1. PROJECT OVERVIEW

TEST PROGRAM SUMMARY

Marathon Petroleum Company LP (MPC) contracted CleanAir Engineering (CleanAir) to perform compliance testing on the B&W Boiler (EU27-B&WBOILER-S1) at the Detroit Refinery. The objective of the test program was 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	0.0014	0.0019
VOC (lb/MMBtu)	USEPA 25A	0.0014	0.0055

[1] Permit limits obtained from MDEQ 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 filterable particulate matter (FPM) only
- volatile organic compounds (VOC) assumed equivalent to total hydrocarbons (THC) less methane (CH_4) and ethane (C_2H_6)
- flue gas composition (e.g., O_2, CO_2, H_2O)
- flue gas temperature
- flue gas flow rate

SCHEDULE

Testing was performed on March 4, 2021. Table 1-2 outlines the on-site schedule followed during the test program.

Table 1-2:
Test Schedule

Run Number	Location	Method	Analyte	Date	Start Time	End Time
1	B&W Boiler Stack	USEPA Method 5	FPM	03/04/21	08:33	09:36
1	B&W Boiler Stack	USEPA Method 3A/18/25A	O_2/CO_2/VOC	03/04/21	08:33	09:36
2	B&W Boiler Stack	USEPA Method 5	FPM	03/04/21	10:16	11:19
2	B&W Boiler Stack	USEPA Method 3A/18/25A	O_2/CO_2/VOC	03/04/21	10:16	11:19
3	B&W Boiler Stack	USEPA Method 5	FPM	03/04/21	11:52	12:54
3	B&W Boiler Stack	USEPA Method 3A/18/25A	O_2/CO_2/VOC	03/04/21	11:52	12:54

DISCUSSION

Filterable Particulate Matter Testing

Three (3) 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 three (3) 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 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 are reported on an as propane basis to facilitate subtraction 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 calculated from the reported constitute values.
- 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	Average
Date (2021)		Mar 4	Mar 4	Mar 4	
Start Time (approx.)		08:33	10:16	11:52	
Stop Time (approx.)		09:36	11:19	12:54	
Process Conditions					
R_P	Steam production (mlb/hr)	171	170	170	**170**
P_1	Firing rate (MMBtu/hr)	239	238	243	**240**
F_d	Oxygen-based F-factor (dscf/MMBtu)	8,584	8,585	8,585	**8,585**
H_i	Actual heat input (MMBtu/hr)	214	214	212	**213**
Cap	Capacity factor (hours/year)	8,760	8,760	8,760	**8,760**
Gas Conditions					
O_2	Oxygen (dry volume %)	6.1	6.3	6.2	**6.2**
CO_2	Carbon dioxide (dry volume %)	8.7	8.6	8.7	**8.7**
T_s	Stack temperature (°F)	346	349	349	**348**
B_w	Actual water vapor in gas (% by volume)	16.2	16.4	16.1	**16.3**
Gas Flow Rate					
Q_a	Volumetric flow rate, actual (acfm)	90,400	91,700	90,000	**90,700**
Q_s	Volumetric flow rate, standard (scfm)	58,200	58,800	57,700	**58,200**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	48,700	49,100	48,400	**48,700**
Sampling Data					
V_{mstd}	Volume metered, standard (dscf)	32.63	33.40	33.29	**33.11**
%I	Isokinetic sampling (%)	102.2	103.7	105.0	**103.6**
Laboratory Data					
m_n	Total FPM (g)	0.00190	0.00201	0.00130	
FPM Results					
C_{sd}	Particulate Concentration (lb/dscf)	1.28E-07	1.33E-07	8.61E-08	**1.16E-07**
C_{sd}	Particulate Concentration (mg/dscm)	2.06	2.12	1.38	**1.85**
$E_{lb/hr}$	Particulate Rate (lb/hr)	0.38	0.39	0.25	**0.34**
E_{Fd}	Particulate Rate - F_d-based (lb/MMBtu)	0.0016	0.0016	0.0010	**0.0014**

