CleanAir Engineering 500 W. Wood Street Palatine, IL 60067-4975 cleanair.com



Marathon Petroleum Company LP 1300 South Fort Street Detroit, MI 48217

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REPORT ON RATA TESTING

Performed for: MARATHON PETROLEUM COMPANY LP DETROIT REFINERY

FCCU REGENERATOR STACK (EU11-FCCU-S1)

Client Reference No: 4100356132 CleanAir Project No: 12687-2 Revision 0: May 1, 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.

Submitted by,

Andy Obuchowski Project Manager abuchowski@cleanair.com (800) 627-0033 ext. 4537 Reviewed by,

Ken Sullivan

Project Manager ksullivan@cleanair.com (800) 627-0033 ext. 4527

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Client Reference No: 4100356132 CleanAir Project No: 12687-2

PROJECT OVERVIEW

INTRODUCTION

Marathon Petroleum Company LP (MPC) contracted Clean Air Engineering (CleanAir) to perform a relative accuracy test audit (RATA) on a continuous emissions monitoring system (CEMS) installed at the Detroit Refinery and to demonstrate compliance with permit limits.

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 John Elzaibak – CleanAir

Test Program Parameters

The testing was performed at the FCCU Regenerator Stack (Emission Unit ID No. EU11-FCCU-S1; Stack ID No. SVFCCU) on March 24, 2015, and included the following emissions measurements:

- oxygen (O₂)
- carbon dioxide (CO₂)
- sulfur dioxide (SO₂)
- nitrogen oxides (NO_X)
- carbon monoxide (CO)

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PROJECT OVERVIEW

TEST PROGRAM SYNOPSIS

Test Schedule

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

Run Number	Location	Method	Analyte	Date	Start Time	End Time
1	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	O2 / CO2 / SO2 / NOX / CO	03/25/15	08:59	09:20
2	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	O2/CO2/SO2/NOX/CO	03/25/15	09:50	10:11
3	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	O ₂ / CO ₂ / SO ₂ / NO _X / CO	03/25/15	10:32	10:53
4	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	O2 / CO2 / SO2 / NOX / CO	03/25/15	11:12	11:33
5	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	O ₂ / CO ₂ / SO ₂ / NO _X / CO	03/25/15	11:50	12:11
6	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	$O_2/CO_2/SO_2/NO_X/CO$	03/25/15	12:35	12:56
7	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	02/CO2/SO2/NOX/CO	03/25/15	13:18	13:39
8	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	02/CO2/SO2/NOX/CO	03/25/15	14:04	14:25
9	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	O2/CO2/SO2/NOX/CO	03/25/15	14:58	15:19
10	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	02/CO2/SO2/NOX/CO	03/25/15	15:39	16:00
11	FCCU Regenerator Stack	USEPA Method 3A / 6C / 7E / 10	O2/CO2/SO2/NOX/CO	03/25/15	16:29	16:50

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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 2-6.

