erthwrks
AIR EMISSIONS TESTING FOR INDUSTRY

Relative Accuracy Test Audit and Performance Testing

for

Marathon Petroleum Company LP

at the

Marathon Detroit Refinery in Detroit, MI

on the

BR-10 (Zurn) Boiler
Unit: EU27-ZURNBOILER-S1
Permit No. MI-ROP-A9831-2012c

Prepared for:

Marathon Petroleum Company LP

Test Date: July 11, 2023
Erthwrks Project No. 9284.1.C1

STAC STACK TESTING ACCREDITATION COUNCIL
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Louisiana Environmental Lab Accreditation Program LELAP
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Endorsement Page

This report was developed in accordance with the requirements designated in the applicable regulatory permit(s) and or regulatory rules. To the best of my knowledge the techniques, instrumentation, and calculations presented in this report will serve to accurately and efficiently detail the results of the test campaign requirements.

Erthwrks, Inc.

Name: Jason Dunn

Title: QA Specialist

Signature: 

This report has been reviewed for accuracy and completeness. The actions presented in this report are, to the best of my knowledge, an accurate representation of the results and findings of the test campaign. Erthwrks, Inc. operates in conformance with the requirements on ASTM D7036-04 Standard Practice for Competence of Air Emission Testing Bodies and is accredited as such by the Stack Testing Accreditation Council (STAC) and the American Association for Laboratory Accreditation (A2LA).

Erthwrks, Inc.

Name: John Wood

Title: Technical Director

Signature: 

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1.0 INTRODUCTION

1.1 Identification, location and dates of tests

Erthwrks, Inc. was contracted to conduct emission testing on the BR-10 (Zurn) Boiler in operation at the Marathon Detroit Refinery, located in Detroit Michigan. The testing program was conducted on July 11, 2023.

1.2 Purpose of Testing

The exhaust from BR-10 (Zurn) Boiler was sampled and analyzed to determine the relative accuracy of the associated carbon monoxide (CO), oxides of nitrogen (NOx), and oxygen (O_2) continuous emissions monitoring system (CEMS) in accordance with the requirements in the Marathon Permit No. MI-ROP-A9831-2012c and the Title 40 CFR Part 60, Appendix F. In addition, compliance testing was conducted to determine the compliance status of the units' emission for sulfuric acid (H_2SO_4) and volatile organic compounds (VOCs).

NOTE: Particulate Matter (PM) sampling was conducted but samples were lost during shipment to the laboratory. Therefore, the PM sampling will be repeated during an additional mobilization. The PM field datasheets were used to calculated the moisture content for the VOC calculations.

1.3 Description of Source

Marathon Petroleum Company LP operates the BR-10 (Zurn) Boiler designated as EU27-ZURNBOILER-S1 in the refinery. This report addresses the RATA for the CEMS associated with the unit as well as the required compliance test for H_2SO_4 and VOC. Table 1.1 below details the CEMS analyzer information.

Table 1.1—Marathon BR-10 (Zurn) Boiler CEMS Details

BR-10 (Zurn) Boiler CEMS	Manufacturer	Model No.	S/N	Install Date
NOx	ABB	Limas 11	3.342678.1	2012
CO	ABB	Uras 26	3.342694.1	2012
O_2	ABB	Magnos 206	3.342697.1	2012

1.4 Contact Information

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Facility Location:
Marathon Petroleum Company LP
Detroit Refinery
1300 South Fort Street
Detroit, MI 48217

2.0 SUMMARY OF RESULTS

Table 2.1—Marathon BR-10 (Zurn) Boiler (EU27-ZURNBOILER-S1) CEMS RATA Results

Pollutant Measured	Performance Specification	Relative Accuracy	Applicable Limit	Pass/Fail
NOx (lb/mmBTU)	Performance Spec. 2	3.1% RA_{AS}	10%	***Pass***
CO (ppmvd)	Performance Spec. 4A	1.6 ppm RA_{4A}	<5 ppm	***Pass***
O_2 (%vd)	Performance Spec. 3	0.13% *RA*	1%	***Pass***

Table 2.2—Marathon BR-10 (Zurn) Boiler (EU27-ZURNBOILER-S1) Compliance Test Results

Pollutant Measured	Methodology	Measured Results	Applicable Limit	Pass/Fail
VOC	EPA Method 25A/4	0.0007 lb/MMBtu	0.0055 lb/MMBtu	***Pass***
H_2SO_4	EPA Method CTM-013	0.0059 ppm	n/a	***n/a***

3.0 SOURCE DESCRIPTION

3.1 Description of the process

Marathon Petroleum Company LP produces refined petroleum products from crude oil and is required to demonstrate that select process emission sources are operating in compliance with permitted emissions limits.

As required in the Tier 3 Gasoline Project Permit (PTI 118-15), the BR-10 (Zurn) Boiler (EU27-ZURNBOILER-S1) utilizes low NO_x burners. This boiler generates steam required by other refinery process components. The unit is fired by natural gas. Emissions are vented to the atmosphere via the BR-10 (Zurn) Boiler Stack (SV22-BR7) where testing was performed.

