AECOM

MI-ROP-A4043-2019b Permit Emissions Test

Michigan Operations Industrial Park (MiOps) Determination of Relative Accuracy – Original CEM

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

Dow Silicones Corporation
Midland, Michigan

Test Date: March 5, 2024

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 from the 2512 THROX treatment system has historically included a continuous emission monitoring system (CEMS) that continuously measures stack gas concentrations of nitrogen oxides (NOx), carbon dioxide (CO_2), and oxygen (O_2) as well as a continuous emission rate monitoring system (CERMS) that continuously measures stack gas pollutant mass emission rates.

Dow uses CEMS and CERMS to demonstrate compliance with the requirements outlined in the Renewable Operating Permit (MI-ROP-A4043-2019b) 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 CEMS employs an exhaust gas volumetric flow rate monitor as part of the associated 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 relative accuracy test audit (RATA) on the CEMS/CERMS Original System that serves the Building 2512 THROX unit due to the emergency replacement of a exhaust flow-meter.

The RATA test was conducted on March 5, 2024. The CEMS/CERMS RATA was performed according to the procedures detailed in 40 CFR Part 60, Appendix B, Performance Specifications (PS) 2, 3, and 6 for NOx, O_2, CO_2, flow rate, and emission rate. Emission concentrations of O_2, CO_2, NOx, and flow rate were measured in accordance with US EPA reference methods (RMs) 2, 3A, and 7E.

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-A4043-2019b • MON MACT (40 CFR 63, Subpart FFFF) • 40CFR60, App. B, Performance Specifications (PS) 2, 3, and 6.
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
Unit Initial Start-up	• 2003
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)
RATA Test Date	• March 5, 2024

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
Process Analyzer	• Conducts all other QA testing and provides records for 7-day drift tests, response time tests, CGAs, etc.	Stephanie Moreno	Dow
Technical Reviewer	• Completes technical review of test data	Rob Sava	AECOM
Field Team Leader	• Ensures field sampling meets quality assurance objectives of plan	Peter Becker	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 CEMS RATA are presented in **Table 1-1**.

The accuracy results indicate that the O_2, CO_2, NO_X, and the flow rate CERMS were operating within the required accuracy criteria, as applicable. Relative accuracy results were calculated for O_2 and CO_2 in units of percent by volume on a dry basis (%vd), for NOx in units of ppmv and pounds per hour (lb/hr), 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 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** describes 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: Peter Becker, Quincy Crawford, and Brady Dangler from AECOM; as well as Brandon Krieger and 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 Summary of Results – 2512 THROX CEMS – Original System

Monitoring System	Parameter (Reporting Tag)	RA Result	Relative Accuracy Criteria – Part 60	Pass / Fail [1]
CEMS	O_2 percent, dry (O_2 %vd)	2.4% of RM 0.24% O_2	≤20.0% of RM (PS 3) [2] ≤1.0% O_2 (PS 3) [2]	Pass
	CO_2 percent, dry (CO_2 %vd)	0.9% of RM 0.01% CO_2	≤20.0% of RM (PS 3) [2] ≤1.0% CO_2 (PS 3) [2]	Pass
	NOx ppmv, dry (NOx ppmvd)	3.7% of RM	≤20% of RM (PS 2) [3]	Pass
	NOx lb/hr (NOx lb/hr)	9.4% of ES	≤20% of RM (PS 2) [3]	Pass
CERMS	Gas Flow Rate, scfm (wet) (Exhaust Flow, SCFM)	8.8% 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 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.
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.

2. Summary and Discussion of Results

The purpose of this CEMS Performance Specification Test (PST) was to demonstrate compliance with US EPA's Regulations for the 2512 THROX CEMS O_2, CO_2, NO_X, and flow rate monitors at the Dow Michigan Operations (MiOps) Incineration Complex in Midland, Michigan. The specific objectives were:

- Determine the relative accuracy of the existing original 2512 THROX O_2, CO_2, NO_X, and exhaust gas flow rate CERMS on the stack outlet for the RATA certification.

