Instead, CleanAir utilized the average of traverse points 2-8 and 2-10 to derive the missing values. The raw data from the Method 2F test runs can be found in Appendix G of this report.

NSFPM and CPM Testing - USEPA Method 5F/202 - Stack

For this test program, PM emission rate is assumed equivalent to NSFPM emission rate and PM_{10} emission rate is assumed equivalent to the sum of NSFPM and CPM emission rates (units of lb/hr, Ton/yr, or lb/Mlb coke for all constituents).

Three (3) 60-minute Method 5F/202 test runs were performed during Condition 1 on November 18, 2014. The final results were expressed as the average of three (3) test runs.

Three (3) 60-minute Method 5F/202 test runs were performed during Condition 2 on November 19-20, 2014. Upon completion of the test program, MPC informed CleanAir that they were unable to log the Coke burn Rate over the entire duration of Run 6. The facility O_2 analyzer was not operating for a period of approximately 42-minutes throughout Run 6. The O_2 value is required in order to calculate a Coke burn rate. Without an official Coke burn rate for the duration of the test run it is not feasible to calculate emission rates in units of pounds per 1,000 pounds of coke burn (lb/Mlb coke). The final results were expressed as the average of two (2) test runs. Parameters and results from Run 6 which do not include Coke burn rate, can be found in Table 2-2 and Appendix C of the report.

Ammonia (NH_3) injection rates shown in Tables 2-1, 2-2, 2-3 and 2-4 is the aqueous ammonia, (11FC2032), times 0.2.

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The analytical procedures in EPA Method 202 include an ammonium titration of the inorganic sample fractions with pH less than 7.0 to neutralize acids with hygroscopic properties such as H_2SO_4 that may be present in the sample. This step speeds up the sample desiccation process and allows the samples to come to a constant weight prior to weighing. The weight of ammonium added to the sample as a result of the titration is subtracted from the analytical result.

The laboratory performing the gravimetric analysis (Clean Air Analytical Services) has determined that only samples with an initial pH less than 4.5 require a significant amount of ammonium neutralization, resulting in a correction in excess of 0.5 mg. Based on this observation, the laboratory has altered their procedures. Only samples with a pH lower than 4.5 are titrated.

All of the inorganic sample fractions from Runs 1 through 6 had a pH less than 4.5 and were titrated. The field train reagent blank had a pH of about 5.9 and was not titrated. The sample fraction was observed to come to a constant weight without having to titrate the sample.

NH_3 Testing – USEPA CTM-027 - Stack

Three (3) 60-minute CTM-027 test runs were performed during Condition 1 on November 18, 2014. Each test run was performed concurrently with Method 5F/202 testing. The final results were expressed as the average of three (3) test runs.

Four (4) 60-minute CTM-027 test runs were performed during Condition 2 on November 19-20, 2014. Runs 5 through 7 were performed concurrently with Method 5F/202 testing while Run 4 was performed independently. The final results were expressed as the average of three (3) test runs. Parameters and results from Run 7 which do not include Coke burn rate, can be found in Table 2-4 and appendix C of the report.

O_2 and CO_2 Testing - USEPA Method 3A – ESP Inlet

Seven (7) Method 3A test runs were performed on November 18-20, 2014. Each test run was performed concurrently with Method 5F/202 and CTM-027 test runs.

General Considerations

The additional parameters outlined in the original protocol were performed during a preceding mobilization in October 2014, CleanAir Project No: 12605-1.

Calculation of Final Results

Sample flow rates as determined by EPA Method 2 without the WAF correction were used to calculate isokinetic sampling conditions. Mass based emission rate in units of pounds per hour (lb/hr) were calculated using the average (pre-run and post-run) flow rate determined by Method 2F combined with the respective WAF correction. Emission rates in units of tons per year (Ton/yr) were calculated using an assumed capacity of 8,760 operation hours per year. Emission rates in units of (lb/Mlb coke) were calculated using coke burn rate data provided by MPC.