3.2 Applicable permit and source designation

Marathon Petroleum Company LP operates the BR-10 (Zurn) Boiler (EU27-ZURNBOILER-S1) under EGLE Renewable Operating Permit No. MI-ROP-A9831-2012c and is required to conduct an annual RATA to demonstrate the relative accuracy of the CEMS associated with this unit and to periodically determine the H_2SO_4 and VOC exhaust emissions.

3.3 Type and quantity of materials processed during tests

During the emission testing on July 11, 2023, at the Marathon Petroleum Company LP Refinery, the BR-10 (Zurn) Boiler was tested while operating at the maximum achievable load condition. **NOTE:** For this testing program, the average steam production was approximately 154 mlb/hr and the average unit firing rate was 179 MMBtu/hr. This operational data was provided by MPC and is located in Attachment F of this report.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 Gaseous Sampling – NOx, CO, and O_2

For the gaseous sampling, Erthwrks utilized a stainless-steel probe, of sufficient length to reach all sampling points, inserted into a sampling port that is located on the stack in accordance with EPA Method 1. The sample is extracted through the probe, a heated Teflon sampling line, to a heating filter. The sample then enters a minimum contact sample conditioner that cools and removes moisture from the gas matrix prior to entering the Erthwrks sampling manifold.

Erthwrks followed all quality assurance and quality control procedures as defined in US EPA 40 CFR 60 Appendix A. The Calibration Error (CE) Test was conducted as specified in EPA Method 7E §8.2.3. In accordance with this requirement, a three-point analyzer calibration error test was conducted prior to sampling. The CE test was conducted by introducing the low, mid, and high-level calibration gasses (as defined in EPA Method 7E §3.3.1-3) sequentially and the response was recorded. The results of the CE test are acceptable if the calculated calibration error is within ±2.0% of calibration span (or ≤ 0.5 ppmv).

The Initial System Bias and System Calibration Error Check was conducted in accordance with EPA Method 7E §8.2.5. The upscale calibration gas was introduced at the probe upstream of all sample system components and the response recorded. The procedure will was repeated with the low-level gas and the response recorded. During this activity, the sample system response time was also be recorded. This specification is acceptable if the calculated values of the system calibration error check are within ±5.0% of the calibration span value (or ≤0.5 ppmv).

After each test run, the sample system bias check is conducted to validate the run data. The low-level and upscale drift are calculated using Equation 7E-4. The run data is valid if the calculated drift is within ±3.0% of the calibration span value (or ≤0.5 ppmv).

After each test run, the corrected effluent gas concentration was calculated as specified in EPA Method 7E §12.6. The arithmetic average of all valid concentration values are adjusted for bias using equation 7E-5B.

4.2 Gaseous Emissions – VOC as THC (Method 25A)

The determination of the VOC as total hydrocarbon compounds (THC) concentration followed all QAQC procedures as specified in the US EPA 40 CFR 60 Appendix A, Method 25A. The calibration error (CE) test was conducted following the procedures specified in EPA Method 25A §8.4. In accordance with this requirement, a four-point analyzer calibration error test was conducted prior to exhaust sampling. This CE test was conducted by introducing the zero, low, mid, and high-level calibration gases (as defined by EPA Method 25A §7.1.2-5) and the responses recorded. The results of the CE test are acceptable if the results for the low and mid-level calibration gasses are within ±5.0% of the predicted responses as defined by the linear curve from the zero and high-level results. During this activity, the sample system response time was also recorded in accordance with EPA Method 25A §8.5.

Immediately following the completion of each test run, the drift determination was conducted to validate the test data in accordance with EPA Method 25A §8.6.2. The test data is valid if the calculated drift is within ±3.0% of the span value (EPA Method 25A §13.1.2). In addition, at the request from EGLE, the THC raw data is corrected for analyzer drift using EPA Method 7E Equation 7E-B5. The THC is measured on a wet basis and is converted to a dry basis using moisture data from a Method 4 or Method 5 sampling train.

Because the THC concentration was found to be below the permitted limit for VOC, the test results are reported as VOC (as THC) and therefore no Method 18 analysis was required to subtract methane and ethane from the THC results.

The figure below details the Erthwrks Gaseous Sampling System.