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 and 7E for O_2, CO_2, and NO_X. 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 **Tables 2-2** for CO_2 measured as percent by volume on a dry basis (%vd), in **Tables 2-3** for NOx measured as ppmvd and pounds per hour (lb/hr), and in **Tables 2-4** for flow rate measured as standard cubic feet per minute on a wet basis (scfm). 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, and flow rate monitors, as applicable, passed the RA criteria in PS 2, PS 3, and PS 6.

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

Project: 2512 THROX RATA
Facility: Dow Midland, MI
2512 THROX
Original CEM
Source: System
Project ID: 60699646

Oxygen Relative Accuracy Results								
		REFERENCE METHOD	Correction for Moisture		STACK ANALYZERS Original CEM		ARITHMETIC DIFFERENCE and RATA Original CEM	
3/5/2024	TIME	Oxygen (%)	Moisture (%)	Oxygen(%, wet)	Oxygen (%, dry)	Use of Run[1]	Oxygen (%, dry)	Use of Run[1]
RATA Run 1	10:10-10:31	11.08	6.36	10.37	11.30		0.22	
RATA Run 2	10:31-10:52	11.08	6.17	10.39	11.30		0.22	
RATA Run 3	10:52-11:13	11.08	6.37	10.38	11.30		0.22	
RATA Run 4	11:32-11:53	11.04	6.08	10.36	11.30		0.26	
RATA Run 5	11:53-12:14	11.05	5.65	10.43	11.30	x	0.25	X
RATA Run 6	12:14-12:35	11.00	6.07	10.33	11.20		0.20	
RATA Run 7	13:07-13:28	10.96	6.07	10.30	11.20		0.24	
RATA Run 8	13:28-13:49	10.92	5.65	10.30	11.20		0.28	
RATA Run 9	13:49-14:10	10.83	5.65	10.22	11.10		0.27	
RATA Run 10	14:28-14:49	10.85	6.45	10.15	11.10	x	0.25	X
RATA Run 11	14:49-15:10	10.87	6.44	10.17	11.10		0.23	
RATA Run 12	15:10-15:31	10.91	6.44	10.21	11.20	x	0.29	X

Number of Runs Used in Calculation (n)	9
Average Difference (d_{AVG})	0.24
Standard Deviation (S_d)	0.03
t-Value ($t_{0.975}$)	2.306
Confidence Coefficient (CC)	0.021
Average of Reference Method (RM_{AVG})	10.98
Relative Accuracy (O_2) ($\lvert d_{AVG} \rvert$)	0.24
Relative Accuracy (O_2) ($\lvert d_{AVG} \rvert + \lvert CC \rvert$)	0.3
Relative Accuracy (% of Reference Method) (RA)	2.4

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

	ACCEPTANCE CRITERIA
Performance Specification 3 (and 4B)	
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 – 2512 THROX CEMS CO_2 (percent by volume, dry)

Project: 2512 THROX RATA
Facility: Dow Midland, MI
Source: 2512 THROX Original CEM System
Project ID: 60699646

Carbon Dioxide Relative Accuracy Results								
		REFERENCE METHOD	Correction for Moisture		STACK ANALYZERS		ARITHMETIC DIFFERENCE and RATA	
					Original CEM		Original CEM	
3/5/2024	TIME	Carbon Dioxide (%)	Moisture (%)	CO2 (%, wet)	Carbon Dioxide (%, dry)	Use of Run[1]	Carbon Dioxide (%, dry)	Use of Run[1]
RATA Run 1	10:10-10:31	4.79	6.36	4.49	4.80		0.01	
RATA Run 2	10:31-10:52	4.75	6.17	4.46	4.80		0.05	
RATA Run 3	10:52-11:13	4.78	6.37	4.48	4.70		-0.08	
RATA Run 4	11:32-11:53	4.75	6.08	4.46	4.70		-0.05	
RATA Run 5	11:53-12:14	4.79	5.65	4.52	4.80		0.01	
RATA Run 6	12:14-12:35	4.78	6.07	4.49	4.80		0.02	
RATA Run 7	13:07-13:28	4.74	6.07	4.45	4.70		-0.04	
RATA Run 8	13:28-13:49	4.74	5.65	4.47	4.70		-0.04	
RATA Run 9	13:49-14:10	4.76	5.65	4.49	4.80		0.04	
RATA Run 10	14:28-14:49	4.75	6.45	4.44	4.70	x	-0.05	X
RATA Run 11	14:49-15:10	4.75	6.44	4.44	4.70	x	-0.05	X
RATA Run 12	15:10-15:31	4.75	6.44	4.44	4.70	x	-0.05	X

