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MI-ROP-A4043-2019 Permit and MON MACT, §63.2505(a)(1)(i)(A) & §63.2505(a)(1)(i)(C), Emissions Performance Test

Michigan Operations Industrial Park (MiOps) Determination of Operating Limits to Comply with Renewable Operating Permit Requirements

Thermal Heat-Recovery Oxidation (THROX) Unit, Building 2512

Dow Silicones Corporation
Midland, Michigan

Test Date(s): October 12-13, 2022

Quality information

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1. Introduction

1.1 Background

Dow Silicones Corporation, a subsidiary of the Dow Chemical Company (Dow), operates a chemical manufacturing facility within the Dow Michigan Operations (MiOps) Industrial Park (I-Park) complex in Midland, MI. The facility uses a thermal oxidizer with a caustic scrubber and two ionizing wet scrubbers (IWS) in Building 2512, which is referred to as the 2512 thermal heat recovery oxidation (THROX) unit, to control emissions from processes at multiple chemical production facilities at the site. The typical heat input rate to the THROX is approximately 28 million British thermal units per hour (MMBtu/hr). The permitted maximum operating rate for the THROX is 95 MMBTU/hr. The production operating rate for this test was >30 MMBTU/hr, which was the maximum achievable rate under normal process operations.

The exhaust duct for the gas stream emanating from the 2512 THROX treatment system includes a continuous emissions monitoring system (CEMS) that continuously measures and records exhaust gas concentrations of nitrogen oxides (NOx), carbon dioxide (CO_2), oxygen (O_2), and total hydrocarbons (THC) as well as a continuous emission rate monitoring system (CERMS) that monitors gas stream volumetric flow rate. The CEMS is an extractive-type system that consists of three subsystems: 1) an extractive sample acquisition/conditioning system, 2) analyzers (NOx, CO_2, O_2, and THC), and 3) a programmable logic controller (PLC). The CEMS/CERMS are required to meet the parameter specific performance specifications annually.

Dow uses CEMS and CERMS to demonstrate compliance with the requirements outlined in the Renewable Operating Permit (MI-ROP-A4043-2019) as well as the MON MACT standards detailed in 40 CFR Part 63, namely §63.2505(a)(1)(i)(A) & §63.2505(a)(1)(i)(C). The exhaust stack employs an exhaust gas volumetric flow rate monitor as part of the CERMS, which allows the measured concentrations of the CEMS to be equated to mass emission rates expressed in units of pounds per hour (lb/hr) and tons per year (ton/yr).

1.2 Overview of the Test Program

AECOM was retained to conduct a periodic quality assurance (QA) relative accuracy test audit (RATA) on the CEMS/CERMS that serve the Building 2512 THROX unit. In addition, an annual performance test measuring emissions of particulate matter (PM) equal to or less than a nominal aerodynamic diameter of 10 micrometers (PM_{10}), carbon monoxide (CO), and total organic compounds (TOC) was conducted. Note that all PM from this source is assumed to be PM_{10}; therefore, the sum of filterable particulate matter (FPM) and condensable particulate matter (CPM) provides the result for total PM_{10} (i.e., PM_{10} = FPM +CPM). Also note that the CO and TOC measurements of the emissions performance test were conducted in conjunction with the measurements for the annual RATA. For purposes of this emissions compliance performance test and in accordance with the MON MACT, TOC emissions are measured as THC using a flame ionization analyzer (FIA).

The RATA and emissions performance test were conducted on October 12 and 13, 2022. All CEMS/CERMS RATAs were performed according to the procedures detailed in 40 CFR Part 60, Appendix B, Performance Specifications (PS) 2, 3, 6, and 8 for NOx, O_2/CO_2, flow rate, and THC, respectively. Emission concentrations of O_2/CO_2, NOx, and THC were measured in accordance with US EPA reference methods (RMs) 3A, 7E, and 25A, respectively. Exhaust gas volumetric flow rate measurements were determined in accordance with RMs 1 through 4 for subsequent calculation of mass emission rates from measured exhaust gas concentrations. Emissions of FPM and CPM were determined using a combined sampling train in accordance with RMs 5 and 202, respectively.

The following table summarizes the pertinent source information for this emissions compliance performance test:

Responsible Groups	• The Dow Chemical Company • Michigan Department of Environment, Great Lakes, and Energy (EGLE) • United States Environmental Protection Agency (US EPA)
Applicable Regulations	• Permit: MI-ROP-A4043-2019 • MON MACT (40 CFR 63, Subpart FFFF) • 40CFR60, Appendix B, Performance Specifications (PS) 2, 3, 6, and 8.
Industry / Plant	• Dow Silicones – Thermal Heat Recovery Oxidation (THROX) Unit
Plant Location	• The Dow Chemical Company Michigan Operations (MiOps) Industrial Park (I-Park) Midland, Michigan 48667
Date of Last Performance Test	• October 2021
Air Pollution Control Equipment	• THROX • Caustic Scrubber • Two Ionizing Wet Scrubbers (IWS)
Emission Points	• Building 2512 THROX
Pollutants/Diluents Monitored/Tested	• Oxygen (O_2) • Carbon Dioxide (CO_2) • Nitrogen Oxides (NO_X) • Total Hydrocarbons (THC) • Carbon Monoxide (CO) • Particulate Matter (PM)
Test Date(s) (RATA and Emissions Performance Test)	• October 12 and 13, 2022

1.3 Key Personnel

The contact for the source and test report is:

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Names and affiliations of personnel, including their roles in the test program, are summarized in the following table.

Role	Role Description	Name	Affiliation
Process Focal Point	• Coordinate plant operation during test • Ensure the unit is operating at the agreed upon conditions in the test plan • Collect any process data and provide all technical support related to process operation	Brandon Krieger	Dow
Environmental Focal Point	• Ensure all regulatory requirements and citations are reviewed and considered for the testing	Becky Meyerholt	Dow
Test Plan Coordinator Back-up	• Leadership of the sampling program • Develop the overall testing plan • Determine the correct sample methods • Completes technical review of test data	Chuck Glenn Air Sample SME	Dow
Technical Reviewer	• Completes technical review of test data	Wayne Washburn	AECOM
Field Team Leader	• Ensures field sampling meets quality assurance objectives of plan	Jack Hoard	AECOM
Test Project Manager	• Ensures data generated meets the quality assurance objectives of the plan	James Edmister	AECOM

1.4 Executive Summary

Results summaries for the RATA and emissions performance test are presented in **Table 1-1** and **Table 1-2**, respectively.

The accuracy results indicate that the O_2/CO_2, NO_X, and THC CEMS and the flow rate CERMS were operating within the required accuracy criteria. Relative accuracy results were calculated for O_2 and CO_2 in units of percent by volume on a dry basis (%vd), for NO_X in units of parts per million by volume on a dry basis (ppmvd) and mass emission rates in units of pounds per hour (lb/hr), for THC in units of parts per million by volume on a wet basis (ppmvw) as measured and corrected for exhaust gas oxygen in units of ppmvd @ 3% O_2, and for exhaust gas volumetric flow rate in units of standard cubic feet per minute (scfm, wet basis). The results of the RATA indicate that the 2512 THROX CEMS/CERMS have passed under the requirements for annual certification.