End of Section 1 – Project Overview

RESULTS

Table 2-1:
NSFPM, CPM and Total PM_{10} (USEPA 5F/202) – Condition 1

Run No.		1	2	3	Average
Date (2014)		Nov 18	Nov 18	Nov 18	
Start Time (approx.)		12:51	17:26	20:28	
Stop Time (approx.)		14:33	18:38	21:38	
Process Conditions					
R_P	Production rate (Mlb Coke/hr)	22.6	22.7	22.7	**22.7**
P_1	FCC charge rate (bpd)	40,999	40,952	40,987	**40,979**
P_2	NH3 injection (lb/hr)	5.53	5.53	5.60	**5.55**
P_3	ESP Operation	Both/LPR	Both/LPR	Both/LPR	
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	**8,760**
Gas Conditions					
O_2	Oxygen (dry volume %)	5.1	2.1	2.9	**3.4**
CO_2	Carbon dioxide (dry volume %)	12.7	15.7	15.0	**14.5**
T_s	Sample temperature (°F)	515	517	518	**517**
B_w	Actual water vapor in gas (% by volume)	7.4	8.8	8.9	**8.4**
Gas Flow Rate[1]					
Q_a	Volumetric flow rate, actual (acfm)	150,000	148,000	143,000	**147,000**
Q_s	Volumetric flow rate, standard (scfm)	80,400	79,900	77,100	**79,100**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	72,600	72,000	69,800	**71,500**
Sampling Data					
V_{mstd}	Volume metered, standard (dscf)	38.85	38.19	38.61	**38.55**
%I	Isokinetic sampling (%)[2]	100.0	100.0	100.0	**100.0**
Laboratory Data					
m_n	Total NSFPM (g)	0.01359	0.01165	0.01142	
m_{CPM}	Total CPM (g)	0.03526	0.04200	0.02979	
m_{Part}	Total particulate (expressed as PM-10) (g)	0.04885	0.05365	0.04121	
DLC	Detection level classification	ADL	ADL	ADL	
NSFPM Results					
C_{sd}	Particulate Concentration (lb/dscf)	7.71E-07	6.73E-07	6.52E-07	**6.99E-07**
$E_{lb/hr}$	Particulate Rate (lb/hr)	3.36	2.91	2.73	**3.00**
$E_{T/yr}$	Particulate Rate (Ton/yr)	14.7	12.7	12.0	**13.1**
E_{RP}	Particulate Rate - Production-based (lb/Mlb Coke)	0.148	0.128	0.120	**0.132**
CPM Results					
C_{sd}	Particulate Concentration (lb/dscf)	2.00E-06	2.43E-06	1.70E-06	**2.04E-06**
$E_{lb/hr}$	Particulate Rate (lb/hr)	8.72	10.5	7.12	**8.78**
$E_{T/yr}$	Particulate Rate (Ton/yr)	38.2	45.9	31.2	**38.4**
E_{RP}	Particulate Rate - Production-based (lb/Mlb Coke)	0.385	0.461	0.314	**0.387**
Total Particulate (as PM10) Results					
C_{sd}	Particulate Concentration (lb/dscf)	2.77E-06	3.10E-06	2.35E-06	**2.74E-06**
$E_{lb/hr}$	Particulate Rate (lb/hr)	12.1	13.4	9.86	**11.8**
$E_{T/yr}$	Particulate Rate (Ton/yr)	52.9	58.6	43.2	**51.6**
E_{RP}	Particulate Rate - Production-based (lb/Mlb Coke)	0.534	0.589	0.434	**0.519**

Average includes 3 runs.

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Detection level classifications are defined as follows:

ADL = Above Detection Level - all fractions are above detection limit

[1] Gas flow rates obtained from bracketing Method 2F test runs combined with the WAF determined by Method 2H.

[2] Sample flow rates as determined by EPA Method 2 were used to calculate isokinetic sampling conditions.

