Source Test Report for 2022 Compliance Testing Regenerative Thermal Oxidizers #1, 2, 3, and 4 General Motors Pontiac, Michigan

Prepared For:

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Review and Certification

All work, calculations, and other activities and tasks performed and presented in this document were carried out by me or under my direction and supervision. I hereby certify that, to the best of my knowledge, Montrose operated in conformance with the requirements of the Montrose Quality Management System and ASTM D7036-04 during this test project.

Signature:	[signature]	**Date:**	06 / 01 / 2022
Name:	Sean Wheeler, QI	**Title:**	Client Project Manager

I have reviewed, technically and editorially, details, calculations, results, conclusions, and other appropriate written materials contained herein. I hereby certify that, to the best of my knowledge, the presented material is authentic, accurate, and conforms to the requirements of the Montrose Quality Management System and ASTM D7036-04.

Signature:	Henry M. Taylor	**Date:**	06 / 01 / 2022
Name:	Henry M. Taylor, QSTO	**Title:**	Reporting Hub Manager

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1.0 Introduction

1.1 Summary of Test Program

General Motors (GM) contracted Montrose Air Quality Services, LLC (Montrose) to perform a compliance emissions test on RTOs #1, 2, 3, and 4 at their Pontiac facility located in Pontiac, Michigan.

The tests were conducted to meet the requirements of Renewable Operating Permit No. MI-ROP-B4032-2020 dated April 30, 2020.

The specific objectives were to:

- Determine the concentration, emission rate and DE of CO from RTOs #1-4
- Conduct the test program with a focus on safety

Montrose performed the tests to measure the emission parameters listed in Table 1-1.

Table 1-1
Summary of Test Program

Test Dates	Unit ID/ Source Name	Activity/Parameters	Test Methods	No. of Runs	Duration (Minutes)
4/11/22	RTO 1 Inlet[1]	O_2, CO_2	EPA 3A	3	60
		CO	EPA 10	3	60
4/11/22	RTO 1 Outlet	Velocity/Volumetric Flow	EPA 1 & 2	3	60
		O_2, CO_2	EPA 3A	3	60
		Moisture	EPA 4	3	60
		CO	EPA 10	3	60
4/12/22	RTO 2 Inlet[1]	O_2, CO_2	EPA 3A	3	60
		CO	EPA 10	3	60
4/12/22	RTO 2 Outlet	Velocity/Volumetric Flow	EPA 1 & 2	3	60
		O_2, CO_2	EPA 3A	3	60
		Moisture	EPA 4	3	60
		CO	EPA 10	3	60

[1]For RTOs 1 and 2, the inlet flow could not be measured. Therefore, according to past testing, the inlet flows were assumed to be 95% of the outlet flows to determine DE of CO.

Table 1-1 (Continued)
Summary of Test Program

Test Dates	Unit ID/ Source Name	Activity/Parameters	Test Methods	No. of Runs	Duration (Minutes)
4/13/22	RTO 4 Inlet &	Velocity/Volumetric Flow	EPA 1 & 2	3	60
	Outlet	O_2, CO_2	EPA 3A	3	60
		Moisture	EPA 4	3	60
		CO	EPA 10	3	60
4/28/22	RTO 3 Inlet &	Velocity/Volumetric Flow	EPA 1 & 2	3	60
	Outlet	O_2, CO_2	EPA 3A	3	60
		Moisture	EPA 4	3	60
		CO	EPA 10	3	60
4/12/22	--	Dilution System Verification	EPA 205	--	--

To simplify this report, a list of Units and Abbreviations is included in Appendix C.1. Throughout this report, chemical nomenclature, acronyms, and reporting units are not defined. Please refer to the list for specific details.

This report presents the test results and supporting data, descriptions of the testing procedures, descriptions of the facility and sampling locations, and a summary of the quality assurance procedures used by Montrose. The average emission test results are summarized and compared to their respective permit limits in Table 1-2. Detailed results for individual test runs can be found in Section 4.0. All supporting data can be found in the appendices.

The tests were conducted according to Test Plan No. MW023AS-014898-PP-400.