Number of Runs Used in Calculation (n)	9
Average Difference (d_{AVG})	-0.01
Standard Deviation (S_d)	0.05
t-Value ($t_{0.975}$)	2.306
Confidence Coefficient (CC)	0.04
Average of Reference Method (RM_{AVG})	4.76
Relative Accuracy (CO_2) ($\lvert d_{AVG} \rvert$)	0.01
Relative Accuracy (CO_2) ($\lvert d_{AVG} \rvert + \lvert CC \rvert$)	0.0
Relative Accuracy (% of Reference Method) (RA)	0.9

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

	ACCEPTANCE CRITERIA
Performance Specification 3 (and 4B)	
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 – 2512 THROX CEMS NOx (ppmvd, lb/hr)

Project: 2512 THROX RATA
Facility: Dow Midland, MI
Source: 2512 THROX Original CEM System
Project ID: 60699646

Oxygen Correction % 0
(if applicable)

Nitrogen Oxides Relative Accuracy Results

		REFERENCE METHOD					Correction for Moisture		STACK ANALYZERS				ARITHMETIC DIFFERENCE			
									Original CEM		Original CEM		Original CEM		Original CEM	
3/5/2024	TIME	Flow (dscfm)	Oxygen (ppm dry)	Nitrogen Oxides (ppm dry)	Nitrogen Oxides (ppm, dry) (Oxygen Corrected)	Nitrogen Oxides (lb/hr)	Moisture (%)	Nitrogen Oxides (ppm, wet)	Nitrogen Oxides (ppm, dry)	Use of Run[1]	Nitrogen Oxides (lb/hr)	Use of Run[1]	Nitrogen Oxides (ppm, dry)	Use of Run[1]	Nitrogen Oxides (lb/hr)	Use of Run[1]
RATA Run 1	10:10-10:31	7,193	11.08	61.1	130.0	3.1	6.4	57.2	58.30	x	2.40		-2.77	X	-0.75	
RATA Run 2	10:31-10:52	7,359	11.08	60.3	128.4	3.2	6.2	56.6	58.00		2.30	x	-2.33		-0.88	X
RATA Run 3	10:52-11:13	7,068	11.08	60.3	128.3	3.1	6.4	56.4	58.00		2.30		-2.26		-0.75	
RATA Run 4	11:32-11:53	7,297	11.04	59.5	126.1	3.1	6.1	55.9	57.10		2.30		-2.43		-0.81	
RATA Run 5	11:53-12:14	7,196	11.05	59.2	125.7	3.1	5.6	55.9	56.70	x	2.30		-2.51	X	-0.75	
RATA Run 6	12:14-12:35	7,300	11.00	59.1	124.8	3.1	6.1	55.5	57.00	x	2.30		-2.14	X	-0.79	
RATA Run 7	13:07-13:28	7,087	10.96	56.8	119.4	2.9	6.1	53.3	55.60		2.20		-1.19		-0.68	
RATA Run 8	13:28-13:49	7,115	10.92	56.1	117.5	2.9	5.6	52.9	54.70		2.20		-1.39		-0.66	
RATA Run 9	13:49-14:10	6,981	10.83	55.2	114.5	2.8	5.6	52.1	53.30		2.20		-1.88		-0.56	
RATA Run 10	14:28-14:49	6,858	10.85	54.9	114.1	2.7	6.4	51.3	53.60		2.20	x	-1.27		-0.50	X
RATA Run 11	14:49-15:10	6,917	10.87	55.3	115.2	2.7	6.4	51.7	54.00		2.20	x	-1.30		-0.54	X
RATA Run 12	15:10-15:31	7,108	10.91	56.1	117.4	2.9	6.4	52.5	55.00		2.30		-1.11		-0.56	