RESULTS

Table 2-2:
NSFPM, CPM and Total PM_{10} (USEPA 5F/202) – Condition 2

Run No.		4	5	6*	Average
Date (2014)		Nov 19	Nov 20	Nov 20	
Start Time (approx.)		14:34	09:51	12:33	
Stop Time (approx.)		15:43	10:58	13:41	
Process Conditions					
R_P	Production rate (Mlb Coke/hr)	22.6	22.9	N/A	**22.7**
P_1	FCC charge rate (bpd)	41,007	41,011	41,022	**41,009**
P_2	NH3 Injection (lb/hr)	5.36	5.33	5.32	**5.34**
P_3	ESP Operation	Both/LPR	Both/LPR	Both/LPR	
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	**8,760**
Gas Conditions					
O_2	Oxygen (dry volume %)	2.7	2.5	2.4	**2.6**
CO_2	Carbon dioxide (dry volume %)	14.7	15.3	15.3	**15.0**
T_s	Sample temperature (°F)	523	519	519	**521**
B_w	Actual water vapor in gas (% by volume)	9.4	7.7	8.4	**8.6**
Gas Flow Rate[1]					
Q_a	Volumetric flow rate, actual (acfm)	153,000	149,000	150,000	**151,000**
Q_s	Volumetric flow rate, standard (scfm)	81,200	80,600	80,900	**80,900**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	73,400	73,300	73,300	**73,400**
Sampling Data					
V_{mstd}	Volume metered, standard (dscf)	38.70	38.35	39.26	**38.53**
%I	Isokinetic sampling (%)[2]	99.4	98.2	98.3	**98.8**
Laboratory Data					
m_n	Total NSFPM (g)	0.02626	0.02694	0.02431	
m_{CPM}	Total CPM (g)	0.03137	0.02638	0.03142	
m_{Part}	Total particulate (expressed as PM-10) (g)	0.05763	0.05332	0.05573	
DLC	Detection level classification	ADL	ADL	ADL	
NSFPM Results					
C_{sd}	Particulate Concentration (lb/dscf)	1.50E-06	1.55E-06	1.37E-06	**1.52E-06**
$E_{lb/hr}$	Particulate Rate (lb/hr)	6.59	6.81	6.00	**6.70**
$E_{T/yr}$	Particulate Rate (Ton/yr)	28.9	29.8	26.3	**29.4**
E_{Rp}	Particulate Rate - Production-based (lb/Mlb Coke)	0.292	0.298	N/A	**0.295**
CPM Results					
C_{sd}	Particulate Concentration (lb/dscf)	1.79E-06	1.52E-06	1.76E-06	**1.65E-06**
$E_{lb/hr}$	Particulate Rate (lb/hr)	7.88	6.67	7.76	**7.27**
$E_{T/yr}$	Particulate Rate (Ton/yr)	34.5	29.2	34.0	**31.9**
E_{Rp}	Particulate Rate - Production-based (lb/Mlb Coke)	0.349	0.292	N/A	**0.320**
Total Particulate (as PM10) Results					
C_{sd}	Particulate Concentration (lb/dscf)	3.28E-06	3.07E-06	3.13E-06	**3.17E-06**
$E_{lb/hr}$	Particulate Rate (lb/hr)	14.5	13.5	13.8	**14.0**
$E_{T/yr}$	Particulate Rate (Ton/yr)	63.4	59.1	60.3	**61.2**
E_{Rp}	Particulate Rate - Production-based (lb/Mlb Coke)	0.640	0.590	N/A	**0.615**

Average includes 2 runs. * indicates that the run is not included in the average. 01615 134255

Detection level classifications are defined as follows:

ADL = Above Detection Level - all fractions are above detection limit

[1] Gas flow rates obtained from bracketing Method 2F test runs combined with the WAF determined by Method 2H.

[2] Sample flow rates as determined by EPA Method 2 were used to calculate isokinetic sampling conditions.