Table 1-2
Summary of Average Compliance Results

April 11 through 13 and 28, 2022

Source	Parameter/Units	Average Results	Emission Limits
RTO 1	**Carbon Monoxide (CO)**		
	ppmvd	32.6	--
	lb/hr	3.0	--
	DE, %	97.9	> 96
RTO 2	**Carbon Monoxide (CO)**		
	ppmvd	39.3	--
	lb/hr	3.4	--
	DE, %	97.5	> 96
RTO 4	**Carbon Monoxide (CO)**		
	ppmvd	55.0	--
	lb/hr	5.0	--
	DE, %	98.2	> 96
RTO 3	**Carbon Monoxide (CO)**		
	ppmvd	39.2	--
	lb/hr	3.7	--
	DE, %	97.8	> 96

1.2 Key Personnel

A list of project participants is included below:

Facility Information

Source Location: General Motors
850 Glenwood Avenue
Pontiac, MI 48340
Project Contact: Jessica Alderton
Role: Senior Environmental Project Engineer
Telephone: 586-863-8490
Email: jessica.alderton@gm.com

Agency Information

Regulatory Agency: Michigan Department of Environment, Great Lakes and Energy
Agency Contact: Tammy Bell
Telephone: 313-330-0105
Email: bellt4@michigan.gov

Testing Company Information

Testing Firm: Montrose Air Quality Services, LLC
Contact: Sean Wheeler
Title: Client Project Manager
Telephone: 630-860-4740
Email: stwheeler@montrose-env.com

Test personnel and observers are summarized in Table 1-3.

Table 1-3
Test Personnel and Observers

Name	Affiliation	Role/Responsibility
Sean Wheeler	Montrose	Client Project Manager/QI/Field Team Leader/Trailer operator
Jeremy Devries	Montrose	Senior Technician/Sample recovery/Sample train operator
Hayden Carl, John Ziber, Scott Dater	Montrose	Field Technician/Sample recovery/Sample train operator
Jacob Cartee	Montrose	Calculations and report preparation
Jessica Alderton	GM	Client Liaison/Test Coordinator

2.0 Plant and Sampling Location Descriptions

2.1 Process Description, Operation, and Control Equipment

2.1.1 Emission Unit Type

General Motors owns and operates an extensive engine testing facility for research and development of internal combustion engines using a wide variety of fuels and test protocols including those mandated by the EPA. Depending on the engine type, the engines can be fueled by unleaded gasoline, leaded gasoline, diesel, or other fuels. A variety of tests with varying test cycles are performed on engines and engine components, depending on the purpose of the test program. The engines are tested with or without additional control equipment, such as catalytic converters and particulate traps.

2.1.2 Type and Quantity of Raw Materials

The facility is designed to supply unleaded gasoline, leaded gasoline, diesel, ethanol, natural gas, methanol, propane, liquefied petroleum gas, and hydrogen for engine testing. The engine fuel used during the emissions test program will be gasoline.

2.1.3 Batch Operations

The facility is configured with 91 engine test cells in Wings 1 and 2 and 11 firing test cells in Wing 3. The cells perform various tests utilizing a variety of test cycles and fuels. In some tests, engines run at a static speed for longer periods of time; in others, engines go through set testing cycles with varying run parameters. Test cell utilization varies with testing demand.

2.1.4 Process Operations

The basic operating parameters are the fuels used, the type and number of engines, and tests run at a given time.

2.1.5 Process Rating

Test cells in Wings 1 & 2 (FG-TESTCELLS) have an equivalent fuel consumption limited to 7,280 MMBtu per calendar day, and 520,000 MMBtu per 12-month rolling time period as determined at the end of each calendar month. Test cells in Wing 3 (FG-TESTCELLS) have a combined spark-ignited fuel consumption limited to 23,312 MMBtu per 12-month rolling time period as determined at the end of each calendar month. The MMBtu is used as a surrogate for fuel consumption.