	s	Table 1-2: ummary of RATA	Results		
<u>Source</u> Constituent (U	Reference nits) Method (USEF	Relative A) Accuracy (%) ¹	Units	Applicable Specification	Specification Limit ²
FCCU Regenerator St	<u>ack</u>				
O ₂ (% dv)	M-3A	0.1	%dv	PS3	±1.0% dv
CO ₂ (% dv)	M-3A	0.1	%dv	PS3	±1.0% dv
SO2 (ppm @ 0%)	D2) M-6C	0.3	% of Std.	PS2	10% of Std.3
NOx (ppm @ 0%0	02) M-7E	5.9	% of Std.	P\$2	10% of Std.⁴
CO (ppm @ 0%O	2) M-10	0.8	% of Std.	PS4A⁵	5% of Std. ⁶
emission standard ² Specification limit ³ Standard = 50 pp ⁴ Standard = 80 pp ⁵ For any sources e	r is expressed in terms of c 4 (% Std.). The specific exp s obtained from 40 CFR 60 mdv SO ₂ @ 0% O ₂ mdv NO _X @ 0% O ₂ mitting less than 200 ppm	ression used depends or , Appendix B, Performand of CO, PS4A applies. Th	n the specification se Specifications. ne PS4A RA limit i	limit s either < 10% of	
emission standard ² Specification limit ³ Standard = 50 ppr ⁴ Standard = 80 ppr ⁵ For any sources e RM, < 5% of Stan	# (% Std.). The specific exp s obtained from 40 CFR 60 mdv SO ₂ @ 0% O ₂ mdv NO _X @ 0% O ₂ mitting less than 200 ppmv dard, or \pm 5 ppmv (abs. ave omdv CO @ 0% O ₂	ression used depends or , Appendix B, Performand of CO, PS4A applies. Th	n the specifications. Se Specifications. Ne PS4A RA limit i a confidence coeff	limit s either < 10% of licient).	042415 153109
emission standard ² Specification limit ³ Standard = 50 ppr ⁴ Standard = 80 ppr ⁵ For any sources e RM, < 5% of Stan ⁶ Standard = 500 pp	# (% Std.). The specific exp s obtained from 40 CFR 60 mdv SO ₂ @ 0% O ₂ mdv NO _X @ 0% O ₂ mitting less than 200 ppmv dard, or \pm 5 ppmv (abs. ave omdv CO @ 0% O ₂	ression used depends or , Appendix B, Performand rof CO, PS4A applies. Th rage difference plus 2.5 : Table 1-3:	h the specifications. The PS4A RA limit is confidence coeff	limit s either < 10% of ficient). Results	042415 153109
emission standard ² Specification limit ³ Standard = 50 ppr ⁴ Standard = 80 ppr ⁵ For any sources e RM, < 5% of Stan ⁶ Standard = 500 pp	4 (% Std.). The specific exp s obtained from 40 CFR 60 mdv SO ₂ @ 0% O ₂ mdv NO _X @ 0% O ₂ mitting less than 200 ppmv dard, or ± 5 ppmv (abs. avo omdv CO @ 0% O ₂ Summary of	ression used depends or , Appendix B, Performand rof CO, PS4A applies. Th rage difference plus 2.5 : Table 1-3:	h the specifications. The PS4A RA limit is confidence coeff iance Test F	limit s either < 10% of licient).	042415 153109 Permit Limit ¹
emission standard ² Specification limit ³ Standard = 50 ppr ⁴ Standard = 80 ppr ⁵ For any sources e RM, < 5% of Stan ⁶ Standard = 500 pr <u>Source</u> <u>Constituent</u>	I (% Std.). The specific exp s obtained from 40 CFR 60 mdv SO ₂ @ 0% O ₂ motive NO _X @ 0% O ₂ mitting less than 200 ppmv dard, or ± 5 ppmv (abs. ave omdv CO @ 0% O ₂ Summary of (Units)	ression used depends or Appendix B, Performand of CO, PS4A applies. Th trage difference plus 2.5 Table 1-3: Emission Compl	h the specifications. The PS4A RA limit is confidence coeff iance Test F	limit s either < 10% of ficient). Results erage	
emission standard ² Specification limit ³ Standard = 50 ppi ⁴ Standard = 80 ppi ⁵ For any sources e RM, < 5% of Stan ⁶ Standard = 500 ppi <u>Source</u> <u>Constituent</u>	I (% Std.). The specific exp s obtained from 40 CFR 60 mdv SO ₂ @ 0% O ₂ motive NO _X @ 0% O ₂ mitting less than 200 ppmv dard, or ± 5 ppmv (abs. ave omdv CO @ 0% O ₂ Summary of (Units)	ression used depends or Appendix B, Performand of CO, PS4A applies. Th trage difference plus 2.5 Table 1-3: Emission Compl	n the specifications. Specifications. The PS4A RA limit is confidence coeff iance Test F Ave Emi	limit s either < 10% of ficient). Results erage	
emission standard ² Specification limit ³ Standard = 50 ppi ⁴ Standard = 80 ppi ⁵ For any sources e RM, < 5% of Stan ⁶ Standard = 500 ppi <u>Source</u> <u>Constituent</u> <u>FCCU Regenerato</u>	4 (% Std.). The specific exp s obtained from 40 CFR 60 mdv SO ₂ @ 0% O ₂ mot NO _X @ 0% O ₂ mitting less than 200 ppmv dard, or ± 5 ppmv (abs. ave omdv CO @ 0% O ₂ Summary of (Units) or Stack	ression used depends or Appendix B, Performand of CO, PS4A applies. Th trage difference plus 2.5 : Table 1-3: Emission Compl Sampling Method	n the specification the Specifications. The PS4A RA limit is confidence coeff iance Test F Ave Emi	limit s either < 10% of ficient). Results erage ssion	Permit Limit ¹

¹ Permit limits obtained from MDEQ Permit To Install No. 63-08D.

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PROJECT OVERVIEW

1-4

Discussion of Test Program

O_2 , CO_2 , SO_2 , NO_X , and CO RATA Testing - USEPA Methods 3A, 6C, 7E, and 10; Performance Specifications 2, 3, and 4/4A

Minute-average data points for O_2 , CO_2 , SO_2 , NO_X , and CO (dry basis) were collected over a period of 21 minutes for each RATA Reference Method (RM) run. The average result for each RM run was calculated and compared to the average result from the facility CEMs over an identical time interval in order to calculate relative accuracy (RA).

- For O_2 , RA is expressed as the average absolute difference between the RM and facility CEMs runs. The final result was below the limit of $\pm 1.0\%$ dv set by PS3.
- For CO₂, RA is expressed as the average absolute difference between the RM and facility CEMs runs. The final result was below the limit of $\pm 1.0\%$ dv set by PS3.
- For SO₂, RA is expressed as the percent difference between RM and facility CEMs runs. The final result was below the limit of 10% of the applicable standard (permit limit listed in Table 1-3) set by PS2.
- For NO_X, RA is expressed as the percent difference between RM and facility CEMs runs. The final result was below the limit of 10% of the applicable standard (permit limit listed in Table 1-3) set by PS2.
- For CO, RA is expressed as the percent difference between RM and facility CEMs runs. The final result was below the limit of 5% of the applicable standard (permit limit listed in Table 1-3) set by PS2.

A total of eleven (11) RM runs were performed. For each constituent, RA was calculated by selecting the nine (9) most comparable runs which yielded the lowest calculated result.