The compliance test results indicate that emissions of PM_{10}, CO, and TOC were within the required emission standards. Emissions compliance results were calculated for PM_{10}, CO, and TOC in units of lb/hr. The result for total PM_{10} was determined as the sum of filterable particulate matter (FPM) and condensable particulate matter (CPM) from a combined sampling train (i.e., PM_{10} = FPM +CPM). The result for TOC emissions is determined from THC measured using a flame ionization analyzer (FIA). The results of the compliance performance test indicate that the 2512 THROX has passed under the Michigan ROP and MON MACT annual test requirements.

The remainder of this document is organized as follows. **Section 2** of this document provides a summary and discussion of results for the RATA and emissions performance test; **Section 3** provides a description of the flue gas monitoring sample port locations and the facility CEMS system; **Section 4** describes the test procedures that were followed and a description of AECOM's portable instrumental analyzer laboratory; **Section 5** describes the Quality Assurance/Quality control measures for the test program; and **Section 6** describes how the data reduction was performed.

Test program participants included: Jack Hoard, James Edmister, and Quincy Crawford from AECOM; as well as Becky Meyerholt from Dow.

Additional information is contained in the Appendices as follows: **Appendix A** provides Reference Method (RM) Emissions Data from AECOM's test activities during the test program, **Appendix B** contains Facility Data for the RATA and emissions performance test and supporting documentation, **Appendix C** contains RM Quality Assurance Data, including Manual Equipment Calibrations and instrumental analyzer Calibration Error Tests, System Bias and Drift Checks, System Response Times, Gas Cylinder Certification Sheets, and QSTI Certificates, and **Appendix D** contains the Test Protocol.

Table 1-1 Relative Accuracy Test Audit Summary of Results – 2512 THROX Stack

Monitoring System	Parameter (Reporting Tag)	RA Result	Relative Accuracy Criteria – Part 60	Pass / Fail [1]
CEMS	O_2 percent, dry (O2 Minute, %)	0.4% of RM 0.01% O_2	≤20.0% of RM (PS 3) [2] ≤1.0% O_2 (PS 3) [2]	Pass
	CO_2 percent, dry (CO2 %)	8.6% of RM 0.42% CO_2	≤20.0% of RM (PS 3) [2] ≤1.0% CO_2 (PS 3) [2]	Pass
	NOx ppmv, dry (NOx ppmv)	5.3% of RM	≤20% of RM (PS 2) [3]	Pass
	THC ppmv, wet (THC ppm)	*117.0% of RM* 2.7% of ES	≤20% of RM (PS 8) [3] ≤10% of ES (PS 8) [3]	Pass
CERMS	Gas Flow Rate, scfm (wet) (Gas Flow THROX Out Stack, scfm)	15.7% of RM	≤20% of RM (PS 6) [4]	Pass
	Gas Flow Rate, scfm (wet) (SICK Flow, SCFM)	6.7% of RM	≤20% of RM (PS 6) [4]	Pass

1. To meet Performance Specification (PS) requirements for relative accuracy (RA), a CEMS or CERMS monitor need only pass the least restrictive of the performance criteria as specified in the regulations under Part 60, Appendix B.
2. Part 60 RA results for O_2 or CO_2 under PS 3 must be either no greater than 20.0% of the average reference method (RM) value or no greater than 1.0% O_2 or CO_2 by difference.
3. Part 60 RA results for NOx under PS 2 and for THC under PS 8 must be either no greater than 20% of RM value or 10% of the emission standard (ES), otherwise known as the permit limit, if applicable. Note: there is no applicable permit limit for NOx concentrations measured in units of ppm. The MON MACT emission standard for TOC is 20 ppmv.
4. Part 60 RA results for CERMS under PS 6 must be no greater than 20% of RM for monitored pollutant mass emission rates. RA for exhaust gas volumetric flow rate monitors is not required to be evaluated by US EPA but is evaluated as required by Michigan EGLE. There is no specification for relative accuracy of a flow rate monitor by itself within the US EPA Performance Specifications. PS 6 speaks of CERMS and provides specifications for emission rate monitors. Flow rate is a component of a CERMS, and the individual value is not addressed by PS 6. However, in this case, flow monitor RA is used as a surrogate to evaluate CERMS performance.

Table 1-2 Emissions Compliance Summary of Results – 2512 THROX Stack

Emissions Parameter	Test Method	Sampling Duration (Minutes/Run)	Emission Standard	Measured Emission Rate [1]	Within Compliance
PM_{10} (Total FPM + CPM)	Methods 5/202	60	3.5 lb/hr 13.4 ton/yr	0.49 lb/hr 2.12 ton/yr [2]	Yes Yes
Carbon Monoxide	Method 10	63	N/A 90 ton/yr	0.000 lb/hr <1 ton/yr [2]	N/A Yes
TOC (measured as THC)	Method 25A	63	6.6 lb/hr N/A	0.03 lb/hr 0.13 ton/yr [2]	Yes N/A

[1] Hourly emission rates are reported as the average of three one-hour compliance test runs.

[2] Annual emission rates (ton/yr) are calculated from the average hourly emission rate (lb/hr) times 8,760 maximum operating hours per year (hr/yr) divided by 2,000 pounds per ton (lb/ton).

2. Summary and Discussion of Results

The purpose of this CEMS Performance Specification Test (PST) and emissions Compliance Performance Test (CPT) was to demonstrate compliance with US EPA's Regulations for the 2512 THROX CEMS O_2, CO_2, NO_X, and THC monitors and CERMS exhaust gas volumetric flow rate monitors performance as well as the air permit compliance status for stack emissions of PM, CO, and TOC at the Michigan Operations Incineration Complex in Midland, Michigan. The specific objectives were:

- Determine the relative accuracy of the 2512 THROX O_2, CO_2, NO_X, and THC CEMS and exhaust gas flow rate CERMS on the stack outlet for the annual PST certification.
- Determine 2512 outlet stack emission rates of PM, CO, and TOC for the annual emissions compliance test evaluated against the air permit limits in the Michigan EGLE ROP.

During these performance tests, the process was operated at a minimum THROX heat input rate of 30 MMBtu/hr as representative of maximum normal operating rates in accordance with the air permit and performance test plan guidelines. Summaries of the results for the Performance Specification Test of the 2512 THROX CEMS and CERMS monitors as well as emissions compliance test mass emission rate results are presented below. This section summarizes and discusses the results of the PST QA test RATA and emissions compliance test results along with the associated process operating data.