RESULTS

Table 2-3:
NH_3 (USEPA CTM-027) – Condition 1

Run No.		1	2	3	Average
Date (2014)		Nov 18	Nov 18	Nov 18	
Start Time (approx.)		12:51	17:26	20:28	
Stop Time (approx.)		14:33	18:38	21:38	
Process Conditions					
R_P	Coke burn-off rate (Mlb coke/hr)	22.6	22.7	22.7	**22.7**
P_1	FCC charge rate (bpd)	41,000	41,000	41,000	**41,000**
P_2	NH3 injection (lb/hr)	5.53	5.53	5.60	**5.55**
P_3	ESP Operation	Both/LPR	Both/LPR	Both/LPR	
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	**8,760**
Gas Conditions					
O_2	Oxygen (dry volume %)	5.6	2.4	1.9	**3.3**
CO_2	Carbon dioxide (dry volume %)	12.1	15.3	15.8	**14.4**
T_s	Sample temperature (°F)	514	517	517	**516**
B_w	Actual water vapor in gas (% by volume)	9.7	9.8	9.5	**9.7**
Gas Flow Rate[1]					
Q_a	Volumetric flow rate, actual (acfm)	150,000	148,000	143,000	**147,000**
Q_s	Volumetric flow rate, standard (scfm)	80,400	79,900	77,100	**79,100**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	72,600	72,000	69,800	**71,500**
Sampling Data					
V_{mstd}	Volume metered, standard (dscf)	36.94	37.25	35.16	**36.45**
%I	Isokinetic sampling (%)[2]	100.7	103.1	102.8	**102.2**
Laboratory Data					
m_n	Total NH_3 collected (mg)	12.17296	10.36861	9.73875	
Ammonia (NH_3) Results					
C_{sd}	Ammonia Concentration (lb/dscf)	7.27E-07	6.14E-07	6.11E-07	**6.50E-07**
C_{sd}	Ammonia Concentration (ppmdv)	16.4	13.9	13.8	**14.7**
$E_{lb/hr}$	Ammonia Rate (lb/hr)	3.17	2.65	2.56	**2.79**
$E_{T/yr}$	Ammonia Rate (Ton/yr)	13.9	11.6	11.2	**12.2**
E_{RP}	Ammonia Rate - Production-based (lb/Mlb coke)	0.140	0.117	0.113	**0.123**

Average includes 3 runs.

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[1] Gas flow rates obtained from bracketing Method 2F test runs combined with the WEF determined by Method 2H.

[2] Sample flow rates as determined by EPA Method 2 were used to calculate isokinetic sampling conditions.

RESULTS

Table 2-4:
NH_3 (USEPA CTM-027) – Condition 2

Run No.		4	5	6	7*	Average
Date (2014)		Nov 19	Nov 19	Nov 20	Nov 20	
Start Time (approx.)		11:28	14:34	09:51	12:33	
Stop Time (approx.)		12:33	15:43	10:58	13:41	
Process Conditions						
R_P	Coke burn-off rate (Mlb coke/hr)	22.5	22.6	22.9	N/A	**22.7**
P_1	FCC charge rate (bpd)	41,000	41,000	41,000	41,000	**41,000**
P_2	NH3 injection (lb/hr)	5.16	5.36	5.33	5.32	**5.28**
P_3	ESP Operation	Both/LPR	Both/LPR	Both/LPR	Both/LPR	
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	8,760	**8,760**
Gas Conditions[1]						
O_2	Oxygen (dry volume %)	2.6	2.7	3.3	2.4	**2.9**
CO_2	Carbon dioxide (dry volume %)	15.0	14.7	14.6	15.2	**14.8**
T_s	Sample temperature (°F)	521	522	519	519	**520**
B_w	Actual water vapor in gas (% by volume)	9.4	9.5	9.0	9.3	**9.3**
Gas Flow Rate						
Q_a	Volumetric flow rate, actual (acfm)	152,000	153,000	149,000	150,000	**151,000**
Q_s	Volumetric flow rate, standard (scfm)	81,800	81,200	80,600	80,900	**81,200**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	74,000	73,400	73,300	73,300	**73,600**
Sampling Data						
V_{mstd}	Volume metered, standard (dscf)	35.89	35.22	35.90	36.43	**35.67**
%I	Isokinetic sampling (%)[2]	102.2	101.9	101.1	100.6	**101.7**
Laboratory Data						
m_n	Total NH_3 collected (mg)	6.73433	7.35202	7.94798	7.78504	
Ammonia (NH_3) Results						
C_{sd}	Ammonia Concentration (lb/dscf)	4.14E-07	4.60E-07	4.88E-07	4.71E-07	**4.54E-07**
C_{sd}	Ammonia Concentration (ppmdv)	9.37	10.4	11.1	10.7	**10.3**
$E_{lb/hr}$	Ammonia Rate (lb/hr)	1.84	2.03	2.15	2.07	**2.00**
$E_{T/yr}$	Ammonia Rate (Ton/yr)	8.05	8.88	9.41	9.07	**8.78**
E_{Rp}	Ammonia Rate - Production-based (lb/Mlb coke)	0.0816	0.0898	0.0940	N/A	**0.0885**