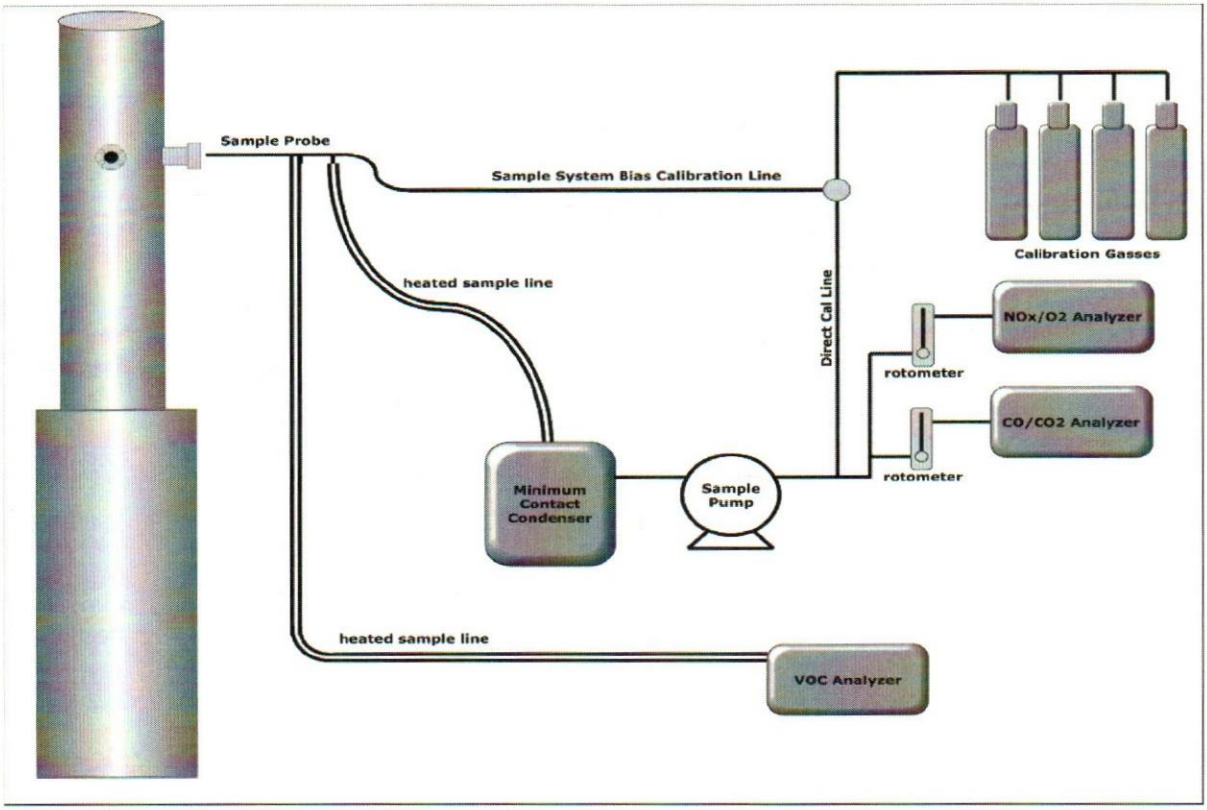


Figure 1: Example Erthwrks Gaseous Sampling System Diagram

4.3 EPA Method CTM-013 (ALT-133 Analysis) H_2SO_4 Determination

The H_2SO_4 emissions were determined utilizing the conditional test method 13 (CTM-013). The sample was extracted at a constant rate through a quartz lined heated probe (>350 ˚F), A heated quartz filter holder and filter (>500 ˚F), and through a Modified Grahm condenser (H_2SO_4 Condenser) with Type C glass frit and 200 cm of 5-mmID glass tubing condenser coil. The H_2SO_4 condenser is maintained between 167 to 185 ˚F. Because SO_2 was not to be determined via this method, the sample was then passed through four impingers with the specifications delineated in EPA Method 4.

The sampling was conducted at a single point at a constant rate of about 10 L/min and the DGM readings and all temperatures were recorded every five minutes. After the completion of the test run, the samples were recovered in accordance with the test method and the samples were sent to Enthalpy Analytical for analysis via Ion Chromatography (ALT-133).

See the figure below that details the CTM-013 Sampling Train.