2.1 Relative Accuracy Test Results – 2512 THROX CEMS/CERMS

Relative accuracy testing was conducted by AECOM using the instrumental analyzer procedures detailed in 40 CFR 60, Appendix A, Reference Methods (RM) 3A, 7E, and 25A for O_2/CO_2, NO_X, and THC, respectively. In addition, relative accuracy testing was conducted by AECOM using the source emissions testing procedures detailed in 40 CFR 60, Appendix A, Reference Methods (RM) 2, 3A, and 4 for exhaust gas velocity, O_2/CO_2, and moisture, respectively, that were used to calculate exhaust gas volumetric rate. The instrumental analysis and source emissions test results are referred to as the Reference Method Results. The results of the RATA program for the facility CEMS and CERMS monitors are presented in **Table 2-1** for O_2 measured as percent by volume on a dry basis (%vd), in **Table 2-2** for CO_2 measured as percent by volume on a dry basis (%vd), in **Table 2-3** for NOx measured as parts per million by volume on a dry basis (ppmvd) , in **Table 2-4** for THC measured as parts per million by volume on a wet basis (ppmvw), and in **Table 2-5** for flow rate measured as standard cubic feet per minute on a wet basis (scfm). In addition, primary process operating parameters for the RATA are presented in **Table 2-6** with the full list of the recorded process parameters itemized in **Table 2-10** and included in **Appendix B**. AECOM field data and calculations are presented in **Appendix A**. Facility CEMS test data and process data corresponding to the RM test run times are presented in **Appendix B**.

The 2512 THROX CEMS/CERMS NOx, O_2/CO_2, flow rate, and THC monitors passed the RA criteria in PS 2, PS 3, PS 6, and PS 8, respectively.

2.2 Emissions Compliance Test Results – 2512 THROX Stack

Emissions compliance testing was conducted by AECOM using the source test procedures detailed in 40 CFR 60, Appendix A, Reference Methods (RM) 5/202, 10, and 25A for PM_{10} (as FPM/CPM), CO, and TOC (as THC), respectively. The results of the emissions compliance test program for the 2512 THROX Stack are presented in **Table 2-7** for CO and TOC and in **Table 2-8** for PM_{10}. In addition, primary process operating parameters for the CO and TOC emissions test are presented in **Table 2-6** and for the PM_{10} emissions test are presented in **Table 2-9** with the full list of the recorded process parameters itemized in **Table 2-10** and included in **Appendix B**. AECOM field data and calculations are presented in **Appendix A**. Facility process-operating data corresponding to the RM test run times are presented in **Appendix B**.

The 2512 THROX Stack measured emission rates were within the Michigan ROP emission limits.

Table 2-1 Relative Accuracy Results – 2512 THROX CEMS O_2 (percent by volume, dry)

Oxygen Relative Accuracy Results						
		REFERENCE METHOD	STACK ANALYZERS		ARITHMETIC DIFFERENCE and RATA	
			O2 Minute (%)		O2 Minute (%)	
10/12/2022	TIME	Oxygen (%, dry)	Oxygen (%, dry)	Use of Run[1]	Oxygen (%, dry)	Use of Run[1]
RA-1	08:58-09:19	10.86	10.90		0.04	
RA-2	09:19-09:40	10.88	10.90		0.02	
RA-3	09:40-10:01	10.83	10.90		0.07	
RA-4	10:25-10:46	10.90	10.90		0.00	
RA-5	10:46-11:07	10.91	10.90		-0.01	
RA-6	11:07-11:28	10.96	10.91		-0.05	
RA-7	11:52-12:13	10.97	10.98		0.01	
RA-8	12:13-12:34	10.96	11.00		0.04	
RA-9	12:34-12:55	10.97	11.00		0.03	
RA-10	13:33-13:54	11.03	10.95		-0.08	
RA-11	13:54-14:15	11.01	10.91		-0.10	
RA-12	14:15-14:36	11.00	10.92		-0.08	

Number of Runs Used in Calculation (n)	12
Average Difference (d_{AVG})	-0.010
Standard Deviation (S_d)	0.056
t-Value ($t_{0.975}$)	2.201
Confidence Coefficient (CC)	0.036
Average of Reference Method (RM_{AVG})	10.94
Relative Accuracy (O_2) ($\|d_{AVG}\|$)	0.01
Relative Accuracy (% of Reference Method) (RA)	0.4

[1] An X in this column denotes a run which is not used in calculation of relative accuracy.

Performance Specification 3 (and 4B)	***ACCEPTANCE CRITERIA***
Absolute value of difference between mean RM and mean CEMS (% O_2)	1.0
Relative Accuracy (% of Reference Method) (RA)	20

Table 2-2 Relative Accuracy Results – 2512 THROX CEMS CO_2 (percent by volume, dry)

Carbon Dioxide Relative Accuracy Results						
		REFERENCE METHOD	STACK ANALYZERS		ARITHMETIC DIFFERENCE and RATA	
			CO2 %		CO2 %	
10/12/2022	TIME	Carbon Dioxide (%, dry)	Carbon Dioxide (%, dry)	Use of Run[1]	Carbon Dioxide (%, dry)	Use of Run[1]
RA-1	08:58-09:19	5.32	4.80		-0.52	
RA-2	09:19-09:40	5.25	4.80		-0.45	
RA-3	09:40-10:01	5.31	4.80		-0.51	
RA-4	10:25-10:46	5.23	4.80		-0.43	
RA-5	10:46-11:07	5.22	4.80		-0.42	
RA-6	11:07-11:28	5.18	4.80		-0.38	
RA-7	11:52-12:13	5.20	4.80		-0.40	
RA-8	12:13-12:34	5.21	4.80		-0.41	
RA-9	12:34-12:55	5.19	4.80		-0.39	
RA-10	13:33-13:54	5.17	4.80		-0.37	
RA-11	13:54-14:15	5.16	4.80		-0.36	
RA-12	14:15-14:36	5.18	4.80		-0.38	

Number of Runs Used in Calculation (n)	12
Average Difference (d_{AVG})	-0.418
Standard Deviation (S_d)	0.051
t-Value ($t_{0.975}$)	2.201
Confidence Coefficient (CC)	0.032
Average of Reference Method (RM_{AVG})	5.22
Relative Accuracy (CO_2) ($\lvert d_{AVG} \rvert$)	0.42
Relative Accuracy (% of Reference Method) (RA)	8.6

[1] An X in this column denotes a run which is not used in calculation of relative accuracy.

Performance Specification 3 (and 4B)	ACCEPTANCE CRITERIA
Absolute value of difference between mean RM and mean CEMS (% CO_2)	1.0
Relative Accuracy (% of Reference Method) (RA)	20

Table 2-3 Relative Accuracy Results – 2512 THROX CEMS NOx (ppmv, dry)

Nitrogen Oxides Relative Accuracy Results

		REFERENCE METHOD			STACK ANALYZERS		ARITHMETIC DIFFERENCE	
		Oxygen Conc for Correction (%)		3	NOx ppmv		NOx ppmv	
10/12/2022	TIME	Oxygen (%, dry)	Nitrogen Oxides (ppmv dry)	Nitrogen Oxides (ppm, dry) (Oxygen Corrected)	Nitrogen Oxides (ppm, dry)	Use of Run[1]	Nitrogen Oxides (ppm, dry)	Use of Run[1]
RA-1	08:58-09:19	10.86	44.2	78.7	47.48		3.33	
RA-2	09:19-09:40	10.88	42.9	76.7	45.53		2.60	
RA-3	09:40-10:01	10.83	43.1	76.6	43.69		0.62	
RA-4	10:25-10:46	10.90	42.1	75.4	40.05		-2.04	
RA-5	10:46-11:07	10.91	42.0	75.2	39.70		-2.25	
RA-6	11:07-11:28	10.96	42.3	76.2	39.70		-2.61	
RA-7	11:52-12:13	10.97	41.9	75.6	39.70		-2.22	
RA-8	12:13-12:34	10.96	42.2	76.1	39.70		-2.54	
RA-9	12:34-12:55	10.97	41.8	75.3	39.70		-2.08	
RA-10	13:33-13:54	11.03	40.9	74.2	39.70		-1.18	
RA-11	13:54-14:15	11.01	41.1	74.4	39.70		-1.41	
RA-12	14:15-14:36	11.00	41.1	74.3	39.70		-1.41	