	Original CEM (ppm, dry)	Original CEM (lb/hr)
Number of Runs Used in Calculation (n)	9	9
Average Difference (d_{AVG})	-1.68	-0.70
Standard Deviation (S_d)	0.54	0.09
t-Value ($t_{0.975}$)	2.306	2.306
Confidence Coefficient (CC)	0.41	0.07
Applicable Standard (or Permit Limit)		8
Average of Reference Method (RM_{AVG})	57.16	2.98
Relative Accuracy (CO, NO_x, SO_2, O_2,CO_2) ($\lvert d_{AVG} \rvert + \lvert CC \rvert$)	2.1	0.8
Relative Accuracy (% of Reference Method) (RA)	3.7	26.0
Relative Accuracy (% of Permit Limit) (RA)	--	9.4

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

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

Table 2-4 Relative Accuracy – 2512 THROX CERMS Flow Rate (scfm, wet)

		REFERENCE METHOD		STACK ANALYZERS SIC Flow		ARITHMETIC DIFFERENCE SIC Flow	
Run Number	TIME	Flow (dscfm)	Flow (scfm)	Flow Rate (scfm)	Use of Run[1]	Flow Rate (scfm)	Use of Run[1]
Flow Run 1	10:10-10:31	7,193	7,682	7,100		-582	
Flow Run 2	10:31-10:52	7,359	7,843	7,000		-843	x
Flow Run 3	10:52-11:13	7,068	7,549	7,000		-549	
Flow Run 4	11:32-11:53	7,297	7,769	7,000		-769	x
Flow Run 5	11:53-12:14	7,196	7,627	7,000		-627	
Flow Run 6	12:14-12:35	7,300	7,772	7,000		-772	x
Flow Run 7	13:07-13:28	7,087	7,545	7,000		-545	
Flow Run 8	13:28-13:49	7,115	7,541	7,100		-441	
Flow Run 9	13:49-14:10	6,981	7,399	7,000		-399	
Flow Run 10	14:28-14:49	6,858	7,331	7,100		-231	
Flow Run 11	14:49-15:10	6,917	7,393	7,100		-293	
Flow Run 12	15:10-15:31	7,108	7,598	7,100		-498	
Number of Runs Used in Calculation (n)						12	
Average Difference (d_{AVG})						-546	
Standard Deviation (S_d)						189	
t-Value ($t_{0.975}$)						2.201	
Confidence Coefficient (CC)						120	
Permit Limit							
Average of Reference Method (RM_{AVG})						7,587	
Relative Accuracy (in dscfm) ($\lvert d_{AVG}\rvert + \lvert CC \rvert$)						666	
Relative Accuracy (% of Reference Method) (RA)						8.8	