Following Run 1, the RM bias did not meet the calibration criterion for CO_2 zero gas. Therefore, Run 1 was not included in the (9) most comparable runs for CO_2 as outlined above. The bias adjusted CO_2 values for Run 2 utilized the initial bias (00) and the post run bias (02). All consecutive bias tests met the necessary criteria.

Calculation of Emission Compliance Results

 SO_2 , NO_X , and CO emission results in units of dry volume-based concentration (ppmdv) were converted to ppmdv at 0% O_2 using data collected by CleanAir concurrent with the applicable constituent measurements.

End of Section 1 – Project Overview

MARATHON PETROLEUM COMPANY LP DETROIT REFINERY

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2-1

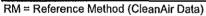
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DEC		

		c		Table 2-1: Iracy (USEPA M-	3A / PS3)	
Run No.	Start Time	Date (2015)	RM Data (%dv)	CEMS Data (%dv)	Difference (%dv)	Difference Percent
1 *	08:59	Mar 25	2.22	2.45	-0.24	-10.7%
2	09:50	Mar 25	2.95	3.14	-0.19	-6.6%
3	10:32	Mar 25	2.76	2.87	-0.11	-3.8%
4	11:12	Mar 25	3.17	3.33	-0.16	-5.1%
5 *	11:50	Mar 25	2.55	2.74	-0.18	-7.2%
6	12:35	Mar 25	2.41	2.49	-0.09	-3.7%
7	13:18	Mar 25	2.35	2.50	-0.15	-6.5%
8	14:04	Mar 25	2.42	2.57	-0.15	-6.1%
9	14:58	Mar 25	2.36	2.48	-0.12	-5.1%
10	15:39	Mar 25	2.37	2.52	-0.15	-6.3%
11	16:29	Mar 25	2.45	2.61	-0.16	-6.4%
	Average		2.58	2.72	-0.14	-5.5%

Relative Accuracy Test Audit Results

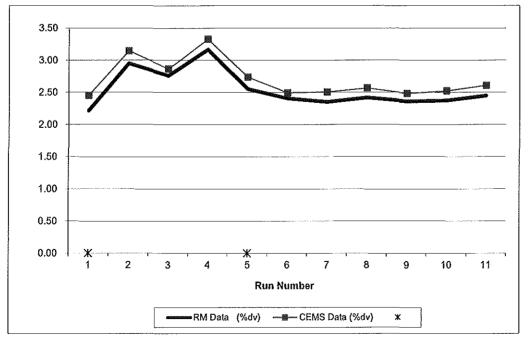
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Standard Deviation of Differences	0.032
Confidence Coefficient (CC)	0.025
t-Value for 9 Data Sets	2.306
Avg. Abs. Diff. (%dv)	0.142



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CEMS = Continuous Emissions Monitoring System (Marathon Petroleum Company Data) RATA calculations are based on 9 of 11 runs. * indicates the excluded runs.



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Difference

Percent

2.4% -0.2%

0.6%

0.5%

1.3%

1.2%

1.0%

1.0% 1.3%

1.0%

0.9% 0.8% 2-2

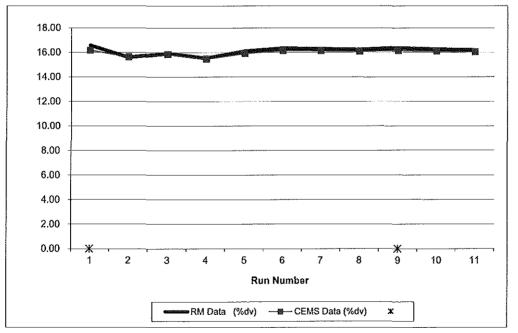
ΞŚ	SULT	ſS				
			CC		⁻ able 2-2: uracy (USEPA M	-3A / PS3)
	Run No.	Start Time	Date (2015)		CEMS Data (%dv)	Difference (%dv)
	1 *	08:59	Mar 25	16.56	16.16	0.40
	2	09:50	Mar 25	15.58	15.62	-0.03
	3	10:32	Mar 25	15.91	15.82	0.09
	4	11:12	Mar 25	15.53	15.45	0.08
	5	11:50	Mar 25	16.11	15.90	0.20
	6	12:35	Mar 25	16.33	16.14	0.19
	7	13:18	Mar 25	16.29	16.12	0.17
	8	14:04	Mar 25	16.22	16.07	0.16
	9 *	14:58	Mar 25	16.36	16.15	0.21
	10	15:39	Mar 25	16.27	16.10	0.17
	11	16:29	Mar 25	16.18	16.03	0.15
-		Average		16.05	15.92	0.13
				Relative A	Accuracy Test Audi	Results
		Stan	dard Devia	ation of Differences	0.074	
			Confiden	ce Coefficient (CC)	0.057	
			t-Va	lue for 9 Data Sets	2.306	
						Limit
			A۱	/g. Abs. Diff. (%dv)	0.138	1.0

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RM = Reference Method (CleanAir Data)

CEMS = Continuous Emissions Monitoring System (Marathon Petroleum Company Data) RATA calculations are based on 9 of 11 runs. * indicates the excluded runs.