Number of Runs Used in Calculation (n)	12
Average Difference (d_{AVG})	-0.933
Standard Deviation (S_d)	2.020
t-Value ($t_{0.975}$)	2.201
Confidence Coefficient (CC)	1.284
Applicable Standard (or Permit Limit)	
Average of Reference Method (RM_{AVG})	42.13
Relative Accuracy (CO, NO_X, SO_2, O_2,CO_2) ($\vert d_{AVG}\vert + \vert CC \vert$)	2.22
Relative Accuracy (% of Reference Method) (RA)	5.3
Relative Accuracy (% of Permit Limit) (RA)	--

[1] An X in this column denotes a run which is not used in calculation of relative accuracy.

Performance Specification 2	ACCEPTANCE CRITERIA
Relative Accuracy (% of Reference Method) (RA)	20
Relative Accuracy (% of Permit Limit) (RA)	10

General Business

Table 2-4 Relative Accuracy Results – 2512 THROX CEMS THC (ppmv, wet)

Total Hydrocarbon Relative Accuracy Results

		REFERENCE METHOD			**STACK ANALYZERS**		**ARITHMETIC DIFFERENCE**	
		Oxygen Conc for Correction (%)		**3**	THC ppm		THC ppm	
10/12/2022	TIME	Oxygen (%)	THC (ppmv, wet)	THC (O_2 Corr) (ppm)	THC (ppmv, wet)	Use of Run[1]	THC (ppmv, wet)	Use of Run[1]
RA-1	08:58-09:19	10.86	0.50	1.00	0.28		-0.22	
RA-2	09:19-09:40	10.88	0.52	1.05	0.47		-0.05	
RA-3	09:40-10:01	10.83	0.44	0.89	0.62		0.18	
RA-4	10:25-10:46	10.90	0.36	0.74	0.65		0.29	
RA-5	10:46-11:07	10.91	0.45	0.91	0.68		0.23	
RA-6	11:07-11:28	10.96	0.43	0.89	0.71		0.28	
RA-7	11:52-12:13	10.97	0.43	0.89	0.80		0.37	
RA-8	12:13-12:34	10.96	0.37	0.77	0.80		0.43	
RA-9	12:34-12:55	10.97	0.29	0.60	0.73		0.44	
RA-10	13:33-13:54	11.03	0.37	0.76	1.00		0.63	
RA-11	13:54-14:15	11.01	0.35	0.70	1.04		0.69	
RA-12	14:15-14:36	11.00	0.28	0.57	1.12		0.84	

Number of Runs Used in Calculation (n)	12
Average Difference (d_{AVG})	0.341
Standard Deviation (S_d)	0.299
t-Value ($t_{0.975}$)	2.201
Confidence Coefficient (CC)	0.190
Applicable Standard (or Permit Limit)	20
Average of Reference Method (RM_{AVG})	0.45
Relative Accuracy (CO, NO_X, SO_2, O_2,CO_2) ($\lvert d_{AVG}\rvert + \lvert CC\rvert$)	0.53
Relative Accuracy (% of Reference Method) (RA)	117.0
Relative Accuracy (% of Permit Limit) (RA)	2.7

[1] An X in this column denotes a run which is not used in calculation of relative accuracy.

Performance Specification 8	***ACCEPTANCE CRITERIA***
Relative Accuracy (% of Reference Method) (RA)	20
Relative Accuracy (% of Permit Limit) (RA)	10

Table 2-5 Relative Accuracy Results – 2512 THROX CERMS Flow Rate, wet (scfm)

		REFERENCE METHOD	STACK ANALYZERS				ARITHMETIC DIFFERENCE			
			Gas Flow THROX Out Stack (scfm)		SICK Flow (SCFM)		Gas Flow THROX Out Stack (scfm)		SICK Flow (SCFM)	
Run Number	TIME	Flow (scfm)	Flow Rate (scfm)	Use of Run[1]	Flow Rate (scfm)	Use of Run[1]	Flow Rate (scfm)	Use of Run[1]	Flow Rate (scfm)	Use of Run[1]
Flow Run 1	08:58-09:19	10,258	11,229		10,810		972		552	
Flow Run 2	09:19-09:40	8,919	11,941	x	10,800	x	3,022	X	1,881	X
Flow Run 3	09:40-10:01	9,662	12,158	x	10,800	x	2,496	X	1,138	X
Flow Run 4	10:25-10:46	10,205	11,679		10,900		1,474		695	
Flow Run 5	10:46-11:07	10,095	12,300		10,970		2,205		875	
Flow Run 6	11:07-11:28	10,171	11,212		10,700		1,041		529	
Flow Run 7	11:52-12:13	10,128	11,121		10,920		994		792	
Flow Run 8	12:13-12:34	10,144	12,660	x	10,710		2,516	X	566	
Flow Run 9	12:34-12:55	10,580	12,322		10,900		1,742		320	
Flow Run 10	13:33-13:54	10,357	11,701		10,890		1,344		533	
Flow Run 11	13:54-14:15	10,720	11,194		11,180		474		460	
Flow Run 12	14:15-14:36	10,525	11,165		10,860		640		335	
Number of Runs Used in Calculation (n)							9		10	
Average Difference (d_{AVG})							1,209.5		565.7	
Standard Deviation (S_d)							543.1		179.8	
t-Value ($t_{0.975}$)							2.306		2.262	
Confidence Coefficient (CC)							417.4		128.6	
Average of Reference Method (RM_{AVG})							10,338		10,318	
Relative Accuracy (in dscfm) ($\lvert d_{AVG}\rvert+\lvert CC\rvert$)							1,627		694	
Relative Accuracy (% of Reference Method) (RA)							15.7		6.7	

[1] An X in this column denotes a run which is not used in calculation of relative accuracy.

Performance Specification 6	ACCEPTANCE CRITERIA
Relative Accuracy (% of Reference Method) (RA)	20

Note: There is no specification for Relative Accuracy of a Flow Monitor by itself within the EPA Performance Specifications. PS6 speaks of CERMS, and provides specifications for emission rate monitors. Flow rate is a component, and the individual value is not addressed.