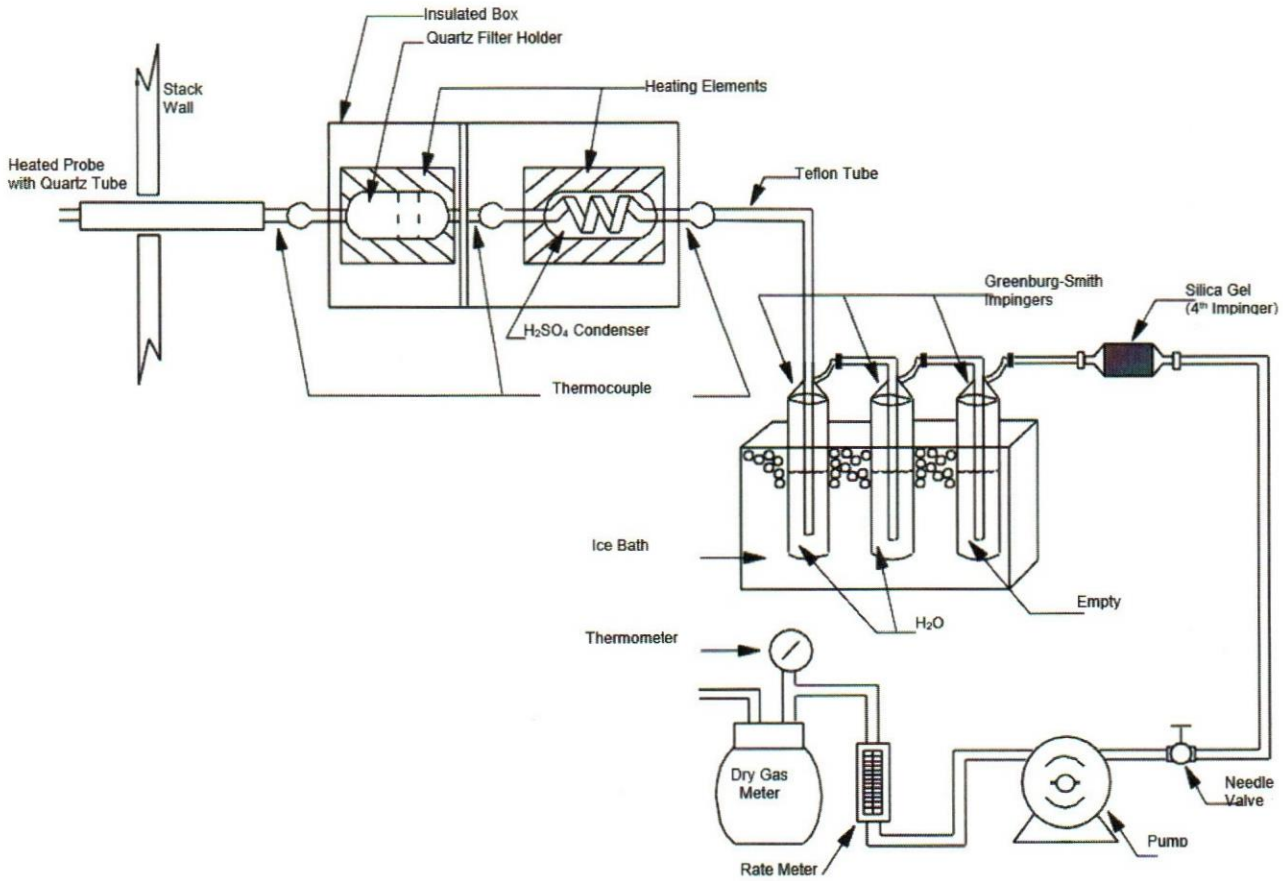


Figure 3: Example Erthwrks H_2SO_4 System Diagram

4.4 RATA Procedures

The RATA testing was conducted following the sampling and measurement procedures found in the EPA Part 60, Appendix B, Performance Specifications which requires that EPA Reference Methods, from EPA Part 60, Appendix A, be utilized to conduct independent stack emissions measurements for comparison with installed CEMS readings. The following performance specifications will be used during this testing program.

- EPA Performance Specification 2 for NOx relative accuracy
- EPA Performance Specification 3 for O_2 relative accuracy
- EPA Performance Specification 4/4A for CO relative accuracy

As required by these methods, the use EPA Protocol 1 gases are mandatory and were used for this portion of the project.

A minimum of nine (9) RATA test runs were conducted at each exhaust stack for a minimum duration of twenty-one (21) minutes for each run. A 3-point traverse located at 16.7%, 50.0%, and 83.3% of the way across the stack (or 0.4, 1.2, and 2.0 meters from the stack wall) was conducted during each RATA test run (7 minutes per point). A maximum of twelve (12) RATA test runs will be conducted and up to three test runs may be discarded and not used to determine relative accuracy. The results of the reference method tests were compared to CEMS measurement data from the same time periods to determine the relative accuracy of the CEMS.

For NOx, the results of the RATA test are considered acceptable if the calculated relative accuracy does not exceed 20.0% as calculated by Equation 2-6 in Performance Specification 2. Alternatively, for affected units where the average of the reference method measurements is less than 50 percent of the emission standard (emission limit), the relative accuracy must not exceed 10% when the applicable emission standard is used in the denominator of Eq. 2-6.

For O_2, the results of the RATA test are considered acceptable if the calculated relative accuracy does not exceed 20.0% as calculated by Equation 3.1 in Performance Specification 3. The results are also acceptable if the result of Equation 3-2 is less than or equal to 1.0 percent.

For CO, the results of the RATA test are considered acceptable if the calculated relative accuracy does not exceed 10.0% as calculated by Equation 2-6 in Performance Specification 2. Alternatively, for affected units where the average of the reference method measurements is less than 50 percent of the emission standard (emission limit), the relative accuracy must not exceed 5% when the applicable emission standard is used in the denominator of Eq. 2-6. Performance Specification 4A criteria may be used to determine relative accuracy for CEMS with low emission standards (less than 200 ppmv). In these cases, the results of the RATA test are considered acceptable if the absolute average difference between the RM and CEMS is within 5 ppmv.

4.5 Discussion of sampling procedure or operational variances

Erthwrks, Inc. conducted the emissions testing with no sampling or procedural variances.

Attachment A
Detailed Results of Emission Test

Erthwrks Relative Accuracy Test Audit--NOx RATA
Performance Specification 2

Zurn Boiler (BR-10)								NOX CEMS RATA - lb/mmBTU	
							Fuel F-Factor	8710	scf/mmBTU
Test Run	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**	**Run 7**	**Run 8**	**Run 9**
Date	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**
Start Time	9:20	9:41	10:02	11:40	12:01	12:22	14:00	14:21	14:42
End Time	9:41	10:02	10:23	12:01	12:22	12:43	14:21	14:42	15:03
RM NOx (ppmvd)	29.94	30.57	30.09	29.93	29.28	29.09	30.22	29.92	29.80
RM O_2 Results (%vd)	3.44	3.44	3.44	3.48	3.46	3.46	3.49	3.45	3.46
RM NOx (lb/mmBTU)	**0.0373**	**0.0381**	**0.0375**	**0.0373**	**0.0365**	**0.0363**	**0.0377**	**0.0373**	**0.0371**
CEMS NOx (lb/mmBTU)	**0.0379**	**0.0381**	**0.0383**	**0.0388**	**0.0391**	**0.0391**	**0.0394**	**0.0396**	**0.0402**
Difference	-0.0006	-0.0001	-0.0009	-0.0014	-0.0026	-0.0028	-0.0017	-0.0023	-0.0030
Accept or Reject	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*