Average includes 3 runs. * Indicates the run is not included in the average. 011315 162451

[1] Gas flow rates obtained from bracketing Method 2F test runs combined with the WEF determined by Method 2H.

[2] Sample flow rates as determined by EPA Method 2 were used to calculate isokinetic sampling conditions.

RESULTS

Table 2-5:
Uncertainty Analysis – NSFPM, CPM and Total PM_{10} – Condtion 1

	NSFPM Results (lb/Mlb coke)		CPM Results (lb/Mlb coke)		Total PM (as PM10) Results (lb/Mlb coke)	
Method		5F/202		5F/202		5F/202
Run No.	1	0.148	1	0.385	1	0.533
	2	0.128	2	0.461	2	0.589
	3	0.120	3	0.314	3	0.434
SD		0.015		0.074		0.078
AVG		**0.132**		**0.387**		**0.519**
RSD		11.0%		19.0%		15.1%
N		3		3		3
SE		0.008		0.042		0.045
RSE		6.3%		11.0%		8.7%
P		95.0%		95.0%		95.0%
TINV		4.30		4.30		4.30
CI +		0.168		0.569		0.713
AVG		**0.132**		**0.387**		**0.519**
CI -		0.096		0.204		0.324
TB +		0.243		0.950		1.119

AVG (average) is the mean value of the runs; N is the number of individual runs.

SD (standard deviation) and RSD (relative standard deviation) are measures of the variability of individual runs.

SE (standard error) and RSE (relative standard error) are measures of the variability of the average of the runs.

P (probability) is the confidence level associated with the two-tailed Student's t-distribution.

TINV (t-value) is the value of the Student's t-distrubution as a function of P (probability) and N-1 (degrees of freedom).

CI (confidence interval) indicates that if the test is conducted again under the same conditions, the average would be expected to fall within the interval (CI- to CI+) about 95% of the time.

TB+ (upper tolerance bound) is the value below which 95% of future runs are expected to fall (assuming testing at the same conditions).

End of Section 2 – Results

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 Fluid Catalytic Cracking Unit (EU11-FCCU) utilizes a primary reactor, a distillation column and a catalyst regeneration unit to continuously generate light hydrocarbon products from heavy crude oil feeds. The FCCU is equipped with an ESP with two (2) bays and variable aqueous NH3 injection to control emissions. Emissions are vented to the atmosphere via the FCCU Regenerator Stack (SVFCCU).

The testing reported in this document was performed at the FCCU Regenerator Stack and FCCU Regenerator Inlet.

DESCRIPTION OF SAMPLING LOCATIONS

Sampling point locations were determined according to USEPA Method 1 and 2H.