Table 2-6 Process Data for CEMS RATA and CO/TOC Emissions Compliance Test

RATA Run	CO/ TOC Run	Heat Input (MMBtu/hr)	Gas Flow Dry Vent (lb/hr)	Gas Flow Wet Vent (lb/hr)	Gas Flow MeCl (lb/hr)	Silicon Loading (lb/hr)	Combustion Chamber Temp (°F)	HCl Scrubber pH
1	1	23.6	401.6	699.8	178.9	0.40	2,000	7.91
2		23.7	384.4	681.9	183.2	0.46	2,000	7.91
3		23.9	467.0	666.5	183.0	0.54	2,000	7.91
4	2	24.0	507.6	668.7	183.0	0.61	2,000	7.91
5		24.1	460.4	669.3	186.7	0.66	2,001	7.91
6		24.1	449.6	704.8	183.3	0.60	1,999	7.91
7	3	24.3	408.8	663.0	184.6	0.60	2,000	7.91
8		24.2	394.6	696.4	183.2	0.72	2,000	7.91
9		24.6	473.0	666.6	185.1	0.72	2,000	7.91
10	N/A	24.2	387.6	618.7	189.9	0.53	2,000	7.91
11		24.3	462.4	599.2	185.2	0.54	2,000	7.91
12		24.5	435.8	602.9	187.5	0.51	2,000	7.91
Average:		**24.1**	**436.1**	**661.5**	**184.5**	**0.57**	**2,000**	**7.91**

Table 2-7 Compliance Test Results – 2512 THROX Stack CO and TOC Emissions

Run Identification	CPT-1	CPT-2	CPT-3	Average
Run Date	10/12/22	10/12/22	10/12/22	
Run Time	08:58-10:01	10:25-11:28	11:52-12:55	
Exhaust Gas Conditions				
Oxygen (%, dry)	10.86	10.93	10.97	**10.92**
Carbon Dioxide (%, dry)	5.29	5.21	5.20	**5.23**
Flue Gas Moisture (%)	11.43	11.92	12.08	**11.81**
Flue Gas Velocity (ft/sec)	11.35	11.96	11.99	**11.77**
Flue Gas Flow Rate (acfm)	10,829	11,414	11,442	**11,228**
Flue Gas Flow Rate (scfm)	9,662	10,171	10,144	**9,992**
Flue Gas Flow Rate (dscfm)	8,558	8,959	8,919	**8,812**
Carbon Monoxide				
Carbon Monoxide (ppmv dry)	0.000	0.000	0.000	**0.000**
Emission rate (lb/hr)	0.000	0.000	0.000	**0.000**
Total Hydrocarbons (as Propane)				
Concentration (ppmvd)	0.55	0.47	0.42	**0.48**
Emission rate (lb/hr) (as propane)	0.032	0.029	0.026	**0.029**

Table 2-8 Compliance Test Results – 2512 THROX Stack PM_{10} Emissions

Run Identification	PM-1	PM-2	PM-3	Average
Run Date	10/13/22	10/13/22	10/13/22	
Run Time	08:40-09:55	10:30-11:35	12:10-13:15	
Exhaust Gas Conditions				
Oxygen (%, dry)	10.89	10.95	10.97	10.94
Carbon Dioxide (%, dry)	5.21	5.21	5.20	5.21
Flue Gas Moisture (%)	12.62	13.33	12.92	12.96
Flue Gas Velocity (ft/sec)	11.45	11.93	12.77	12.05
Flue Gas Flow Rate (acfm)	10,926	11,386	12,184	11,499
Flue Gas Flow Rate (scfm)	9,573	9,942	10,660	10,058
Flue Gas Flow Rate (dscfm)	8,366	8,617	9,282	8,755
PM_{10} (as Total FPM + CPM)				
Concentration (gr/dscf)	0.00598	0.00671	0.00667	0.00645
Emission rate (lb/hr)	0.429	0.495	0.530	0.485

Table 2-9 Process Data for PM_{10} Emissions Compliance Test

PM_{10} Run	Heat Input (MMBtu/hr)	Gas Flow Dry Vent (lb/hr)	Gas Flow Wet Vent (lb/hr)	Gas Flow MeCl (lb/hr)	Silicon Loading (lb/hr)	Combustion Chamber Temp (°F)	HCl Scrubber pH
1	24.7	446.8	756.7	168.8	0.77	2,001	7.78
2	24.7	491.8	745.8	187.4	0.77	2,000	6.33
3	24.9	464.5	709.2	174.5	0.86	2,000	7.26
Average:	**24.8**	**467.7**	**737.2**	**176.9**	**0.80**	**2,000**	**7.12**

Table 2-10 Process Data Parameters for the RATA and Emissions Compliance Tests

Process Monitoring Parameter	Process Tag Unit
NOx (ppmvd)	ppmv
THC (ppmvw)	ppm
O_2 (%, dry)	Minute (%)
CO_2 (%, dry)	%
CO_2 Emissions	Mtons/yr
Gas Flow, THROX Out Stack – monitoring solutions instrument	scfm, wet
Gas Flow, THROX – SICK Instrument	kscfm, wet
Heat Input	MMBtu/hr
Combustion Chamber Temperature	Degrees F
HCl Scrubber pH	pH units
Gas Flow, Dry Vent	lb/hr
Gas Flow, Wet Vent	lb/hr
Gas Flow, MeCl	lb/hr
Silicon Loading	lb/hr
IWS 1 Water Flow Rate	GPM
IWS 1 Voltage	KV
IWS 1 Current	mA
IWS 2 Water Flow Rate	GPM
IWS 2 Voltage	KV
IWS 2 Current	mA

3. Facility Process and CEMS Description

3.1 Process Description

This section briefly describes the 2512 THROX treatment system. The THROX and its associated air pollution control equipment are utilized to treat emissions from various processes at the chemical facility. Some of these processes are continuous and others are batch, the test was conducted at maximum representative normal operating conditions of the THROX. Operating parameters for the THROX and its associated air pollution control equipment are specified in table FGTHROX of renewable operating permit (ROP) No. MI-ROP-A4043-2019 and the malfunction abatement plan.

Building 2512 uses a site wide thermal heat recovery oxidation (THROX) unit that destroys/removes TOC, hazardous air pollutants (HAPs), PM_{10}, hydrogen halides, and other toxic air contaminants from the consolidated vent system prior to discharge to atmosphere. Air pollution control equipment associated with the THROX includes a quencher, absorber, and two-stage ionizing wet scrubbers (IWS) in series.

3.2 Applicable Regulations and Performance Requirements

Applicable Regulations
MI-ROP-A4043-2019
CFR Part 63, Subpart FFFF
CFR 50.21 PSD
40 CFR Part 98 GHG Rule
40 CFR Part 60, Appendix B, Performance Specifications 2, 3, 6, and 8

Pollutants/Diluent Measured - Relative Accuracy (RATA)
NO_x RA <20% of RM – PS 2
Oxygen (O_2) RA <20.0% of RM or absolute difference <1.0% – PS 3
Carbon Dioxide (CO_2) RA <20.0% of RM or absolute difference <1.0% – PS 3
Flow RA <20% of RM (as surrogate for PS 6 compliance)
Total Hydrocarbon (THC) RA <20% of RM or 10% of ES (20 ppmv) – PS 8

Pollutants/Diluent Measured – Compliance Test (SV2514-006)
PM_{10}: 3.5 lb/hr and 13.4 tons/yr
CO: 90 tons/yr
TOC: 6.6 lb/hr

Under the Miscellaneous Organic NESHAP (40 CFR Part 63, Subpart FFFF – MON MACT), the facility is choosing to comply with the alternative standard in §63.2505 and is subject to the following emission limitations:

- §63.2505(a)(1)(i)(A) requires the THROX to reduce HAP emissions to an outlet total organic compounds (TOC) concentration of 20 ppmv or less.
- §63.2505(a)(1)(i)(C) provides an alternative for reducing hydrogen halide and halogen HAP generated in the combustion device by ≥95 percent by weight in the scrubber.
  - In accordance with the provisions for hydrogen halide and halogen HAP emissions from process vents in §63.2465 and Table 3 to Subpart FFFF, the scrubbers must reduce the hydrogen halide and halogen HAP to ≥ 99% (or to an outlet concentration of ≤ 20 ppmv or the halogen atom mass emission rate must be reduced to ≤ 0.45 kg/hr).

