1. PROJECT OVERVIEW

TEST PROGRAM SUMMARY

Marathon Petroleum Company LP (MPC) contracted CleanAir Engineering (CleanAir) to complete testing on the B&W Boiler (EU27-B&WBOILER-S1) at the Detroit Refinery. The test program included the following objective:

- Perform filterable particulate matter (FPM), sulfuric acid mist (H_2SO_4), and volatile organic compounds (VOCs) testing to demonstrate compliance with the Michigan Department of Environment, Great Lakes, and Energy (EGLE) 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]
B&W Boiler Stack			
PM (lb/MMBtu)	USEPA 5	0.0013	0.0019
VOC (lb/MMBtu)	USEPA 25A	0.0010	0.0055

[1] Permit limits obtained from EGLE Renewable Operating Permit No. MI-ROP-A9831-2012c.

TEST PROGRAM DETAILS

PARAMETERS

The test program included the following measurements:

- particulate matter (PM) assumed equivalent to FPM only
- VOCs assumed equivalent to total hydrocarbons (THCs) minus methane and ethane
- flue gas composition (e.g., O_2, CO_2, H_2O)
- flue gas temperature
- flue gas flow rate

SCHEDULE

Testing was performed on March 5, 2020. 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	B&W Boiler	USEPA Method 5	FPM	03/05/20	10:40	11:43
2	B&W Boiler	USEPA Method 5	FPM	03/05/20	12:13	13:16
3	B&W Boiler	USEPA Method 5	FPM	03/05/20	13:44	14:47
4	B&W Boiler	USEPA Method 5	FPM	03/05/20	15:09	16:11
1	B&W Boiler	USEPA Method 25A / 18	VOC	03/05/20	10:05	10:55
2	B&W Boiler	USEPA Method 25A / 18	VOC	03/05/20	12:00	13:00
3	B&W Boiler	USEPA Method 25A / 18	VOC	03/05/20	16:00	17:00

DISCUSSION

Filterable Particulate Matter Testing

A total of four (4) 60-minute EPA Method 5 test runs were performed. FPM 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) test runs.

Volatile Organic Compounds Testing

VOC emissions were determined using EPA Method 25A to quantify THC emissions. The results were comprised of three (3) 60-minute test runs. The final result was expressed as the average of the three (3) test runs.

Oxygen concentrations from concurrent Method 3A test runs were utilized to convert VOC results to lb/MMBtu. THC data was converted from an actual (wet) basis to a dry basis using moisture data collected from nearly concurrent Method 5 test runs. VOC emissions are reported on a propane basis.

An integrated gas sample was collected during each test run for follow-up analysis for methane and ethane by Method 18 at CleanAir's Analytical Services in Palatine, Illinois. The methane and ethane results were subtracted from the Method 25A THC results.

Fuel F_d Factor

Emission results in units of dry volume-based concentration (lb/dscf, ppmdv) were converted to units of lb/MMBtu by calculating a combination oxygen-based fuel factor (F_d) for natural gas and refinery gas per EPA Method 19 specifications.

- For natural gas, the volume-based gross heat content (GCV_V) was obtained from a gas analysis report provided by MPC. The natural gas F_d factor was obtained from 40 CFR Part 75, Appendix F, Table 1. This approach should yield worst-case calculated emission results.
- For refinery gas, the heat content and F_d factor was calculated from percent volume composition analytical data, provided by MPC, and tabulated heating values for each of the measured constituents.

A refinery gas and natural gas combined F_d factor was calculated for each run based on respective fuel flow during the run.

Test Conditions

The unit was operated at the maximum normal operating capacity during each of the emissions compliance test runs. Test run process data is presented in Section 2 results tables. 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.