2.1.6 Control Device Type

Engine exhaust is captured and discharged to four identical RTOs. Two of four RTOs will be set into standby mode during each RTO destruction efficiency test. This is intended to represent a worst-case condition since the RTO retention time will be lower while running all exhaust through two RTOs rather than four RTOs. Capture of exhaust is verified by monitoring several pressure transducers to verify the exhaust capture system maintain the appropriate negative(suction) pressure. Additionally, four wing header purge dampers are installed to meet safety regulations during start up. The positions of these dampers are monitored while the engine testing takes place.

2.1.7 Operating Parameters

RTO combustion chamber temperature is the primary indicator of system performance. GM expects the RTOs to operate between 1400 and 1600°F. Wing header exhaust ducts are controlled at -2 inches water gage. Main header exhaust ducts are controlled at -2 inches water gage.

2.1.8 Rated Capacity

Each RTO is rated at 27,500 scfm and is designed to destroy VOC at greater than 96% destruction efficiency as calculated by mass.

2.1.9 Maintenance

Each RTO undergoes monthly and quarterly preventative maintenance tasks which include inspection of poppet valve seals and cylinders, insulation, burner and combustion blower system, thermocouple checks, hydraulic system, etc. Some parts may require lubrication. System temperatures and pressures are observed.

2.2 Flue Gas Sampling Locations

Information regarding the sampling locations is presented in Table 2-1.

Table 2-1
Sampling Locations

Sampling Location	Stack Inside Diameter (in.)	Distance from Nearest Disturbance Downstream EPA "B" (in./dia.)	Upstream EPA "A" (in./dia.)	Number of Traverse Points
RTO 3 & 4 Inlet	31.0	360/11.6	180/5.8	Flow: 16 (8/port) Gaseous: 3
RTOs 1-4 Outlet	43.5	360/8.3	180/4.1	Flow: 16 (8/port) Gaseous: 3

The sample locations were verified in the field to conform to EPA Method 1. Absence of cyclonic flow conditions was confirmed following EPA Method 1, Section 11.4. See Appendix A.1 for more information.

2.3 Operating Conditions and Process Data

The emission tests were performed while the units and air pollution control devices were operating at the conditions required by the permit.

Plant personnel were responsible for establishing the test conditions and collecting all applicable unit-operating data. The process data that was provided is presented in Appendix B.

3.0 Sampling and Analytical Procedures

3.1 Test Methods

The test methods for this test program have been presented in Table 1-1. Additional information regarding specific applications or modifications to standard procedures is presented below.

3.1.1 EPA Method 1, Sample and Velocity Traverses for Stationary Sources

EPA Method 1 is used to assure that representative measurements of volumetric flow rate are obtained by dividing the cross-section of the stack or duct into equal areas, and then locating a traverse point within each of the equal areas. Acceptable sample locations must be located at least two stack or duct equivalent diameters downstream from a flow disturbance and one-half equivalent diameter upstream from a flow disturbance.

Pertinent information regarding the performance of the method is presented below:

- Method Options:
  - None
- Method Exceptions:
  - None

The sample port and traverse point locations are detailed in Appendix A.

3.1.2 EPA Method 2, Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)

EPA Method 2 is used to measure the gas velocity using an S-type pitot tube connected to a pressure measurement device, and to measure the gas temperature using a calibrated thermocouple connected to a thermocouple indicator. Typically, Type S (Stausscheibe) pitot tubes conforming to the geometric specifications in the test method are used, along with an inclined manometer. The measurements are made at traverse points specified by EPA Method 1. The molecular weight of the gas stream is determined from independent measurements of O_2, CO_2, and moisture. The stack gas volumetric flow rate is calculated using the measured average velocity head, the area of the duct at the measurement plane, the measured average temperature, the measured duct static pressure, the molecular weight of the gas stream, and the measured moisture.

Pertinent information regarding the performance of the method is presented below:

- Method Options:
  - S-type pitot tube coefficient is 0.84
- Method Exceptions:
  - None

The typical sampling system is detailed in Figure 3-2.