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

Table 2-5 Process Data for CEMS RATA

RATA Run	Natural Gas Input (MMBtu/hr)	Gas Flow Dry Vent (lb/hr)	Gas Flow Wet Vent (lb/hr)	Gas Flow MeCl (lb/hr)	SiO_2 Loading (lb/hr)	Combustion Chamber Temp (°F)	Absorber pH
1	23.5	975	697	238	0.8	2,000	5.9
2	23.7	1007	691	286	0.8	2,000	5.8
3	24.3	1010	736	295	0.8	2,000	5.8
4	24.2	1066	673	286	0.8	2,000	5.8
5	24.4	1073	712	290	0.8	2,000	5.8
6	24.2	1059	753	282	0.8	2,000	5.8
7	23.7	1042	732	257	0.8	1,999	5.9
8	24.5	1138	716	265	0.8	2,000	5.4
9	24.4	1068	707	304	0.8	2,001	5.5
10	23.6	1015	683	262	0.8	2,000	6.0
11	23.9	1031	642	272	0.8	2,000	5.9
12	23.9	1015	680	248	0.8	2,000	5.7
Average	**24.0**	**1041.6**	**701.8**	**273.8**	**0.8**	**2000.0**	**5.8**

Table 2-6 Manual Method Results – 2512 THROX Stack

Run Number	Flow Run 1	Flow Run 2	Flow Run 3	Flow Run 4	Flow Run 5	Flow Run 6	Flow Run 7	Flow Run 8	Flow Run 9	Flow Run 10	Flow Run 11	Flow Run 12
Moisture Run Number	Moisture 1	Moisture 1	Moisture 1	Moisture 2	Moisture 2	Moisture 2	Moisture 3	Moisture 3	Moisture 3	Moisture 4	Moisture 4	Moisture 4
Date	05-Mar-24	05-Mar-24	05-Mar-24	05-Mar-24	05-Mar-24	05-Mar-24	05-Mar-24	05-Mar-24	05-Mar-24	05-Mar-24	05-Mar-24	05-Mar-24
Time Start	10:10	10:31	10:52	11:32	11:53	12:14	13:07	13:28	13:49	14:28	14:49	15:10
Time Finish	10:31	10:52	11:13	11:53	12:14	12:35	13:28	13:49	14:10	14:49	15:10	15:31
Overall Time	10:10-10:31	10:31-10:52	10:52-11:13	11:32-11:53	11:53-12:14	12:14-12:35	13:07-13:28	13:28-13:49	13:49-14:10	14:28-14:49	14:49-15:10	15:10-15:31
Operator	PB	PB	PB	PB	PB	PB	PB	PB	PB	PB	PB	PB
Duct Diameter (ft) (Circular)	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Stack Width (ft) (Rectangular)		0	0	0	0	0	0	0	0	0	0	0
Stack Depth (ft) (Rectangular)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stack CrossSectional Area (sq ft)	15.9043128	15.9043128	15.9043128	15.9043128	15.9043128	15.9043128	15.9043128	15.9043128	15.9043128	15.9043128	15.9043128	15.9043128
Pitot Tube Correction Factor (Cp)	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Dry Gas Meter Calibration (Yd)	1.009	1.009	1.009	1.009	1.09	1.009	1.009	1.09	1.09	1.009	1.009	1.009
Barometric Pressure Measured ("Hg)	29.29	29.32	29.32	29.33	29.34	29.34	29.34	29.34	29.34	29.34	29.34	29.34
Stack Elevation Relative to Barometer (ft)	40	40	40	40	40	40	40	40	40	40	40	40
Barometric Pressure used in Calculations ("Hg)	29.25	29.28	29.28	29.29	29.30	29.30	29.30	29.30	29.30	29.30	29.31	29.31
Static Pressure ("H2O)	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04
Meter Volume (acf)	34.310	34.310	34.310	34.879	34.879	34.879	34.390	34.390	34.390	34.624	34.624	34.624
Average Square Root of ΔP	0.148	0.151	0.146	0.150	0.147	0.150	0.146	0.146	0.143	0.141	0.143	0.147
Average ΔH ("H2O)	1.00	1.000	1.000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Average Stack Temperature (°F)	99	98	99	98	98	98	99	99	99	100	102	103
Average Dry Gas Meter Temp (°F)	50	49.9	49.9	51.9	51.9	51.9	53.1	53.1	53.1	54.1	54.1	54.1
Condensed Water (g)	51.1	51.1	51.1	48.8	48.8	48.8	48.0	48.0	48.0	51.4	51.4	51.4
% CO2	4.70	4.75	4.78	4.75	4.79	4.78	4.74	4.74	4.76	4.75	4.75	4.75
% O2	11.00	11.08	11.08	11.04	11.05	11.00	10.96	10.92	10.83	10.85	10.87	10.91
% N2	84.3	84.2	84.1	84.2	84.2	84.2	84.3	84.3	84.4	84.4	84.4	84.3
Meter Volume (dscf)	35.134	35.170	35.170	35.626	38.499	35.639	35.054	37.868	37.868	35.224	35.236	35.236
Flue Gas Moisture - Saturation (%)	6.4	6.2	6.4	6.2	6.2	6.1	6.5	6.4	6.4	6.6	6.9	7.3
Flue Gas Moisture - Measured (%)	6.43	6.42	6.42	6.08	5.65	6.07	6.07	5.65	5.65	6.45	6.44	6.44
Flue Gas Moisture for Calculations (%)	6.36	6.17	6.37	6.08	5.65	6.07	6.07	5.65	5.65	6.45	6.44	6.44
Gas Molecular Weight (Wet) (g/g-mole)	28.48	28.51	28.49	28.52	28.58	28.52	28.52	28.56	28.56	28.47	28.47	28.47
Absolute Stack Pressure ("Hg)	29.25	29.28	29.28	29.29	29.30	29.30	29.30	29.30	29.30	29.30	29.31	29.31
Absolute Stack Temperature (°R)	559	558	559	558	558	558	559	559	559	560	562	563
Average Gas Velocity (ft/sec)	8.72	8.87	8.56	8.79	8.62	8.79	8.56	8.55	8.38	8.32	8.41	8.67
Avg Flow Rate (acfm)	8,318	8,468	8,166	8,388	8,230	8,385	8,164	8,155	7,998	7,941	8,029	8,276
Avg Flow Rate (scfm)	7,682	7,843	7,549	7,769	7,627	7,772	7,545	7,541	7,399	7,331	7,393	7,598
Avg Flow Rate (dscfm)	7,193	7,359	7,068	7,297	7,196	7,300	7,087	7,115	6,981	6,858	6,917	7,108