Table 2-1:
B&W Boiler Stack – FPM Emissions

Run No.		1	2	3	4	Average
Date (2020)		Mar 5	Mar 5	Mar 5	Mar 5	
Start Time (approx.)		10:40	12:13	13:44	15:09	
Stop Time (approx.)		11:43	13:16	14:47	16:11	
Process Conditions						
R_P	Steam Production (mlb/hr)	125	124	124	123	**124**
P_1	Firing Rate (MMBtu/hr)	278	277	278	278	**278**
F_d	Oxygen-based F-factor (dscf/MMBtu)	8,391	8,391	8,391	8,391	**8,391**
H_i	Actual heat input (MMBtu/hr)	252	252	252	252	**252**
Gas Conditions						
O_2	Oxygen (dry volume %)	5.6	5.7	5.6	5.7	**5.7**
CO_2	Carbon dioxide (dry volume %)	8.5	8.4	8.5	8.4	**8.5**
T_s	Sample temperature (°F)	335	337	337	336	**336**
B_w	Actual water vapor in gas (% by volume)	15.3	15.7	15.9	16.0	**15.7**
Gas Flow Rate						
Q_a	Volumetric flow rate, actual (acfm)	96,700	96,000	98,500	95,800	**96,700**
Q_s	Volumetric flow rate, standard (scfm)	62,900	62,300	64,000	62,200	**62,900**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	53,300	52,500	53,800	52,300	**53,000**
Sampling Data						
V_{mstd}	Volume metered, standard (dscf)	35.48	38.00	39.45	37.83	**37.69**
%I	Isokinetic sampling (%)	96.8	105.1	106.6	105.2	**103.4**
Laboratory Data						
m_n	Total FPM (g)	0.00238	0.00187	0.00169	0.00172	
FPM Results[2]						
C_{sd}	Particulate Concentration (lb/dscf)	1.48E-07	1.09E-07	9.45E-08	1.00E-07	**8.98E-01**
$E_{lb/hr}$	Particulate Rate (lb/hr)	0.473	0.342	0.305	0.315	**0.359**
E_{Fd}	Particulate Rate - F_d-based (lb/MMBtu)	0.00170	0.00125	0.00108	0.00116	**0.00130**

Table 2-2:
B&W Boiler Stack – VOC Emissions

Run No.		1	2	3	Average
Date (2020)		Mar 5	Mar 5	Mar 5	
Start Time (approx.)		10:42	12:16	13:46	
Stop Time (approx.)		11:42	13:16	14:46	
Process Conditions					
R_P	Steam Production (mlb/hr)	125	124	124	**124**
P_1	Firing rate ((MMBtu/hr)	278	277	278	**278**
F_d	Oxygen-based F-factor (dscf/MMBtu)	8,391	8,391	8,391	**8,391**
H_i	Actual heat input (MMBtu/hr)	252	252	252	**252**
Gas Conditions					
O_2	Oxygen (dry volume %)	5.58	5.71	5.68	**5.66**
CO_2	Carbon dioxide (dry volume %)	8.76	8.67	8.68	**8.70**
T_s	Sample temperature (°F)	335	337	337	**336**
B_w	Actual water vapor in gas (% by volume)[1]	15.3	15.7	16.0	**15.7**
Gas Flow Rate[2]					
Q_a	Volumetric flow rate, actual (acfm)	96,700	96,000	95,800	**96,100**
Q_s	Volumetric flow rate, standard (scfm)	62,900	62,300	62,200	**62,500**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	53,300	52,500	52,300	**52,700**
THC Results (as C_3H_8)					
C_{sd}	Concentration (ppmdv)	11.2	12.1	12.1	**11.8**
C_{sd}	Concentration (lb/dscf)	1.29E-06	1.38E-06	1.39E-06	**1.35E-06**
E_{Fd}	Mass Rate (lb/MMBtu) - Fd	0.0147	0.0160	0.0160	**0.0156**
Methane Results					
C_{sd}	Concentration (ppmdv)	19.3	21.2	22.9	**21.1**
Methane Results (as C_3H_8)					
C_{sd}	Concentration (ppmdv)	6.4	7.1	7.6	**7.0**
C_{sd}	Concentration (lb/dscf)	7.36E-07	8.09E-07	8.72E-07	**8.06E-07**
E_{Fd}	Mass Rate (lb/MMBtu) - Fd	0.00842	0.00934	0.0100	**0.00927**
Ethane Results					
C_{sd}	Concentration (ppmdv)	5.87	6.56	5.73	**6.05**
Ethane Results (as C_3H_8)					
C_{sd}	Concentration (ppmdv)	3.91	4.37	3.82	**4.04**
C_{sd}	Concentration (lb/dscf)	4.48E-07	5.01E-07	4.37E-07	**4.62E-07**
E_{Fd}	Mass Rate (lb/MMBtu) - Fd	0.00513	0.00578	0.00504	**0.00531**
VOC Results (as C_3H_8)					
C_{sd}	Concentration (ppmdv as C_3H_8)	0.90	0.66	0.71	**0.76**
C_{sd}	Concentration (lb/dscf)	1.03E-07	7.57E-08	8.11E-08	**8.66E-08**
E_{Fd}	Emission Rate - F_d-based (lb/MMBtu)	0.00118	0.000874	0.000934	**0.00100**

[1] Moisture data used for ppmw v to ppmdv correction obtained from nearly concurrent M-5 runs.

[2] Flow data used in lb/hr calculations w as obtained from nearly concurrent M-5 runs.

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 B&W Boiler (EU27-B&WBOILER1-S1) generates steam required by other refinery process components. The unit is fired by natural gas and refinery fuel gas. Emissions are vented to the atmosphere via the B&W Boiler Stack (SV-B&WBOILER1), where testing was conducted.