3.3 Process Emissions Control Description

The air pollution control system downstream of the THROX consists of a quencher, absorber, and two-stage ionizing wet scrubbers (IWS) in series. The THROX is designed to thermally treat liquid and solid wastes. As necessary, fuel gas is used as a supplemental fuel. Destruction of organic compounds takes place in the combustion chambers. The THROX typically operates above 1,800°F. The permitted maximum nominal thermal output capacity of this unit is 95 million British thermal units per hour (MMBtu/hr). The typical feed rate to the THROX is 28 MMBtu/hr. The waste supplies most of the heat. Natural gas is used to maintain the temperature when the Btu content of the waste is limited and to maintain the flame during startups and shutdowns.

After the combustion gases exit the oxidizer chamber, they enter the boiler section where heat is recovered to generate steam. Next, the gases enter the quench section, then a packed bed absorber. The absorber uses caustic water to neutralize hydrogen chloride in the vapor. Finally, the gases pass through two (2) ionizing wet scrubbers in series. The ionizing wet scrubbers remove particulate by passing the stream through a charged field. The particles become charged and are attracted to the charged plates, then they are removed by a continuous flow of water down the plates and through the packed beds.

The ROP currently requires Dow Silicones Corporation to use the Verantis equation to demonstrate compliance with the lb/hr PM_{10} emission rate (as described in the plan entitled "Parametric Monitoring Plan and Verification of IWS Particulate Removal Efficiency from EUTHROX").

The emission test point for this test was the 2512 THROX Scrubber Stack.

3.4 Flue Gas Sampling Locations

Sampling was conducted on the 2512 THROX scrubber outlet stack. The reference method sampling ports in the stack are at least two equivalent diameters downstream from the nearest control device, the point of pollutant generation, or other point at which a change in the pollutant concentration occurs, and at least one-half equivalent diameters upstream from the effluent exhaust or control device. The stack has sampling ports installed as shown in **Figure 3.1**.

For the RATA and CO/THC emissions compliance test runs, the instrumental analyzer and moisture train samples were drawn from the stack for a period of three consecutive 21-minute runs continuously following a stratification test conducted at the three traverse points of 16.7, 50.0, and 83.3 percent of the measurement line that passes through the centroidal area of the stack cross section. For RATA velocity measurements, pitot tube and temperature readings were taken from the stack for each 21-minute run at twelve (12) US EPA Method 1 sampling points in accordance with the following table. For the PM_{10} emissions compliance test runs, the Method 5/202 train samples were drawn from the stack over a period of 60 minutes spanning twelve (12) Method 1 sampling points in accordance with the following table.

Isokinetic 12 Point Circular Traverse Layout for Outlet

Division: MIOP
Facility/Block: DSC 2514 THROX

Stack ID: 54 inches
Port Ext: 6 inches

Duct Downstream Length: 50 Feet
Duct Upstream Length: 25 Feet

Duct Downstream Diameters: 11 Diameters
Duct Upstream Diameters: 5.5 Diameters

Traverse Point	Stack ID	Port Ext	Traverse Pt Distance	Traverse Pt Distance ♭	Final Probe Mark
1	54	6	2 6/16	2 6/16	8 6/16
2	54	6	7 14/16	7 14/16	13 14/16
3	54	6	16	16	22
4	54	6	38	38	44
5	54	6	46 2/16	46 2/16	52 2/16
6	54	6	51 10/16	51 10/16	57 10/16

3.5 Facility CEMS Description

The facility employs a CEMS to monitor NOx, O_2, CO_2, and THC, along with two exhaust gas flow rate CERMS in order to comply with MON MACT monitoring requirements and to demonstrate continuous compliance with the emission limits specified in their air permit (Michigan EGLE Permit MI-ROP-A4043-2019).

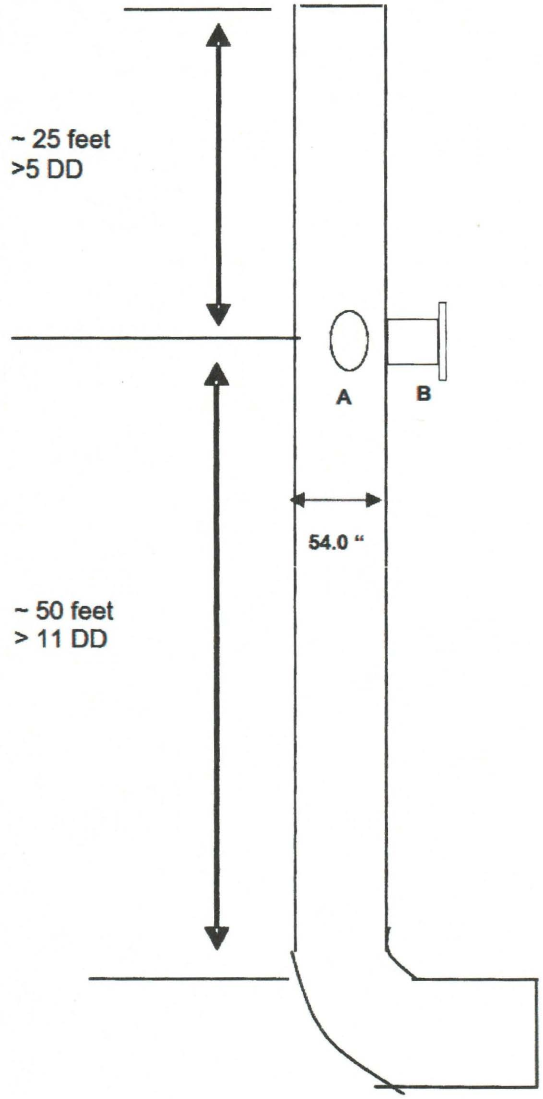
The CEMS is a dry-extractive non-dilution type that was designed and installed to meet emissions monitoring requirements outlined in 40 CFR Part 60, Appendix B, Performance Specifications (PS) 2, 3, and 8 for emissions of NOx, O_2/CO_2, and THC, respectively. The CERMS was designed and installed to measure exhaust gas volumetric flow rate meet emissions monitoring requirements outlined in 40 CFR Part 60, Appendix B, Performance Specifications (PS) 2

Each CEMS consists of an extractive sample probe, with a sintered metal element filter at the probe inlet tip. A heated sample line runs between the probe and CEMS cabinet to a sample conditioning system. The CEMS analyzers are housed in a climate-controlled shelter, which is located at the base of the stack. The CEMS analyzers are wired into the DAHS, which in turn calculates emissions from analyzer outputs and provides the required regulatory reports. Specifications for each CEMS/CERMS monitor are presented in **Table 3-1**. A schematic of the facility emissions stack layout showing the sample test port locations is provided in **Figure 3-1**.