Table 2-7 Process Data Parameters

Process Monitoring Parameter	Process Tag Unit
NOx (lb/hr)	lb/hr
O_2 (%, dry)	%
CO_2 (%, dry)	%
Exhaust Gas Flow, THROX Out Stack (scfm, wet)	SCFM
Natural Gas Heat Input (MMBtu/hr)	MMBTU
Combustion Chamber Temperature – Thermocouple 1	Degrees F
Combustion Chamber Temperature – Thermocouple 2	Degrees F
Absorber (pH units)	PH
Gas Flow, Acetylene	lb/hr
Gas Flow, Dry Vent	lb/hr
Gas Flow, Wet Vent	lb/hr
Gas Flow, MeCl	lb/hr
SiO_2 Loading (lb/hr)	pph
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-A4043-2019b 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-A4043-2019b
40 CFR Part 60, Appendix B, Performance Specifications 2, 3, and 6

Pollutants/Diluent Measured - Relative Accuracy (RATA)
NOx 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)

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 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 (first 6 runs) and emissions compliance test (3 CPT runs) performed concurrently on October 17, the instrumental analyzer and moisture train samples were drawn from the stack for a particulate matter (PM) sampling run of sixty (60) minutes encompassing two thirty (30) minute RATA runs. For the RATA runs performed independent of CPT runs (last 6 runs on October 17 and all runs on October 18), the instrumental analyzer and moisture train samples were drawn from the stack for a moisture sampling run of sixty-three (63) minutes encompassing three thirty (30) minute RATA runs. A stratification test was 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 to 30-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 Downstream Diameters: 11 Diameters
Duct Upstream Length: 25 Feet | 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