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MARATHON PETROLEUM COMPANY LP DETROIT REFINERY

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2-3

		so	Ta Relative Accur	ible 2-3: acv (USEPA M-0	6C / PS2)	
Run No.	Start Time	Date (2015)	RM Data (ppm@0%O2)	CEMS Data (ppm@0%O2)	Difference (ppm@0%O2)	
1	08:59	Mar 25	0.00	0.09	-0.09	
2	09:50	Mar 25	0.00	0.17	-0.17	
3	10:32	Mar 25	0.00	0.12	-0.12	
4	11:12	Mar 25	0.00	0.12	-0.12	
5 *	11:50	Mar 25	0.00	0.25	-0.25	
6	12:35	Mar 25	0.00	0.12	-0.12	
7	13:18	Mar 25	0.00	0.14	-0.14	
8	14:04	Mar 25	0.00	0.15	-0.15	
9	14:58	Mar 25	0.00	0.14	-0.14	
10 *	15:39	Mar 25	0.00	0.33	-0.33	
11	16:29	Mar 25	0.00	0.14	-0.14	
	Average		0.00	0.13	-0.13	
			Relative Ac	curacy Test Audit I	Results	
	Star	idard Deviat	ion of Differences	0.025		
		Confidenc	e Coefficient (CC)	0.019		
			le for 9 Data Sets	2.306		
					Limit	
	Relative	Accuracy (a	s % of Appl. Std.)	0.3%	10.0%	
	Арр	l. Std. = 50	ppm@0%O2			

RM = Reference Method (CleanAir Data)

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CEMS = Continuous Emissions Monitoring System (Marathon Petroleum Company Data) RATA calculations are based on 9 of 11 runs. * indicates the excluded runs.

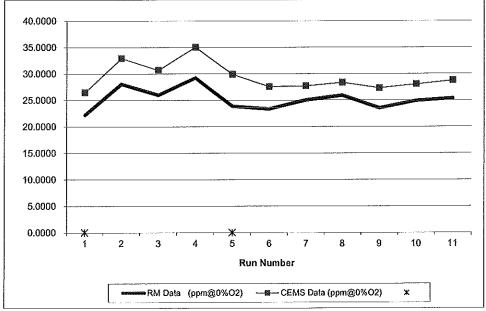
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MARATHON PETROLEUM COMPANY LP DETROIT REFINERY

Client Reference No: 4100356132 CleanAir Project No: 12687-2

2-4

5tart Time 08:59 09:50 10:32 11:12 11:50	NO _x Date (2015) Mar 25 Mar 25 Mar 25 Mar 25	Relative Accur RM Data (ppm@0%O2) 22.2100 28.0322 25.9799	CEMS Data (ppm@0%O2) 26.4672 32.9002	Difference (ppm@0%O2) -4.2572 -4.8680	Difference Percent -19.2% -17.4%
'ime 08:59 09:50 10:32 11:12	(2015) Mar 25 Mar 25 Mar 25	(ppm@0%O2) 22.2100 28.0322	(ppm@0%O2) 26.4672 32.9002	(ppm@0%O2) -4.2572 -4.8680	Percent -19.2%
09:50 10:32 11:12	Mar 25 Mar 25	28.0322	32.9002	-4.8680	
10:32 11:12	Mar 25				-17.4%
11:12		25.9799	00 0774		
	Mor 05		30.6771	-4.6972	-18.1%
1:50	wai 20	29.2240	35.0127	-5.7888	-19.8%
	Mar 25	23.8573	29.8820	-6.0247	-25.3%
12:35	Mar 25	23.3360	27.5282	-4.1922	-18.0%
13:18	Mar 25	25.0187	27.6917	-2.6730	-10.7%
14:04	Mar 25	25.9021	28.3237	-2.4216	-9.3%
14:58	Mar 25	23.5102	27.2760	-3.7658	-16.0%
15:39	Mar 25	24.8941	28.0098	-3.1157	-12.5%
16:29	Mar 25	25.3567	28.7155	-3.3588	-13.2%
erage		25,6949	29.5706	-3.8757	-15.19
Stan					
		Relative Ac	curacy lest Audit I	Results	
	Confidenc	e Coefficient (CC)	0.852369		
			2.306		
				Limit	
Re	lative Accu	racy (as % of RM)	18.4%	20.0%	
			5.9%	10.0%	
			Nr		042415 132
			m (Marathon Petrol	eum Company Data'	
		d on 9 of 11 runs. * in			
	4:04 4:58 5:39 6:29 erage Stan Re elative Applerence Continu	4:04 Mar 25 (4:58 Mar 25 (5:39 Mar 25 (6:29 Mar 25 (6:29 Mar 25 (6:29 Mar 25) (6:29 Mar 25) (7:40 Ma	4:04 Mar 25 25.9021 4:58 Mar 25 23.5102 5:39 Mar 25 24.8941 6:29 Mar 25 25.3567 erage 25.6949 Relative Acc Standard Deviation of Differences Confidence Coefficient (CC) t-Value for 9 Data Sets Relative Accuracy (as % of RM) elative Accuracy (as % of Appl. Std.) Appl. Std. = 80 ppm@0%O2 erence Method (CleanAir Data) continuous Emissions Monitoring System	44:04 Mar 25 25.9021 28.3237 14:58 Mar 25 23.5102 27.2760 15:39 Mar 25 24.8941 28.0098 16:29 Mar 25 25.3567 28.7155 erage 25.6949 29.5706 Relative Accuracy Test Audit I Standard Deviation of Differences 1.108892 Confidence Coefficient (CC) 0.852369 t-Value for 9 Data Sets 2.306 Relative Accuracy (as % of RM) 18.4% elative Accuracy (as % of Appl. Std.) 5.9% Appl. Std. = 80 ppm@0%O2 5.9% continuous Emissions Monitoring System (Marathon Petroletered)	Control Line Line 14:04 Mar 25 25.9021 28.3237 -2.4216 14:58 Mar 25 23.5102 27.2760 -3.7658 15:39 Mar 25 24.8941 28.0098 -3.1157 16:29 Mar 25 25.3567 28.7155 -3.3588 erage 25.6949 29.5706 -3.8757 Relative Accuracy Test Audit Results Standard Deviation of Differences 1.108892 Confidence Coefficient (CC) 0.852369 t-Value for 9 Data Sets 2.306 Limit Relative Accuracy (as % of RM) 18.4% 20.0% elative Accuracy (as % of Appl. Std.) 5.9% 10.0% Appl. Std. = 80 ppm@0%O2 Evence Method (CleanAir Data) Continuous Emissions Monitoring System (Marathon Petroleum Company Data)