Table 3-1 Facility CEMS/CERMS Equipment Specifications

CEMS / CERMS	Monitor System	Measurement Units	Equipment	S/N
CEMS	Oxygen FGTHROX	%v, dry	Brad Gaus Model 4705	10687
	Carbon Dioxide FGTHROX	%v, dry	California Analytical Model ZRE	A9E4415T
	Total Hydrocarbons FGTHROX	ppmv, wet	California Analytical Model 700 HFID	A09023
	Nitrogen Oxides FGTHROX	ppmv, dry	Thermo Scientific Model 42I	0733125534
CERMS	Air Flow FGTHROX	scfm	Monitoring Solutions Model CEM Flow	0128080001017
	Air Flow FGTHROX	scfm	SIC Model FLSE100-PK17835HSHS	13488341

Figure 3-1 Schematic of Stack Sample Port Locations



4. Performance Test Procedures

The following is a description of the testing that was completed on the 2512 THROX scrubber stack to fulfill the annual CEMS/CERMS RATA and emissions compliance requirements of 40 CFR Part 60 as specified in the Michigan EGLE air permit (MI-ROP-A4043-2019).

4.1 Manual Test Methods

4.1.1 Flow Rate, Gas Composition, and Moisture

Concurrent with the performance of RATA test runs, emissions compliance test runs, and isokinetic sampling trains, measurements were made to determine stack gas volumetric flow rate from measurements of gas velocity and temperature (EPA Method 2), gas molecular weight composition (EPA Method 3A), and gas moisture (EPA Method 4).

4.1.2 Filterable and Condensable Particulate Matter Sampling and Analysis

EPA Method 5 was utilized in conjunction with EPA Method 202 to determine both filterable particulate matter (FPM) and condensable particulate matter (CPM) concentrations during each PM_{10} emissions compliance test run.

Using EPA Method 5 procedures, total particulate matter (i.e., FPM) is withdrawn isokinetically from the source and collected on a glass fiber filter maintained at stack temperature. The FPM mass is determined gravimetrically after the removal of uncombined water.

EPA Method 202 procedures were used to collect CPM in dry impingers after FPM had been collected on a filter maintained as specified in Method 5 of Appendix A-6 to 40 CFR Part 60. The organic and aqueous fractions of the impingers and an out-of-stack CPM filter were then taken to dryness and weighed at an off-site analytical laboratory. The total of the impinger fractions and the CPM filter represents the CPM test result. Analyses for FPM and CPM were completed by Enthalpy Analytical.

4.2 Instrumental Analyzer Test Methods

AECOM followed the instrumental analyzer procedures specified in EPA Methods 3A, 7E, 10, and 25A (40 CFR Part 60, Appendix A) for the determination of O_2/CO_2, NOx, CO, and THC concentrations, respectively. Exhaust gas volumetric flow rates were calculated using measurements made following the source testing procedures specified in EPA Methods 2 and 4 (40 CFR Part 60, Appendix A) for the determination of gas velocity and moisture, respectively. The following subsections describe the sample procedures in more detail.

AECOM conducted a minimum of nine 21-minute test periods for the RATA using the AECOM transportable instrumental analyzer laboratory, which is described later in this section. For emissions compliance testing, each set of three (3) consecutive 21-minute RATA test runs were combined to comprise one 63-minute compliance test run. Average undiluted dry concentrations by volume of O_2, CO_2, NOx, and CO as well as undiluted hot-wet concentrations by volume of THC were determined for each test run. During each test run, the sample probe extracted a continuous sample along a traverse line through the center of the stack cross section as is specified in Performance Specification 2 (PS 2) of 40 CFR Part 60, Appendix B. Prior to sampling, a stratification test was completed where the sample probe was traversed across the stack at three points (16.7%, 50.0%, and 83.3%) of a measurement line passing through the stack centroid. The results of the Stratification Test are presented in **Appendix A**.

Relative accuracy (RA) determinations followed calculations delineated in PS 2, PS 3, PS 6, and PS 8 (40 CFR 60, Appendix B) for NOx, O_2/CO_2, flow rate, and THC, respectively. RA results are evaluated in accordance with the criteria specified in 40 CFR Part 60, Appendix B (PS 2, 3, 6, and 8). Each monitor of the CEMS/CERMS passes the RATA if it meets the least restrictive RA criterion in the applicable performance specification. The least restrictive Part 60 RA criterion for each O_2/CO_2 monitor was 1.0% O_2/CO_2 by difference, for each NOx and flow rate monitor was ≤20 percent of the average RM value, and for the THC monitor was ≤10 percent of the emission standard (20 ppmv MON MACT emission standard).

The O_2, CO_2, NOx, CO, THC, and flow rate RM test run data and calculation results are presented in **Appendix A**.

4.3 Transportable Instrumental Analyzer Laboratory

A transportable instrumental analyzer laboratory (i.e., Mobile Lab) was used to provide an environmentally controlled shelter to house RM analyzers and the sample delivery and conditioning system to measure O_2, CO_2, NOx, and CO by volume on a dry basis as well as THC by volume on a hot-wet basis. The AECOM RM monitoring system is contained in a temperature controlled portable shelter that was delivered to the site and set up prior to the start of the test program. The sample delivery and conditioning system consists of a stainless-steel sample probe, a heated particulate filter assembly, a heat-traced Teflon sample line, a refrigerated gas conditioning system (for moisture and condensable particulate removal), a sample gas manifold, and a sample pump. The clean dry sample was then delivered to the gas analyzers for the determination of undiluted O_2, CO_2, NOx, and CO concentrations. For measurement of THC, a portion of the hot-wet sample is diverted directly to the THC analyzer via a heated jumper line prior to the sample being introduced to the moisture condenser.

The analog output signals from each analyzer were connected to a data acquisition system (DAS) using a software package to perform the test calculations. The DAS then stored the data in engineering units and provided 1-minute and 10-second averages based upon a minimum of 60 readings per minute. The O_2 and CO_2 were measured using a Servomex 1440 Series analyzer with paramagnetic and non-dispersive infrared (NDIR) detectors on approximate span gas ranges of 0-25% and 0-20%, the NOx was measured using a Thermo Model 42 chemiluminescent analyzer on an approximate span gas range of 0-100 ppm, the CO was measured using a Thermo Model 48 gas filter correlation (GFC) / NDIR analyzer on an approximate span gas range of 0-100 ppm, and the THC was measured using a VIG Model 20 flame ionization analyzer (FIA) on an approximate span range of 0-100 ppm.

4.4 RM Instrumental Analyzer Calibration Procedures

The initial phase of the instrumental analyzer methods (e.g., Methods 3A, 6C, 7E, 10, and 25A) requires initial measurement system performance tests to be performed, including calibration error tests, system bias checks, response-time tests, an NO_2 converter test (for NO_X analyzers), and interference checks, as applicable.

Prior to performing test runs with the dry-measurement analyzers (i.e., Methods 3A, 6C, 7E, and 10 instruments), AECOM conducted direct instrument calibration error tests using zero and two upscale gases each for the O_2/CO_2, NOx, and CO analyzers prior to initiation of testing. Following these direct calibrations, an initial system bias check was performed by sending zero and one upscale gas, from one gas cylinder at a time, up to the sample probe and back down through the components of the sampling system. Following the initial system bias checks, response-time data was obtained for each analyzer. Subsequently, system bias and drift checks were performed both prior to and following each test run set of up to three consecutive runs using zero and one upscale calibration gas. These system checks allowed for the determination of initial and final system bias, as well as system drift for each test run set.