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

Run No.		1	2	3	Average
Date (2021)		Mar 4	Mar 4	Mar 4	
Start Time (approx.)		08:33	10:16	11:52	
Stop Time (approx.)		09:36	11:19	12:54	
Process Conditions					
R_P	Steam Production (mlb/hr)	171	170	170	**170**
P_1	Firing rate (MMBtu/hr)	239	238	243	**240**
F_d	Oxygen-based F-factor (dscf/MMBtu)	8,584	8,585	8,585	**8,585**
H_i	Actual heat input (MMBtu/hr)	214	214	212	**213**
Gas Conditions					
O_2	Oxygen (dry volume %)	6.13	6.31	6.16	**6.20**
CO_2	Carbon dioxide (dry volume %)	8.71	8.58	8.66	**8.65**
T_s	Sample temperature (°F)	346	349	349	**348**
B_w	Actual water vapor in gas (% by volume)[1]	16.2	16.4	16.1	**16.3**
Gas Flow Rate[2]					
Q_a	Volumetric flow rate, actual (acfm)	90,400	91,700	90,000	**90,700**
Q_s	Volumetric flow rate, standard (scfm)	58,200	58,800	57,700	**58,200**
Q_{std}	Volumetric flow rate, dry standard (dscfm)	48,700	49,100	48,400	**48,700**
THC Results (as C_3H_8)					
C_{sd}	Concentration (ppmdv)	16.6	16.2	16.1	**16.3**
C_{sd}	Concentration (lb/dscf)	1.90E-06	1.86E-06	1.84E-06	**1.87E-06**
E_{Fd}	Mass Rate (lb/MMBtu) - Fd	0.023	0.023	0.022	**0.023**
Methane Results					
C_{sd}	Concentration (ppmdv)	25.6	22.6	22.9	**23.7**
Methane Results (as C_3H_8)					
C_{sd}	Concentration (ppmdv)	9.3	8.2	8.3	**8.6**
C_{sd}	Concentration (lb/dscf)	1.1E-06	9.4E-07	9.5E-07	**9.9E-07**
E_{Fd}	Mass Rate (lb/MMBtu) - Fd	0.013	0.012	0.012	**0.012**
Ethane Results					
C_{sd}	Concentration (ppmdv)	10.7	8.2	10.5	**9.8**
Ethane Results (as C_3H_8)					
C_{sd}	Concentration (ppmdv)	7.3	5.6	7.2	**6.7**
C_{sd}	Concentration (lb/dscf)	8.3E-07	6.4E-07	8.2E-07	**7.6E-07**
E_{Fd}	Mass Rate (lb/MMBtu) - Fd	0.010	0.0078	0.010	**0.0093**
VOC Results (as C_3H_8)					
C_{sd}	Concentration (ppmdv as C_3H_8)	0.04	2.4	0.58	**1.0**
C_{sd}	Concentration (lb/dscf)	4.5E-09	2.8E-07	6.7E-08	**1.2E-07**
E_{Fd}	Mass Rate (lb/MMBtu) - Fd	0.000055	0.0034	0.00081	**0.0014**

[1] Moisture data used for ppmw v to ppmdv correction obtained from concurrent M-5 runs.
[2] Flow data used in lb/hr calculations w as obtained from 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