Applicable Standard (lb/mmBTU)	0.08	
Mean of the Difference (d_{avg})	-0.0017	
Standard Deviation (S_d)	0.0010	
Confidence Coefficient (CC)	0.0008	
Relative Accuracy via AS, *RA $_{AS}$* †	**3.14%**	← ***Pass***

† *RA_{AS} (Applicable Standard) must be less then 10%*

Erthwrks Relative Accuracy Test Audit--O_2 RATA
Performance Specification 3

Zurn Boiler (BR-10)									O_2 CEMS RATA
Test Run	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**	**Run 7**	**Run 8**	**Run 9**
Date	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**
Start Time	9:20	9:41	10:02	11:40	12:01	12:22	14:00	14:21	14:42
End Time	9:41	10:02	10:23	12:01	12:22	12:43	14:21	14:42	15:03
RM O_2 Result (%vd)	**3.44**	**3.44**	**3.44**	**3.48**	**3.46**	**3.46**	**3.49**	**3.45**	**3.46**
CEMS O_2 Data (%vd)	**3.55**	**3.56**	**3.57**	**3.58**	**3.56**	**3.56**	**3.61**	**3.56**	**3.74**
Difference	-0.11	-0.12	-0.13	-0.10	-0.10	-0.10	-0.12	-0.11	-0.28
Accept or Reject	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*

Mean of the Difference (d_{avg})	-0.13	
Standard Deviation (S_d)	0.06	
Confidence Coefficient (CC)	0.04	
Relative Accuracy via RM, *RA* $_{RM\text{-}CEMS}$*	**0.13%**	← Pass

**RA* $_{RM\text{-}CEMS}$ *(Reference Method - CEMS) Absolute difference must be less than 1.0%*

Erthwrks Relative Accuracy Test Audit--CO RATA
Performance Specification 4/4A

Zurn Boiler (BR-10)								CO CEMS RATA at Stack Conditions	
Test Run	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**	**Run 7**	**Run 8**	**Run 9**
Date	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**	**7/11/2023**
Start Time	9:20	9:41	10:02	11:40	12:01	12:22	14:00	14:21	14:42
End Time	9:41	10:02	10:23	12:01	12:22	12:43	14:21	14:42	15:03
RM CO Result (ppmvd)	**1.15**	**1.04**	**0.99**	**1.32**	**1.32**	**1.38**	**1.03**	**1.23**	**1.13**
CEMS CO Data (ppmvd)	**-0.18**	**-0.20**	**-0.22**	**-0.25**	**-0.26**	**-0.25**	**-0.33**	**-0.26**	**-0.31**
Difference	1.33	1.24	1.21	1.57	1.58	1.63	1.36	1.49	1.44
Accept or Reject	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*	*Accept*

Mean of the Difference (d_{avg})	1.43	
Standard Deviation (S_d)	0.15	
Confidence Coefficient (CC)	0.12	
Relative Accuracy via M.4A, *RA* $_{4A}$ ‡	**1.55**	← ***Pass***

‡*RA* $_{4A}$ *must be less than 5 ppmv*

VOC Testing Summary of Results

Date: 7/11/2023
Client: Marathon Petroleum Company
Facility: Detroit
Unit ID: Zurn Boiler (BR-10)
Erthwrks Tech: Luke Morrison, Adam Loes

Run Information				
Run Number	**Run 1**	**Run 2**	**Run 3**	
Date	7/11/2023	7/11/2023	7/11/2023	
Run Start Time	9:20	9:41	10:02	
Run End Time	9:41	10:02	10:23	
Unit Fuel Flow Data				**Averages**
Fuel F Factor (Fd) (scf/mmBTU)	8710	8710	8710	8710.0
Emission Concentrations				
O_2 (%vd)	3.41	3.44	3.44	3.43
CO_2 (%vd)	9.62	9.68	9.67	9.66
THC (ppmvw) reported as MDL*	< 0.50	< 0.50	< 0.50	< 0.50
Moisture (%)	17.12	17.00	17.45	17.19
THC (ppmvd)	< 0.60	< 0.60	< 0.61	< 0.60
Emission Concentrations O_2 Corrected		**Corrected To: 0 % Oxygen**		
THC (ppmv @ %O2)	< 0.60	< 0.60	< 0.60	< 0.60
Emission Rates (lb/scf)				
THC (lb/scf)	< 6.90E-08	< 6.89E-08	< 6.93E-08	< 6.91E-08
Emission Rates (lb/mmBTU)				
THC (lb/mmBTU)	< 0.0007	< 0.0007	< 0.0007	**< 0.0007**