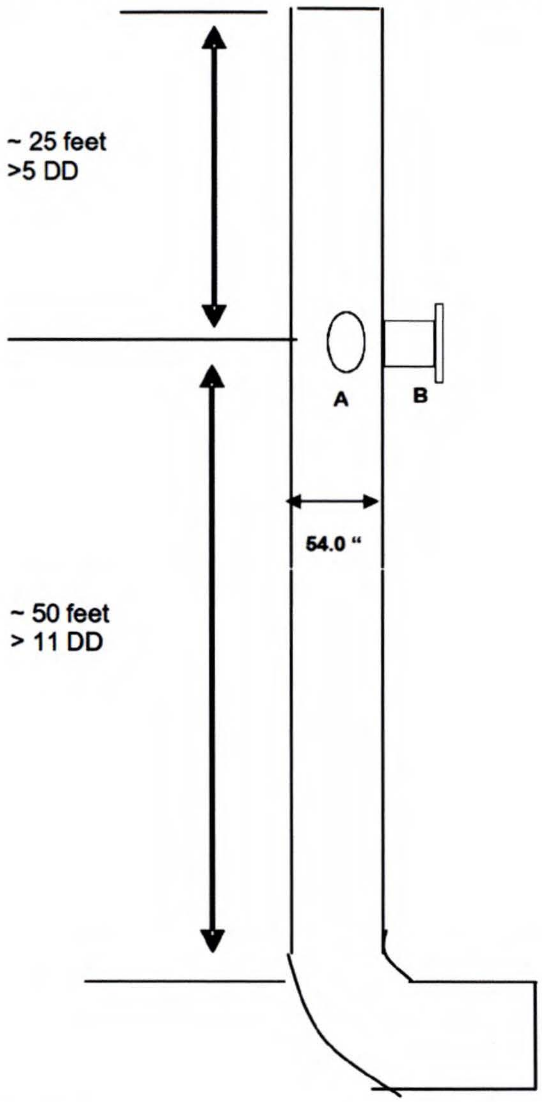
The facility employs a CEMS to monitor NOx, O_2, CO_2 along with the exhaust gas flow rate CERMS in order to comply with MON MACT monitoring requirements and to demonstrate continuous compliance with the emission limits specified in their air permit (Michigan EGLE Permit MI-ROP-A4043-2019b). The CEMS are extractive type systems that was designed and installed to meet emissions monitoring requirements outlined in 40 CFR Part 60, Appendix B, Performance Specifications (PS) 2, 3, and 6 for NOx, O_2, CO_2, emission rate, and flow rate.

The 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 the 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

Monitor System	Measurement Units	Equipment	ID/Serial number (S/N) (Original System)
Oxygen FGTHROX	%v, dry	Brand Gaus - 4705	10687
Carbon Dioxide FGTHROX	%v, dry	California Analytical Instruments Model - ZRE	N4K1905
Nitrogen Oxides FGTHROX	%v, dry	Thermo Scientific – 42i-HL	0733125534
Air Flow FGTHROX	scfm	Monitoring Solutions and SIC	21488420 and 21488420

Figure 3-1 Schematic of Stack Sample Port Locations



4. 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 requirements of 40 CFR Part 60 as specified in the Michigan EGLE air permit (MI-ROP-A4043-2019b).

4.1 Manual Test Methods

4.1.1 Flow Rate, Gas Composition, and Moisture

Concurrent with the performance of RATA test runs, 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).

4.2 Instrumental Analyzer Test Methods

AECOM followed the instrumental analyzer procedures specified in EPA Methods 3A and 7E (40 CFR Part 63, Appendix A) for the determination of O_2, CO_2, and NOx concentrations. 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 to 30-minute test periods for the RATA using the AECOM transportable instrumental analyzer laboratory, which is described later in this section. Average undiluted dry concentrations by volume of O_2, CO_2, and NOx 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,and PS 6 (40 CFR 60, Appendix B) for NOx, O_2, CO_2, and flow rate. RA results are evaluated in accordance with the criteria specified in 40 CFR Part 60, Appendix B (PS 2, 3, and 6). 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, and for each NOx and flow rate monitor was ≤20 percent of the average RM value.