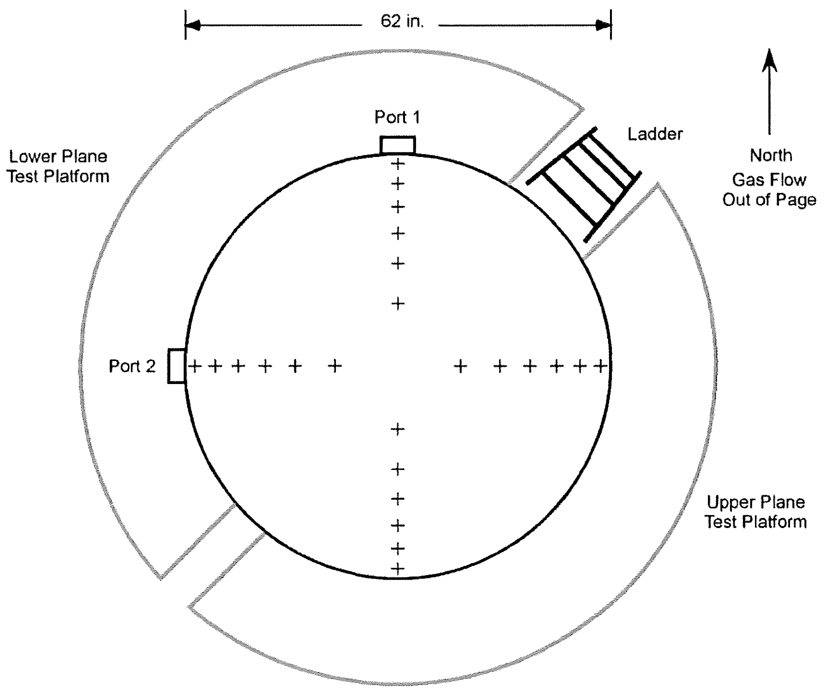
The sample point placement was determined by EPA Method 1 specifications. Table 3-1 presents the sampling information for the test location. The figure represents the layout of the test location.

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	1-3	2	12	2.5	60	3-1
O_2 / CO_2 / THC	3A / 18 / 25A	1-3	1	1	60	60	N/A[1]

[1] Method 25A sampling was conducted from a single point near the center of the duct.

Figure 3-1:
B&W Boiler Stack Sample Point Layout (EPA Method 1)



Sampling Point	% of Stack Diameter	Port to Point Distance (in)
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 USEPA and Michigan Department of Environment, Great Lakes, and Energy (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 2F	"Determination of Stack Gas Velocity and Volumetric Flow Rate with Three-Dimensional Probes"
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 18	"Measurement of Gaseous Organic Compound Emissions by Gas Chromatography"
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 METHODS 3A, 18 AND 25A

Oxygen (O_2) and carbon dioxide (CO_2) emissions were determined using a paramagnetic/non-dispersive infrared (NDIR) analyzer per EPA Method 3A. VOC emissions were determined using EPA Method 25A to quantify THC emissions.

The Method 3A/25A sampling system consisted of a heated probe, heated filter, and heated sample line. Flue gas was extracted at a constant rate and delivered at approximately 250°F to a tee at the end of the heated sample line.

- One leg of the tee was connected to a flame ionization analyzer (FIA), which continuously measured minute-average THC concentration expressed in terms of propane (C_3H_8) on an actual (wet) basis.
- The other leg of the tee was connected to 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).
- The Method 18 gas sample was collected by pulling a slipstream from the flow panel and delivered it into a FlexFoil bag at a constant rate. The moisture condensate was not collected for analysis as CH_4 and C_2H_6 are insoluble in water. Each bag was filled over a period of approximately one hour for each test run.

THC analyzer calibration was performed by introducing zero air, high, mid-, and low range C_3H_8 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.

O_2/CO_2 calibration error checks were performed by introducing zero N_2, high 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

A traditional verification of the absence of cyclonic flow following EPA Method 1 specifications was not performed. However, absence of cyclonic flow was demonstrated by measuring the resultant angle of flow using an EPA Method 2F flow traverse. The resultant angle of flow was less than 20°. Data is included in Appendix F of this report.

H_2O data used for moisture correction of VOC concentration data was obtained from the concurrent Method 5 test runs. Method 4 measurements are incorporated into the sampling and recovery procedures. O_2 and CO_2, data used for Method 5 flow calculations were obtained from the concurrently operated CEM sample runs.

End of Section