MDL is defined as 1% of the calibration range

H_2SO_4 Summary of Results

Client: Marathon Petroleum Company
Facility: Detroit Refinery
Unit ID: Zurn Boiler (B-10)
Erthwrks Tech: M. Oleszko

Run Information				
Run Number	**Run 1**	**Run 2**	**Run 3**	
Date	7/11/2023	7/11/2023	7/11/2023	
Run Start Time	9:20	11:45	14:00	
Run End Time	10:20	12:45	15:00	
Unit Fuel Flow Data				**Averages**
Fuel F Factor (F_d) (scf/MMBtu)	8710	8710	8710	**8710**
Emission Concentrations				
H_2SO_4 (ug)	29.60	6.65	4.80	**13.68**
Train volume (scf)	20.17	19.91	19.83	**19.97**
O_2 (%vd)	3.44	3.47	3.47	**3.46**
Emission Rates				
H_2SO_4 (lb/scf)	3.24E-09	7.36E-10	5.34E-10	**1.50E-09**
H_2SO_4 (ppm)	0.0127	0.0029	0.0021	**0.0059**
H_2SO_4 (lb/MMBtu)	3.37E-05	7.69E-06	5.57E-06	**1.57E-05**

Attachment B
Quality Control Documentation

Erthwrks Method 1 Traverse Point Location Worksheet

Client:	Marathon Petroleum Company
Project #:	9284.1.C1
Facility:	Detroit
Unit ID:	Zurn Boiler (BR-10)
Technician:	Luke Morrison, Adam Loes

Stack ID Measurements

Stack ID + Port (inches):	88.75
Port Extension (inches):	22.75
Stack Diameter (inches):	66

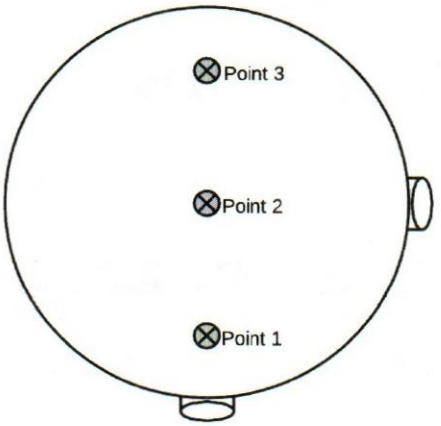
Port Location Measurements

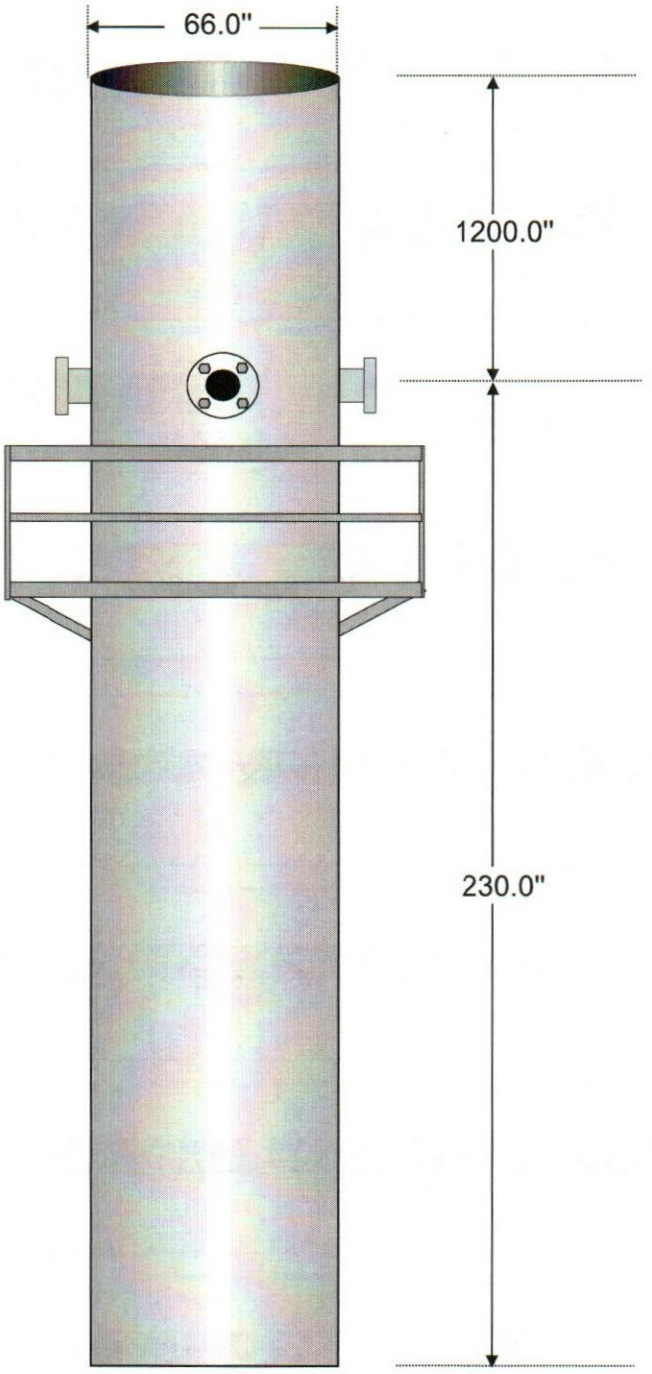
Distance Upstream (A) (inches):	1200
Distance Downstream (B) (inches):	230
Stack Diameters Upstream (A):	18.2
Stack Diameters Downstream (B):	3.5

Total Traverse Points to be used:	3
Traverse Points per Diameter:	3

Traverse Point Locations[1][2]	
Point 1:	11.02"
Point 2:	33.00"
Point 3:	54.98"

Stack Cross Section View





[1]For stack diameter >4.0" and <2.4 meters, stratification is measured at 16.7%, 50.0%, and 83.3" of stack diameter (M7E, §8.1.2).