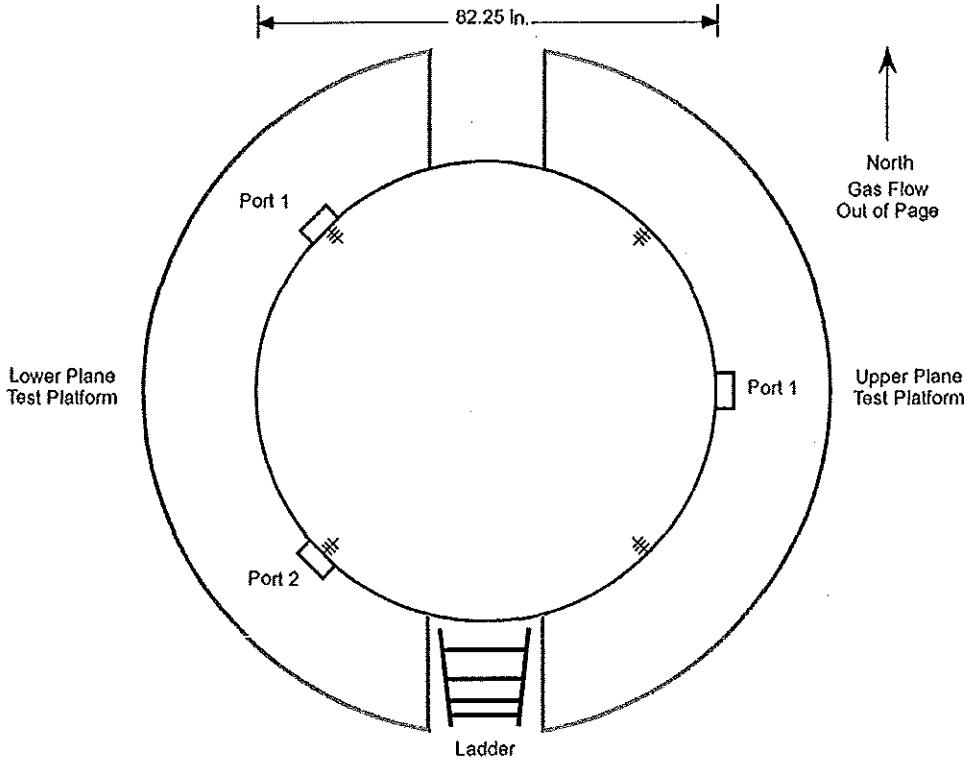
Table 3-1 outlines the sampling point configurations. The figures shown on the following pages illustrate the sampling points and orientation of sampling ports.

Table 3-1:
Sampling Points

Source Constituent	Method	Run No.	Ports	Points per Port	Minutes per Point	Total Minutes	Figure
FCCU Regenerator Stack							
Velocity Decay	USEPA 2H	1-3	2	6	Varied	Varied	3-1
3-D Flow	USEPA 2F	1-10	2	12	Varied	Varied	3-2
NSFPM/CPM	USEPA 5F/202	1-6	2	12	2.5	60	3-2
NH_3	USEPA CTM-027	1-7	2	12	2.5	60	3-2
FCCU Regenerator ESP Inlet							
O_2/CO_2	USEPA 3A	1-7	1	1	Varied	Varied	N/A[1]

[1] Sampling was performed at a single point near the center of the duct.