Prior to performing test runs with the hot-wet measurement analyzers (i.e., Method 25A instruments), AECOM conducted whole-system calibration error tests using zero and three upscale gases for the THC analyzer prior to initiation of testing. The initial system calibration error test was performed by sending zero and each of three upscale gases, from one gas cylinder at a time, up to the sample probe and back down through the components of the sampling system. Following these system calibrations, response-time data was obtained. Subsequently, system drift checks were performed both prior to and following each test run set of up to three consecutive runs using zero and one upscale calibration gas. These system checks allowed for the determination of system drift for each test run set.

Test run sets of three 21-minute RATA test runs were performed during a continuous and uninterrupted period of 63 minutes followed by a system bias and drift check. The calibration gases used during this program were prepared in accordance with EPA Protocol G1 procedures as specified by the National Institute of Standards and Technology (NIST). The O_2/CO_2/CO combination, NOx, and THC (propane) calibration compressed gas standards were contained in individual cylinders having a purified nitrogen gas balance.

Interference check data provided by each instrument's manufacturer is maintained on file to meet the requirements of Method 7E (Subsection 8.2.7) as referenced in Methods 3A, 6C, and 10, as applicable.

The RM calibration data, including initial calibration error tests, pre-run and post-run system bias and drift checks, system response time tests, NO_2 converter efficiency test data, and certificates of analysis for the RM test calibration gases, are provided in **Appendix A**.

5. Quality Assurance/ Quality Control Measures

5.1 Overview

During the sampling and measurements phase of the program, a strict quality assurance/quality control (QA/QC) program was adhered to. The QA/QC aspects of the program are discussed below.

5.2 Leak Check Procedure

Prior to conducting the instrumental analyzer testing, AECOM's Instrumental Measurements System was leak checked and verified to be leak free. Following the initial leak check, the system bias and drift criteria (as referenced in EPA Method 7E, 40 CFR Part 60, Appendix A) served as a continuous sample integrity check.

5.3 Instrumental Measurements System Calibrations

During the test program, AECOM used EPA instrumental analyzer methods (i.e., 3A, 6C, 7E, and 10, as applicable, in 40 CFR Part 60, Appendix A) for the measurement of O_2/CO_2, NOx, and CO. The initial phase of instrumental analysis requires calibration of the involved monitors. Prior to performing test runs, AECOM conducted direct instrument calibration error tests using zero and two upscale gases each for the O_2/CO_2 and CO instruments prior to initiation of testing. Following these direct calibrations, an initial system bias check was performed by sending zero and one upscale gas, from one gas cylinder at a time, up to the sample probe and back down through the relevant components of the sampling system. During the initial system bias checks, response-time data was obtained for each analyzer. Subsequently, system bias checks were performed both prior to and following each test run using zero and one upscale calibration gas. These system checks allowed for the determination of initial and final system bias, as well as system drift for each test run. The calibration gases used during this program were prepared to EPA Protocol G1/G2 standards. Certificates of analysis for the calibration gases are presented in Appendix B. The measurement system performance criteria in 40 CFR Part 60, Appendix A, Methods 3A and 10 are listed below and were the performance criteria for the reference method instruments during this program.

Procedure	Performance Criterion
Calibration error	<±2% of the calibration span
System bias	<±5% of the calibration span
System drift	<±3% of the calibration span

The instrumental analysis methods also require correction of data for calibration drift and/or bias. The values used for the determination of relative accuracy were corrected for system drift and bias observed during each test run. System bias and drift as well as response-time data are presented in **Appendix A** of this report.

5.4 Interference Checks

Interference checks are required for each make and model of instrumental analyzer used for reference method measurements and signed documentation of the results must be included in each test report (as referenced in 40 CFR 60, Appendix A, Method 7E, Subsection 8.2.7). Copies of the instrument specific test results are presented in **Appendix A** of this document.

6. Data Reduction

6.1 Overview

The objective of the monitoring program was to determine the relative accuracy (RA) of the MACT CO/O_2 CEMS/CERMS. RA results have been reported on an individual analyzer basis (concentrations) and for exhaust gas volumetric flow rate. Photocopies of the raw field data sheets and data printouts are also presented in the appendices. Equations and example calculations from the data reduction process are presented in **Appendix A**. Equations for the calculation of relative accuracy (RA) are presented in this section.

6.2 Calculation of Relative Accuracy

Standard Deviation

The standard deviation (SD) between the minimum of nine test runs chosen must be calculated. The following equation was used to calculate standard deviation:

$$S_D = \sqrt{\left[\frac{(Sum\ of\ d^2) - \frac{(Sum\ of\ d)^2}{n}}{n-1}\right]}$$

Where:

SD = Standard deviation of a minimum of nine selected runs

d = Arithmetic difference between the facility CEMS and RM test run averages

n = Number of sample test runs used for standard deviation calculation

Confidence Coefficient

The 95% confidence coefficient (CC) of the minimum of nine test runs chosen must be calculated. The student T Value of 2.306 (for nine runs) in the equation comes from Table 2-1 (t-Values) of PS 2 in 40 CFR Part 60, Appendix B. The T Value needs to be adjusted for the chosen number of test runs according to Table 2-1 in PS 2. The following equation was used to calculate the confidence coefficient:

$$CC = 2.306 \times \left(\frac{S_D}{\sqrt{n}}\right)$$

Where:

CC = Confidence coefficient

Sd = Standard deviation of the minimum of nine selected test runs

n = Number of sample test runs used for standard deviation calculation

Relative Accuracy

The relative accuracy of the CEMS/CERMS were calculated as required by PS 3, PS 4B, and PS 6 for O_2 (%vd), CO (ppmvd), and flow rate (scfm and dscfm), respectively. The relative accuracies are calculated to verify:

- RA for O_2 (%vd) is no greater than 20.0% of RM or 1.0% O_2 absolute difference (not including CC) as specified in PS 3 of 40CFR60, Appendix B
- RA for CO (ppmvd) is no greater than 10% of RM, 5% of ES (applicable emission standard), or 5 ppm CO absolute difference plus CC as specified in PS 4B of 40CFR60, Appendix B
- RA for flow rate (scfm and dscfm) is no greater than 20% as specified in PS 6 of 40CFR60, Appendix B

Relative Accuracy (% of RM or % of ES)

$$RA = \left[\frac{(|avg\ d| + |CC|)}{avg\ RM}\right] x\ 100\%$$

Relative Accuracy (by Absolute Difference)

For Pollutant Parameters (e.g., SO_2, NOx, CO): RA = |avg d| + |CC|

For Diluent Gas Parameters (e.g., O_2 and CO_2): RA = |avg d|

Where:

RA = Relative accuracy

CC = Confidence coefficient

d = Arithmetic difference between RM and CEMS values for each test run

avg d = Average arithmetic difference between RM and CEMS values for all test runs

RM = Reference Method value

ES = Emission Standard substituted for RM