Revision 0, Final Report

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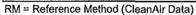
MARATHON PETROLEUM COMPANY LP DETROIT REFINERY

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2-5

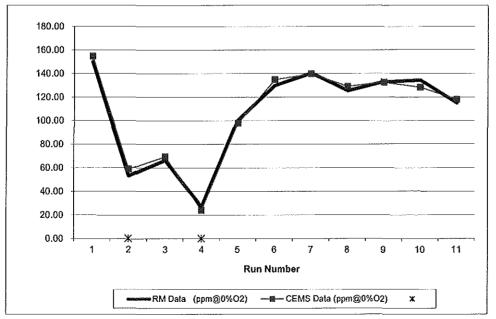
		со	Ta Relative Accura	ble 2-5: icy (USEPA M-1	0 / PS4A)	
Run No.	Start Time	Date (2015)	RM Data (ppm@0%O2)	CEMS Data (ppm@0%O2)	Difference (ppm@0%O2)	Difference Percent
1	08:59	Mar 25	149.96	154.55	-4.58	-3.1%
2 *	09:50	Mar 25	53.15	58.88	-5.73	-10.8%
3	10:32	Mar 25	66.35	69.31	-2.96	-4.5%
4 *	11:12	Mar 25	27.00	23.94	3.06	11.3%
5	11:50	Mar 25	100.51	97.81	2.70	2.7%
6	12:35	Mar 25	129.78	134.76	-4.98	-3.8%
7	13:18	Mar 25	140.33	139.60	0.73	0.5%
8	14:04	Mar 25	125.30	128.97	-3.67	-2.9%
9	14:58	Mar 25	133.01	132.65	0.36	0.3%
10	15:39	Mar 25	134.39	128.22	6.17	4.6%
11	16:29	Mar 25	115.06	117.95	-2.89	-2.5%
	Average		121.63	122.65	-1.01	-0.8%

Standard Deviation of Differences	3.761	
Confidence Coefficient (CC)	2.891	
t-Value for 9 Data Sets	2.306	
		Limit
Relative Accuracy (as % of RM)	3.2%	10.0%
Relative Accuracy (as % of Appl. Std.)	0.8%	5.0%
Appl. Std. = 500 ppm@0%O2		



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CEMS = Continuous Emissions Monitoring System (Marathon Petroleum Company Data) RATA calculations are based on 9 of 11 runs. * indicates the excluded runs.