DESCRIPTION OF INSTALLATION



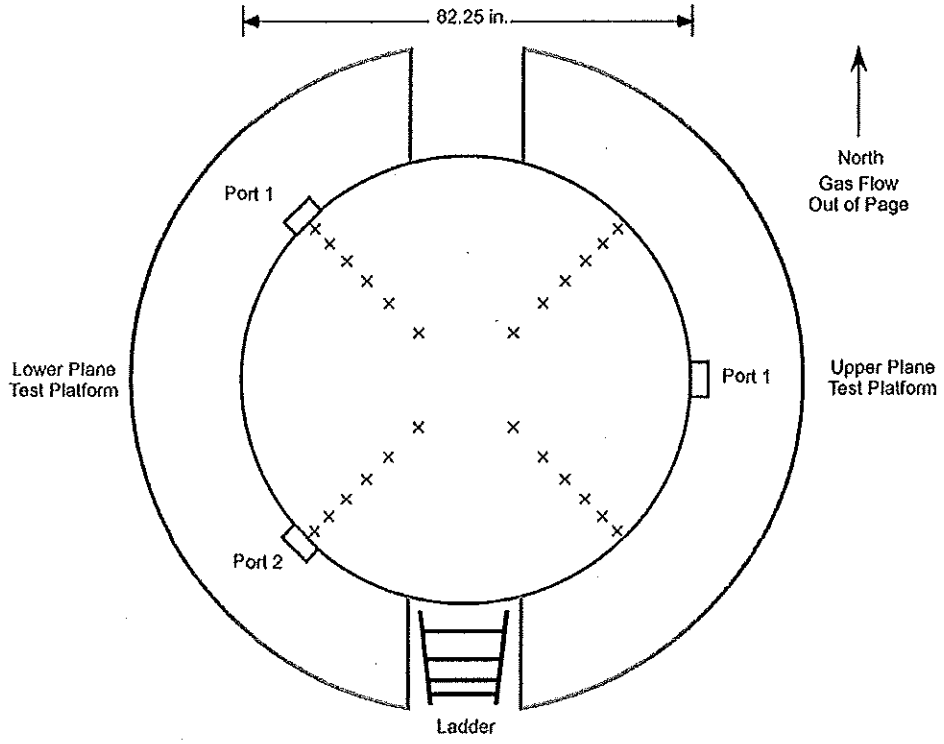
Note: Ports on the lower plane were used for these points.

Sampling Point	Port to Point Distance (in.)
1	81.25
2	80.25
3	79.25
4	3.0
5	2.0
6	1.0

Duct diameters upstream from flow disturbance (A):	2.2	Limit: 0.5
Duct diameters downstream from flow disturbance (B):	3.4	Limit: 2.0

Figure 3-1: FCCU Regenerator Stack Sampling Points (USEPA M-2H)

DESCRIPTION OF INSTALLATION



Note: Ports on the lower plane were used for these points.

Sampling Point	Port to Point Distance (in.)
1	80.5
2	76.7
3	72.5
4	67.7
5	61.7
6	53.0
7	29.3
8	20.6
9	14.6
10	9.7
11	5.5
12	1.7

Duct diameters upstream from flow disturbance (A):	2.2	Limit: 0.5
Duct diameters downstream from flow disturbance (B):	3.4	Limit: 2.0

Figure 3-2: FCCU Regenerator Stack Sampling Points (USEPA 2F, 5F/202, CTM-027)

End of Section 3 – Description of Installation

METHODOLOGY

Clean Air Engineering followed procedures as detailed in USEPA Methods 1, 2, 2F, 2H, 3, 3A, 3B, 4, 5F, 202, and Conditional Test Method (CTM) 027. The following table summarizes the methods and their respective sources.

Table 4-1:
Summary of Sampling Procedures

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 2F	"Determination of Stack Gas Velocity And Volumetric Flow Rate with Three-Dimensional Probes"
Method 2H	"Determination of Stack Gas Velocity Taking into Account Velocity Decay near the Stack Wall"
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 5F	"Determination of Nonsulfate 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"
Conditional Test Methods (CTM)	
CTM-027	"Procedure for Collection and Analysis of Ammonia in Stationary Sources"

These methods appear in detail in Title 40 of the Code of Federal Regulations (CFR) and are located on the internet at http://ecfr.gpoaccess.gov.

Diagrams of the sampling apparatus and major specifications of the sampling, recovery and analytical procedures are summarized for each method in Appendix A.

CleanAir followed specific quality assurance and quality control (QA/QC) procedures as outlined in the individual methods and as prescribed in CleanAir's internal Quality Manual. Results of all QA/QC activities performed by CleanAir are summarized in Appendix D.

METHODOLOGY

PM and PM_{10} Testing - USEPA Method 5F/202

PM and PM_{10} emissions were determined using USEPA Method 5F/202.