The O_2, CO_2, NOx, 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, and NOx by volume on a dry 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, and NOx concentrations.

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%, and the NOx was measured using a Thermo Model 42iQ chemiluminescent analyzer on an approximate span gas range of 0-120 ppm.

4.4 RM Instrumental Analyzer Calibration Procedures

The initial phase of the instrumental analyzer methods (e.g., Methods 3A and 7E) 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.

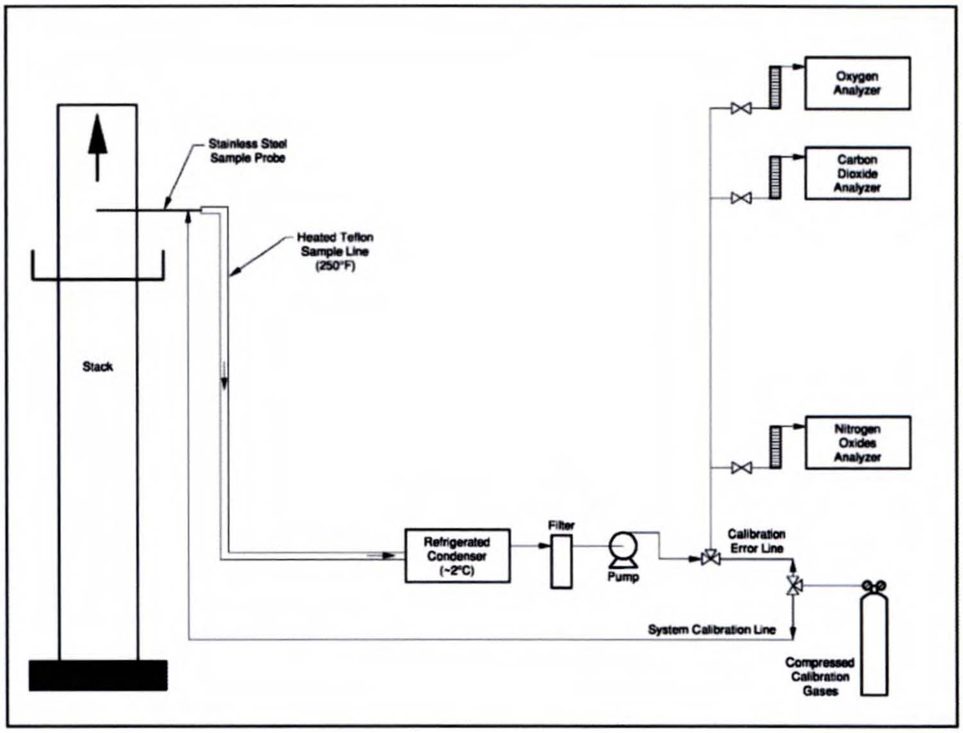
Prior to performing test runs with the dry-measurement analyzers (i.e., Methods 3A and 7E), AECOM conducted direct instrument calibration error tests using zero and two upscale gases each for the O_2/CO_2 and NOx analyzers prior to initiation of testing. Following these direct calibrations, an initial 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.

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).

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 the Reference Methods, 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**.

Figure 4-1 Instrumental Extractive Sampling System



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, and NOx. 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 NOx 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 7E 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.

6. Data Reduction

6.1 Overview

The objective of the monitoring program was to determine the relative accuracy (RA) of the NOx, O_2, and CO_2, and flow rate 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 2, PS 3, and PS 6. The relative accuracies are calculated to verify:

- RA for O_2 and CO_2 (%vd) is no greater than 20.0% of RM or 1.0% absolute difference (not including CC) as specified in PS 3 of 40CFR60, Appendix B
- RA for NOx (ppmvd, lb/hr) is no greater than 20% of RM, 10% of ES (applicable emission standard), or PS 2 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