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RESULTS

2-6

	SO ₂ , NO _X , and	Tabl I CO Emissio		PA M-6C	7E / 10)		
Run No.		1	2	3	4	5	6
Date (201	15)	Mar 25	Mar 25	Mar 25	Mar 25	Mar 25	Mar 25
Start Time	e (approx.)	08:59	09:50	10:32	11:12	11:50	12:35
Stop Time	е (арргох.)	09:20	10:11	10:53	11:33	12:11	12:56
Process	Conditions						
P ₁	FCC charge rate (bpd)	23,314	22,394	22,812	23,155	23,411	23,500
P ₂	NH ₃ Injection (lb/hr)	17.89	17.98	17.83	17.83	17.77	17.80
Gas Con	ditions						
O ₂	Oxygen (dry volume %)	2.22	2.95	2.76	3.17	2.55	2.4
CO ₂	Carbon dioxide (dry volume %) ¹	16.6	15.6	15.9	15.5	16.1	16.
-	oxide Results ²				1010		
C _{sd}	Concentration (ppmdv)	<0.45	<0.45	<0.45	<0.45	<0.45	<0.4
C _{sd-x}	Concentration @ 0% O ₂ (ppmdv)	< 0.45 < 0.51	< 0.45	< 0.45 < 0.52	<0.45 < 0.53	< 0.45	< 0.4
C _{sd}	Concentration (ib/dscf)	<7.52E-08	<7.52E-08	<7.52E-08	<7.52E-08	<7.52E-08	<7.52E-0
-	Oxides Results	40.0	04.4	00.5	04.0	00.0	20.
C _{sd} C _{sd-x}	Concentration (ppmdv) Concentration @ 0% O ₂ (ppmdv)	19.9 22.2	24.1 28.0	22.5 26.0	24.8 29.2	20.9 23.9	20.
C _{sd}	Concentration (ib/dscf)	22.2 2.37E-06	2.87E-06	20.0 2.69E-06	29.2 2.96E-06	2.50E-06	2.47E-0
	• •	2.572-00	2.071.00	£,000-00	2.002-00	2.001-00	2.472-0
Sarbon N	Monoxide Results				00 D (
~							114.8
C _{sd} C _{sd-x}	Concentration (ppmdv) Concentration @ 0% O ₂ (ppmdv)	134.07 150.0	45.65 53.2	67.69 66.3	22.91 27.0	88.23 100.5	129.
C _{sd·x}							
	Concentration @ 0% O ₂ (ppmdv)	150.0	53.2	66.3	27.0	100.5	129.
C _{sd·x} Run No. Date (201	Concentration @ 0% O ₂ (ppmdv)	150.0 7	53.2 8	66.3 9	27.0	100.5	129.
C _{sd•x} Run No. Date (201 Start Time	Concentration @ 0% O₂ (ppmdv) 15)	150.0 7 Mar 25	53.2 8 Mar 25	66.3 9 Mar 25	27.0 10 Mar 25	100.5 11 Mar 25	129.
C _{sd-x} Run No. Date (201 Start Time Stop Time	Concentration @ 0% O ₂ (ppmdv) 5) e (approx.)	150.0 7 Mar 25 13:18	53.2 8 Mar 25 14:04	66.3 9 Mar 25 14:58	27.0 10 Mar 25 15:39	100.5 11 Mar 25 16:29	129.
C _{sd-x} Run No. Date (201 Start Time Stop Time	Concentration @ 0% Ó ₂ (ppmdv) 15) e (approx.) e (approx.)	150.0 7 Mar 25 13:18	53.2 8 Mar 25 14:04	66.3 9 Mar 25 14:58	27.0 10 Mar 25 15:39	100.5 11 Mar 25 16:29	129. Averaç
C _{sd-x} Run No. Date (201 Start Time Stop Time Process (Concentration @ 0% Ó ₂ (ppmdv) 15) e (approx.) e (approx.) Conditions	150.0 7 Mar 25 13:18 13:39	53.2 8 Mar 26 14:04 14:25	66.3 9 Mar 25 14:58 15:19	27.0 10 Mar 25 15:39 16:00	100.5 11 Mar 25 16:29 16:50	129. Averaç 23,25
C _{sd-x} Run No. Date (201 Start Time Stop Time Process 0 P1 P2	Concentration @ 0% O ₂ (ppmdv) 5) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (lb/hr)	150.0 7 Mar 25 13:18 13:39 23,451	53.2 8 Mar 26 14:04 14:25 23,438	66.3 9 Mar 25 14:58 15:19 23,460	27.0 10 Mar 25 15:39 16:00 23,478	100.5 11 Mar 25 16:29 16:50 23,387	129. Averaç 23,25
C _{sd-x} Run No. Date (201 Start Time Stop Time Process 0 P ₁ P ₂	Concentration @ 0% O ₂ (ppmdv) 5) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (lb/hr)	150.0 7 Mar 25 13:18 13:39 23,451	53.2 8 Mar 26 14:04 14:25 23,438	66.3 9 Mar 25 14:58 15:19 23,460	27.0 10 Mar 25 15:39 16:00 23,478	100.5 11 Mar 25 16:29 16:50 23,387	129. Averag 23,25 17.8
C _{sd-x} Run No. Date (201 Start Time Stop Time Process (P1 P2 Stas Cond	Concentration @ 0% O ₂ (ppmdv) (5) e (approx.) e (approx.) conditions FCC charge rate (bpd) NH ₃ injection (lb/hr) ditions	150.0 7 Mar 25 13:18 13:39 23,451 17.67	53.2 8 Mar 26 14:04 14:25 23,438 17.80	66.3 9 Mar 25 14:58 15:19 23,460 17.77	27.0 10 Mar 25 15:39 16:00 23,478 17.76	100.5 11 Mar 25 16:29 16:50 23,387 17.77	129. Averag 23,25 17.8 2.5