- For this test program, PM assumed is equivalent to non-sulfate filterable particulate matter (NSFPM). Per 40 CFR Subpart Ja §60.104a, USEPA Method 5F is permitted for measuring front-half PM emissions from FCCUs.
- PM_{10} is equivalent to the sum of filterable particulate matter less than 10 micrometers (μm) in diameter (FPM_{10}) and condensable particulate matter (CPM). The Method 5F/202 sample train yields a front-half, non-sulfate FPM result and a back-half, CPM result. The total non-sulfate PM result (NSFPM plus CPM) from Method 5F/202 can be used as a worst-case estimation of Total PM_{10} since Method 5F will collect all non-sulfate filterable particulate matter present in the flue gas (regardless of particle size).

The front-half (Method 5F portion) of the sampling train consisted of a glass nozzle, glass liner and filter holder heated to 320°F, and a quartz fiber filter heated to 320°F. Flue gas samples were extracted isokinetically; nozzle and probe liner recoveries were performed using de-ionized water (DI H_2O) as the recovery solvent.

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 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 was 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.

METHODOLOGY

The front-half portion of the sample train (nozzle, probe and heated filter) was recovered per Method 5F requirements. 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.

NH_3 Testing – USEPA CTM-027

NH_3 emissions were determined using a CTM-027 and an isokinetic, multi-point sample train. The sampling system consisted of a glass nozzle, in-stack quartz filter, glass-lined heated probe, impinger train (for NH_3 collection and H_2O removal and measurement) and a dry gas meter. The NH_3-collecting impingers were charged with 0.1 N sulfuric acid (H_2SO_4) solution.

The sampling system traversed all of the Method 1 points during each run. A minimum volume of 0.9 dry standard cubic meters (dscm), or 31.8 dry standard cubic feet (dscf), were sampled during each sixty (60) minute run.

The sample train was recovered per CTM-027 requirements. The front-half assembly (components prior to the in-stack filter) was not recovered or analyzed, as gaseous NH_3 passed through without reacting or changing state. The three (3) NH_3-collecting impingers were recovered separately per CTM-027 requirements. The back-half of the sample train prior to Impinger 1 (heated probe and connecting glassware) was rinsed into Impinger 1.

A field blank and reagent blank were collected and archived. Samples were analyzed on-site per IC analysis.

METHODOLOGY

O_2 and CO_2 Testing - USEPA Method 3A

O_2 and CO_2 emissions were determined using a paramagnetic/NDIR analyzer per EPA Method 3A. The Method 3A sampling system consisted of a heated probe, heated filter and heated sample line. Flue gas was extracted at a constant rate and delivered at 250°F to a a gas conditioner which removed moisture before delivering the gas to a flow panel and the O_2/CO_2 analyzers which measured concentration on a dry basis (units of %dv).

O_2 / CO_2 calibration error checks were performed by introducing zero nitrogen (N_2), 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 Method 3A, the average results for each run were drift-corrected.

General Considerations

O_2 and CO_2 data for the non-instrumental (wet) sampling methods (used in molecular weight calculations and calculation of production-based emissions) was obtained using a modified version of EPA Method 3B:

- Multi-point, integrated gas samples (IGS) were continuously collected at a constant rate from a slipstream of the exhaust of the sample trains into a flexible vinyl bag (IGS bag) per Method 3B specifications.
- A calibrated paramagnetic/IR analyzer was used in place of a traditional Orsat analyzer to measure O_2 and CO_2 concentrations of the IGS bags per Method 3A specifications.
- Documentation of preliminary instrument calibrations and post-analysis calibration checks are included in Appendix E.

H_2O data used for moisture correction of concentration data was obtained (when required) in the following manner during the test program:

- For Method 5F/202 and CTM-027, Method 4 measurements are incorporated into the sampling and recovery procedures.

O_2, CO_2, H_2O data used for Method 2H and Method 2F flow calculations was obtained from the most concurrently operated Method 5F/202 or CTM-027 sample trains.

End of Section 4 – Methodology

APPENDIX

TEST METHOD SPECIFICATIONS

A

I hereby certify that all pages contained within this Appendix have been reviewed and, to the best of my ability, verified as accurate.

QA/QC Initials: RSD

Date: 1/16/15

CleanAir.