TEST LOCATION

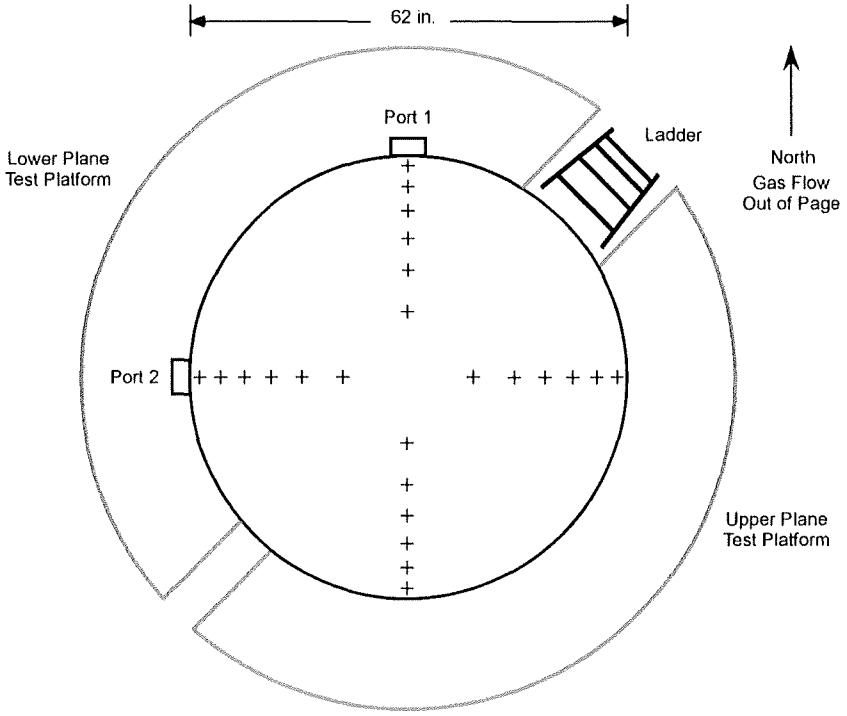
The sample point locations were determined by EPA Method 1 specifications. Table 3-1 presents the sampling information for the test location. The figure shown on page 7 represents the layout of the test location.

Table 3-1:
Sampling Information

Source Constituent	Method (USEPA)	Run No.	Ports	Points per Port	Minutes per Point	Total Minutes	Figure
B&W Boiler Stack							
PM	5	1-4	2	12	5	120	3-1
O_2 / CO_2 / THC	3A / 25A	1-3	1	1	60	60	N/A[1]

[1] Method 25A and CTM-013 (Mod) sampling was conducted from a single point near the center of the duct.

Figure 3-1:
FPM Sample Point Layout (EPA Method 1)



Sampling Point	% of Stack Diameter	Port to Point Distance (inches)
1	97.9	60.7
2	93.3	57.8
3	88.2	54.7
4	82.3	51.0
5	75.0	46.5
6	64.4	39.9
7	35.6	22.1
8	25.0	15.5
9	17.7	11.0
10	11.8	7.3
11	6.7	4.2
12	2.1	1.3

Duct diameters upstream from flow disturbance (A): 9.5 Limit: 0.5
Duct diameters downstream from flow disturbance (B): 2.3 Limit: 2.0

End of Section

4. METHODOLOGY

PROCEDURES AND REGULATIONS

The test program sampling measurements followed procedures and regulations outlined by the United States Environmental Protection Agency (USEPA) and the Michigan EGLE. 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 19	"Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide and Nitrogen Oxide Emission Rates"
Method 25A	"Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer"

METHODOLOGY DISCUSSION

FILTERABLE PARTICULATE MATTER TESTING – USEPA METHOD 5

FPM emissions were determined using EPA Method 5. 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 of the sampling train consisted of 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 moisture collected in the knock-out jars was measured to determine the flue gas moisture. 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. After measuring the moisture gain in the back-half portion of the sample train, the contents were discarded.

Reagent blanks were collected to quantify background contamination. All samples and blanks were returned to CleanAir Analytical Services in Palatine, Illinois, for gravimetric analysis.

VOC Testing – USEPA Method 25A

VOC emissions were determined using EPA Method 25A to quantify THC emissions as propane. The Method 25A sampling system consists of a heated probe, heated filter, and heated sample line. Flue gas was delivered at 250°F to a flame ionization analyzer (FIA), which continuously measured minute-average THC concentration expressed in terms of propane on an actual (wet) basis.

FIA calibration was performed by introducing zero nitrogen (N_2), high, mid- and low range propane calibration gases to the inlet of the sampling system's heated filter. Bias checks were performed before and after each sampling run in a similar manner.

End of Section