C_{sd-x} Run No. Date (201 Start Time Stop Time Process (P1 P2 Gas Cond O2 CO2	Concentration @ 0% O ₂ (ppmdv) (5) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (lb/hr) ditions Oxygen (dry volume %) Carbon dioxide (dry volume %) ¹	150.0 7 Mar 25 13:18 13:39 23,451 17.67 2.35	53.2 8 Mar 26 14:04 14:25 23,438 17.80 2.42	66.3 9 Mar 25 14:58 15:19 23,460 17.77 2.36	27.0 10 Mar 25 15:39 16:00 23,478 17.76 2.37	100.5 11 Mar 25 16:29 16:50 23,387 17.77 2.45	129. Averag 23,25 17.8 2.5
C_{sd-x} Run No. Date (201 Start Time Stop Time Process P P1 P2 Gas Conc O2 CO2 Sulfur Dia	Concentration @ 0% O ₂ (ppmdv) (5) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (lb/hr) ditions Oxygen (dry volume %) Carbon dioxide (dry volume %) ¹ oxide Results ²	150.0 7 Mar 25 13:18 13:39 23,451 17.67 2.35 16.3	53.2 8 Mar 25 14:04 14:25 23,438 17.80 2.42 16.2	66.3 9 Mar 25 14:58 15:19 23,460 17.77 2.36 16.4	27.0 10 Mar 25 16:39 16:00 23,478 17.76 2.37 16.3	100.5 11 Mar 25 16:29 16:50 23,387 17.77 2.45 16.2	129. Avera 23,25 17.8 2.5 16.
C_{sd-x} Run No. Date (201) Start Time Stop Time Process P Process P Pass Cond O_2 CO_2	Concentration @ 0% O ₂ (ppmdv) (5) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (lb/hr) ditions Oxygen (dry volume %) Carbon dioxide (dry volume %) ¹	150.0 7 Mar 25 13:18 13:39 23,451 17.67 2.35	53.2 8 Mar 26 14:04 14:25 23,438 17.80 2.42	66.3 9 Mar 25 14:58 15:19 23,460 17.77 2.36	27.0 10 Mar 25 15:39 16:00 23,478 17.76 2.37	100.5 11 Mar 25 16:29 16:50 23,387 17.77 2.45	129.
C_{sd-x} Run No. Date (201 Start Time Stop Time Process P Process P P P Sas Cond O ₂ CO ₂ Sulfur Did C _{sd}	Concentration @ 0% O ₂ (ppmdv) (5) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (ib/hr) ditions Oxygen (dry volume %) Carbon dioxide (dry volume %) ¹ oxide Results ² Concentration (ppmdv)	150.0 7 Mar 25 13:18 13:39 23,451 17.67 2.35 16.3 <0.45	53.2 8 Mar 25 14:04 14:25 23,438 17.80 2.42 16.2 <0.45	66.3 9 Mar 25 14:58 15:19 23,460 17.77 2.36 16.4 <0.45	27.0 10 Mar 25 15:39 16:00 23,478 17.76 2.37 16.3 <0.45	100.5 11 Mar 25 16:29 16:50 23,387 17.77 2.45 16.2 <0.45	129. Averas 23,25 17.8 2.5 16. <0.4 <0.5
C_{sd-x} Run No. Date (201 Start Time Stop Time Process (P1 P2 Gas Cone O2 CO2 Sulfur Die Csd Csd Csd Csd Csd	Concentration @ 0% O ₂ (ppmdv) (5) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (lb/hr) ditions Oxygen (dry volume %) Carbon dioxide (dry volume %) ¹ oxide Results ² Concentration (ppmdv) Concentration @ 0% O ₂ (ppmdv) Concentration (lb/dscf)	150.0 7 Mar 25 13:18 13:39 23,451 17.67 2.35 16.3 <0.45 < 0.51	53.2 8 Mar 25 14:04 14:25 23,438 17.80 2.42 16.2 <0.45 < 0.51	66.3 9 Mar 25 14:58 15:19 23,460 17.77 2.36 16.4 <0.45 < 0.51	27.0 10 Mar 25 15:39 16:00 23,478 17.76 2.37 16.3 <0.45 < 0.51	100.5 11 Mar 25 16:29 16:50 23,387 17.77 2.45 16.2 <0.45 < 0.51	129. Averas 23,25 17.8 2.5 16. <0.4 <0.5
C _{sd-x} Run No. Date (201 Start Time Stop Time Process C P1 P2 Bas Cone O_2 CO ₂ Sulfur Die C _{sd} C _{sd} C _{sd} C _{sd} Sulfur Die C _{sd}	Concentration @ 0% O ₂ (ppmdv) 15) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (lb/hr) ditions Oxygen (dry volume %) Carbon dioxide (dry volume %) ¹ oxide Results ² Concentration (ppmdv) Concentration @ 0% O ₂ (ppmdv) Concentration (lb/dscf) Oxides Results	150.0 7 Mar 25 13:18 13:39 23,451 17.67 2.35 16.3 <0.45 <0.45 <0.51 <7.52E-08	53.2 8 Mar 25 14:04 14:25 23,438 17.80 2.42 16.2 <0.45 < 0.51 <7.52E-08	66.3 9 Mar 25 14:58 15:19 23,460 17.77 2.36 16.4 <0.45 < 0.51 <7.52E-08	27.0 10 Mar 25 15:39 16:00 23,478 17.76 2.37 16.3 <0.45 < 0.51 <7.52E-08	100.5 11 Mar 25 16:29 16:50 23,387 17.77 2.45 16.2 <0.45 < 0.51 <7.52E-08	129. Averas 23,25 17.8 2.5 16. <0.4 <0.5 <7.52E-0