[2] For stack diameter >2.4 meters, stratification is measured at 0.4, 1.2, and 2.0 meters from stack wall (M7E, §8.1.2).

Erthwrks Gaseous Sample Collection and Quality Assurance Worksheet

Date: 7/11/2023
Client: Marathon Petroleum Company
Facility: Detroit
Project No: 9284.1.C1
Unit ID: Zurn Boiler (BR-10)
Erthwrks Tech: Luke Morrison, Adam Loes

Calibration Gas Verification

Pollutant	Low-Level Gas Conc. (C_{ma})	Cylinder Serial #	Mid-Level Gas Conc. (C_{ma})	Cylinder Serial #	High-Level Gas Conc. (C_{ma}/CS)	Cylinder Serial #	Dilutor Root Gas
NO_X	n/a	n/a	53.17	ALM038860	94.39	ALM053649	NA
CO	n/a	n/a	25.94	CC73561	49.37	ALM038860	NA
O_2	n/a	n/a	10.02	CC216514	19.97	CC268441	NA
CO_2	n/a	n/a	9.689	CC216514	20.06	CC268441	NA
THC	12.56	CC734035	26.17	CC73561	50.77	ALM038860	NA

Reference Method Analyzer Info

Make	Model	Serial No.
Teledyne	T200H	896
Teledyne	T300M	820
Teledyne	T200H	896
Teledyne	T300M	820
CAI	600	A01012

Calibration Error Test

Pollutant	Zero Gas Response (C_{dir})	Calibration Error (ACE)*	Low-Level Response (C_{dir})	Calibration Error (ACE)*	Mid-Level Response (C_{dir})	Calibration Error (ACE)*	High-Level Response (C_{dir})	Calibration Error (ACE)*
NO_X	-0.01	-0.01%	n/a	n/a	53.45	0.29%	94.54	0.16%
CO	0.29	0.59%	n/a	n/a	26.27	0.66%	49.34	-0.06%
O_2	0.01	0.06%	n/a	n/a	9.98	-0.21%	19.98	0.07%
CO_2	0.00	0.00%	n/a	n/a	9.68	-0.06%	20.17	0.57%
THC*	-0.02	-0.04%	12.30	-2.50%	25.92	-1.46%	51.04	0.54%

** ACE must either be within ± 2.0% or ≤ 0.5 ppmv absolute difference, or +-5 % for THC for the mid and low gas*

NO_2 to NO Conversion Efficiency Test	
NO_2 Cal Gas Cyl. Number	CC502130
NO_2 Cal Gas Concentration	61.79
NO_X Analyzer Response	60.97
NO_2-NO Conv. Efficiency (Eff_{NO2})[1]	98.7%

[1] Eff_{NO2} must be ≥ 90%

Method 7E Traverse Point Determination			
Stack ID (inches)		Trav. Location	Inside ID + Port
66	Point 1	11.02	33.77
Port Ext. (inches)	Point 2	33.00	55.75
22.75	Point 3	54.98	77.73

Initial Sample System Bias and Response Time

Pollutant	Upscale Gas Cert. Conc. (C_{ma})	Upscale Gas Direct (C_{dir})	Upscale Response (C_s)	Sample System Bias (SB)*	Response Time (sec)	Downscale Response (C_s)	Sample System Bias (SB)*	Response Time (sec)
NO_X	53.17	53.45	53.27	-0.19%	52	0.43	0.46%	50
CO	25.94	26.27	25.70	-1.16%	54	0.03	-0.53%	52
O_2	10.02	9.98	9.90	-0.38%	49	0.02	0.07%	46
CO_2	9.69	9.68	9.61	-0.31%	49	0.00	0.01%	46
THC	26.17	25.92	25.92	0.00%	15	-0.02	0.00%	15

** SB must either be within ± 5.0% or ≤ 0.5 ppmv absolute difference*

Sample Collection Raw Data--Pre and Post Sample System Calibration (SSC) and Raw Run Results

Run #: **Run 1**
Start Time: 9:20
End Time: 9:41

Pollutant	Initial Zero SSC (C_{sv})	Initial Upscale SSC (C_{sv})	Raw Results (C_{avg})	Final Zero SSC (C_{sv})	Final Upscale SSC (C_{sv})
NO_X	0.43	53.27	30.51	0.19	54.62
CO	0.03	25.70	0.99	-0.34	25.27
O_2	0.02	9.90	3.40	0.01	9.83
CO_2	0.00	9.61	9.63	0.00	9.65
THC	-0.02	25.92	-0.28	-0.36	26.37