C_{sd-x} Run No. Date (201 Start Time Stop Time Process (P1 P2 Bas Cond O2 CO2 Builfur Dia Csd Csd Csd Csd Csd Csd Start Dia Csd Csd Csd Csd Csd Csd Csd Csd Csd Csd	Concentration @ 0% O ₂ (ppmdv) (5) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (lb/hr) ditions Oxygen (dry volume %) Carbon dioxide (dry volume %) ¹ Oxide Results ² Concentration (ppmdv) Concentration (ib/dscf) Oxides Results Concentration (ppmdv)	150.0 7 Mar 25 13:18 13:39 23,451 17.67 2.35 16.3 <0.45 <0.45 <0.51 <7.52E-08 22.2	53.2 8 Mar 25 14:04 14:25 23,438 17.80 2.42 16.2 <0.45 < 0.51 <7.52E-08 22.9	66.3 9 Mar 25 14:58 15:19 23,460 17.77 2.36 16.4 <0.45 < 0.51 <7.52E-08 20.9	27.0 10 Mar 25 15:39 16:00 23,478 17.76 2.37 16.3 <0.45 < 0.51 <7.52E-08 22.1	100.5 11 Mar 25 16:29 16:50 23,387 17.77 2.45 16.2 <0.45 < 0.51 <7.52E-08 22.4	129. Averas 23,25 17.8 2.5 16. <0.4 <0.5 <7.52E-0 22.
C_{sd-x} Run No. Date (201 Start Time Stop Time Process (P1 P2 Co2 Co2 Sulfur Dia Co3 Co3 Co3 Co3 Co3 Co3 Co3 Co3 Co3 Co3	Concentration @ 0% O ₂ (ppmdv) 15) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (lb/hr) ditions Oxygen (dry volume %) Carbon dioxide (dry volume %) ¹ oxide Results ² Concentration (ppmdv) Concentration @ 0% O ₂ (ppmdv) Concentration (lb/dscf) Oxides Results	150.0 7 Mar 25 13:18 13:39 23,451 17.67 2.35 16.3 <0.45 <0.45 <0.51 <7.52E-08	53.2 8 Mar 25 14:04 14:25 23,438 17.80 2.42 16.2 <0.45 < 0.51 <7.52E-08	66.3 9 Mar 25 14:58 15:19 23,460 17.77 2.36 16.4 <0.45 <0.51 <7.52E-08 20.9 23.5	27.0 10 Mar 25 15:39 16:00 23,478 17.76 2.37 16.3 <0.45 < 0.51 <7.52E-08	100.5 11 Mar 25 16:29 16:50 23,387 17.77 2.45 16.2 <0.45 < 0.51 <7.52E-08	129. Averas 23,25 17.8 2.5 16. <0.4 <0.5 <7.52E-0 22. 25.
$C_{sd \cdot x}$ Run No. Date (201 Start Time Stop Time Process (Process (Proces) (Pro	Concentration $\textcircled{0}$ 0% O_2 (ppmdv) 15) e (approx.) e (approx.) conditions FCC charge rate (bpd) NH ₃ injection (lb/hr) ditions Oxygen (dry volume %) Carbon dioxide (dry volume %) ¹ oxide Results ² Concentration (ppmdv) Concentration (b/dscf) Oxides Results Concentration (ppmdv) Concentration (b/dscf)	150.0 7 Mar 25 13:18 13:39 23,451 17.67 2.35 16.3 <0.45 <0.45 <0.51 <7.52E-08 22.2 25.0	53.2 8 Mar 25 14:04 14:25 23,438 17.80 2.42 16.2 <0.45 < 0.51 <7.52E-08 22.9 25.9	66.3 9 Mar 25 14:58 15:19 23,460 17.77 2.36 16.4 <0.45 < 0.51 <7.52E-08 20.9	27.0 10 Mar 25 15:39 16:00 23,478 17.76 2.37 16.3 <0.45 < 0.51 <7.52E-08 22.1 24.9	100.5 11 Mar 25 16:29 16:50 23,387 17.77 2.45 16.2 <0.45 <0.51 <7.52E-08 22.4 25.4	129. Averas 23,25 17.8 2.5 16. <0.4 <0.5
$C_{sd \cdot x}$ Run No. Date (201 Start Time Stop Time Process (Process (Proces) (Pro	Concentration @ 0% O ₂ (ppmdv) 15) e (approx.) e (approx.) Conditions FCC charge rate (bpd) NH ₃ injection (lb/hr) ditions Oxygen (dry volume %) Carbon dioxide (dry volume %) ¹ oxide Results ² Concentration (ppmdv) Concentration (b/dscf) Oxides Results Concentration (ppmdv) Concentration (ppmdv) Concentration (ppmdv) Concentration (ppmdv) Concentration (ppmdv) Concentration (ppmdv) Concentration (ppmdv) Concentration (ppmdv)	150.0 7 Mar 25 13:18 13:39 23,451 17.67 2.35 16.3 <0.45 <0.45 <0.51 <7.52E-08 22.2 25.0	53.2 8 Mar 25 14:04 14:25 23,438 17.80 2.42 16.2 <0.45 < 0.51 <7.52E-08 22.9 25.9	66.3 9 Mar 25 14:58 15:19 23,460 17.77 2.36 16.4 <0.45 <0.51 <7.52E-08 20.9 23.5	27.0 10 Mar 25 15:39 16:00 23,478 17.76 2.37 16.3 <0.45 < 0.51 <7.52E-08 22.1 24.9	100.5 11 Mar 25 16:29 16:50 23,387 17.77 2.45 16.2 <0.45 <0.51 <7.52E-08 22.4 25.4	129. Averas 23,25 17.8 2.5 16. <0.4 <0.5 <7.52E-0 22. 25.

Average includes 11 runs.

¹ Average CO₂ includes 10 run, Run 1 is not included.

² For SO₂, '<' Indicates a measured response below the detection limit (assumed to be 1% of the instrument calibration span).

End of Section 2 – Results