Run #: **Run 2**
Start Time: 9:41
End Time: 10:02

Initial Zero SSC (C_{sv})	Initial Upscale SSC (C_{sv})	Raw Results (C_{avg})	Final Zero SSC (C_{sv})	Final Upscale SSC (C_{sv})
0.43	53.27	31.15	0.19	54.62
0.03	25.70	0.88	-0.34	25.27
0.02	9.90	3.40	0.01	9.83
0.00	9.61	9.62	0.00	9.65
-0.02	25.92	-0.34	-0.36	26.37

Sample Collection Raw Data--Pre and Post Sample System Calibration (SSC) and Raw Run Results

Run #: **Run 3**
Start Time: 10:02
End Time: 10:23

Pollutant	Initial Zero SSC (C_{sv})	Initial Upscale SSC (C_{sv})	Raw Results (C_{avg})	Final Zero SSC (C_{sv})	Final Upscale SSC (C_{sv})
NO_X	0.43	53.27	30.66	0.19	54.62
CO	0.03	25.70	0.83	-0.34	25.27
O_2	0.02	9.90	3.40	0.01	9.83
CO_2	0.00	9.61	9.62	0.00	9.65
THC	-0.02	25.92	-0.36	-0.36	26.37

Run #: **Run 4**
Start Time: 11:40
End Time: 12:01

Initial Zero SSC (C_{sv})	Initial Upscale SSC (C_{sv})	Raw Results (C_{avg})	Final Zero SSC (C_{sv})	Final Upscale SSC (C_{sv})
0.19	54.62	30.59	0.05	53.89
-0.34	25.27	1.08	-0.10	25.39
0.01	9.83	3.43	0.05	9.84
0.00	9.65	9.60	0.01	9.66
-0.36	26.37	0.14	-0.27	26.14

Sample Collection Raw Data--Pre and Post Sample System Calibration (SSC) and Raw Run Results

Run #: **Run 5**
Start Time: 12:01
End Time: 12:22

Pollutant	Initial Zero SSC (C_{sv})	Initial Upscale SSC (C_{sv})	Raw Results (C_{avg})	Final Zero SSC (C_{sv})	Final Upscale SSC (C_{sv})
NO_X	0.19	54.62	29.94	0.05	53.89
CO	-0.34	25.27	1.08	-0.10	25.39
O_2	0.01	9.83	3.41	0.05	9.84
CO_2	0.00	9.65	9.61	0.01	9.66
THC	-0.36	26.37	0.17	-0.27	26.14

Run #: **Run 6**
Start Time: 12:22
End Time: 12:43

Initial Zero SSC (C_{sv})	Initial Upscale SSC (C_{sv})	Raw Results (C_{avg})	Final Zero SSC (C_{sv})	Final Upscale SSC (C_{sv})
0.19	54.62	29.74	0.05	53.89
-0.34	25.27	1.14	-0.10	25.39
0.01	9.83	3.41	0.05	9.84
0.00	9.65	9.61	0.01	9.66
-0.36	26.37	0.11	-0.27	26.14

Sample Collection Raw Data--Pre and Post Sample System Calibration (SSC) and Raw Run Results

Run #: **Run 7**
Start Time: 14:00
End Time: 14:21

Pollutant	Initial Zero SSC (C_{sv})	Initial Upscale SSC (C_{sv})	Raw Results (C_{avg})	Final Zero SSC (C_{sv})	Final Upscale SSC (C_{sv})
NO_X	0.05	53.89	30.48	0.01	53.32
CO	-0.10	25.39	0.88	-0.18	25.27
O_2	0.05	9.84	3.46	0.05	9.83
CO_2	0.01	9.66	9.59	0.01	9.60
THC	-0.27	26.14	0.02	-0.17	27.34

Run #: **Run 8**
Start Time: 14:21
End Time: 14:42

Initial Zero SSC (C_{sv})	Initial Upscale SSC (C_{sv})	Raw Results (C_{avg})	Final Zero SSC (C_{sv})	Final Upscale SSC (C_{sv})
0.05	53.89	30.17	0.01	53.32
-0.10	25.39	1.07	-0.18	25.27
0.05	9.84	3.42	0.05	9.83
0.01	9.66	9.62	0.01	9.60
-0.27	26.14	0.12	-0.17	27.34

Sample Collection Raw Data--Pre and Post Sample System Calibration (SSC) and Raw Run Results

Run #: **Run 9**
Start Time: 14:42
End Time: 15:03

Pollutant	Initial Zero SSC (C_{sv})	Initial Upscale SSC (C_{sv})	Raw Results (C_{avg})	Final Zero SSC (C_{sv})	Final Upscale SSC (C_{sv})
NO_X	0.05	53.89	30.06	0.01	53.32
CO	-0.10	25.39	0.97	-0.18	25.27
O_2	0.05	9.84	3.43	0.05	9.83
CO_2	0.01	9.66	9.62	0.01	9.60
THC	-0.27	26.14	0.88	-0.17	27.34

Sample Collection Raw Data--Pre and Post Sample System Calibration (SSC) and Raw Run Results