3.1.3 EPA Methods 3A and 10, Determination of Oxygen, Carbon Dioxide, and Carbon Monoxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedures)

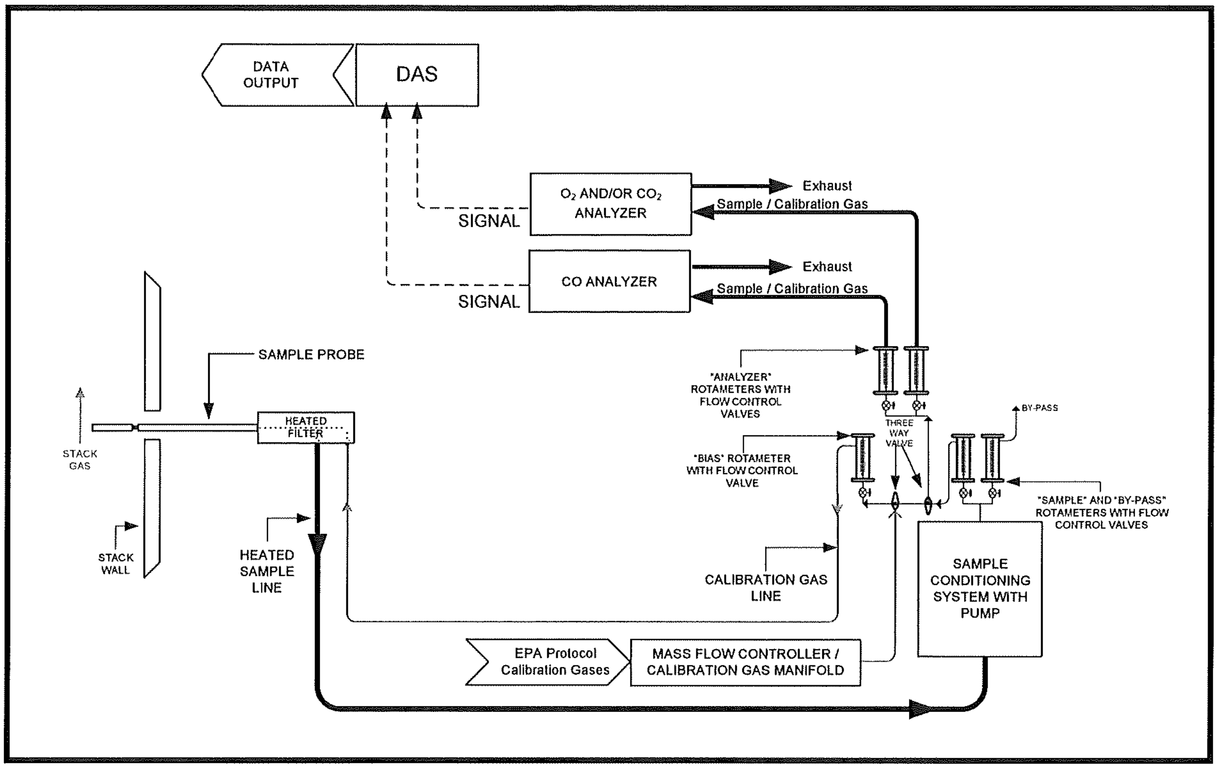
Concentrations of O_2, CO_2, and CO are measured simultaneously using EPA Methods 3A and 10, which are instrumental test methods. Conditioned gas is sent to a series of analyzers to measure the gaseous emission concentrations. The performance requirements of the method must be met to validate the data.

Pertinent information regarding the performance of the method is presented below:

- Method Options:
  - A dry extractive sampling system is used to report emissions on a dry basis
  - A paramagnetic analyzer is used to measure O_2
  - A nondispersive infrared analyzer is used to measure CO_2
  - A gas filter correlation nondispersive infrared analyzer is used to measure CO
- Method Exceptions:
  - None
- Target and/or Minimum Required Sample Duration: 60 minutes

The typical sampling system is detailed in Figure 3-1.

FIGURE 3-1
EPA METHOD 3A AND 10 SAMPLING TRAIN



3.1.4 EPA Method 4, Determination of Moisture Content in Stack Gas

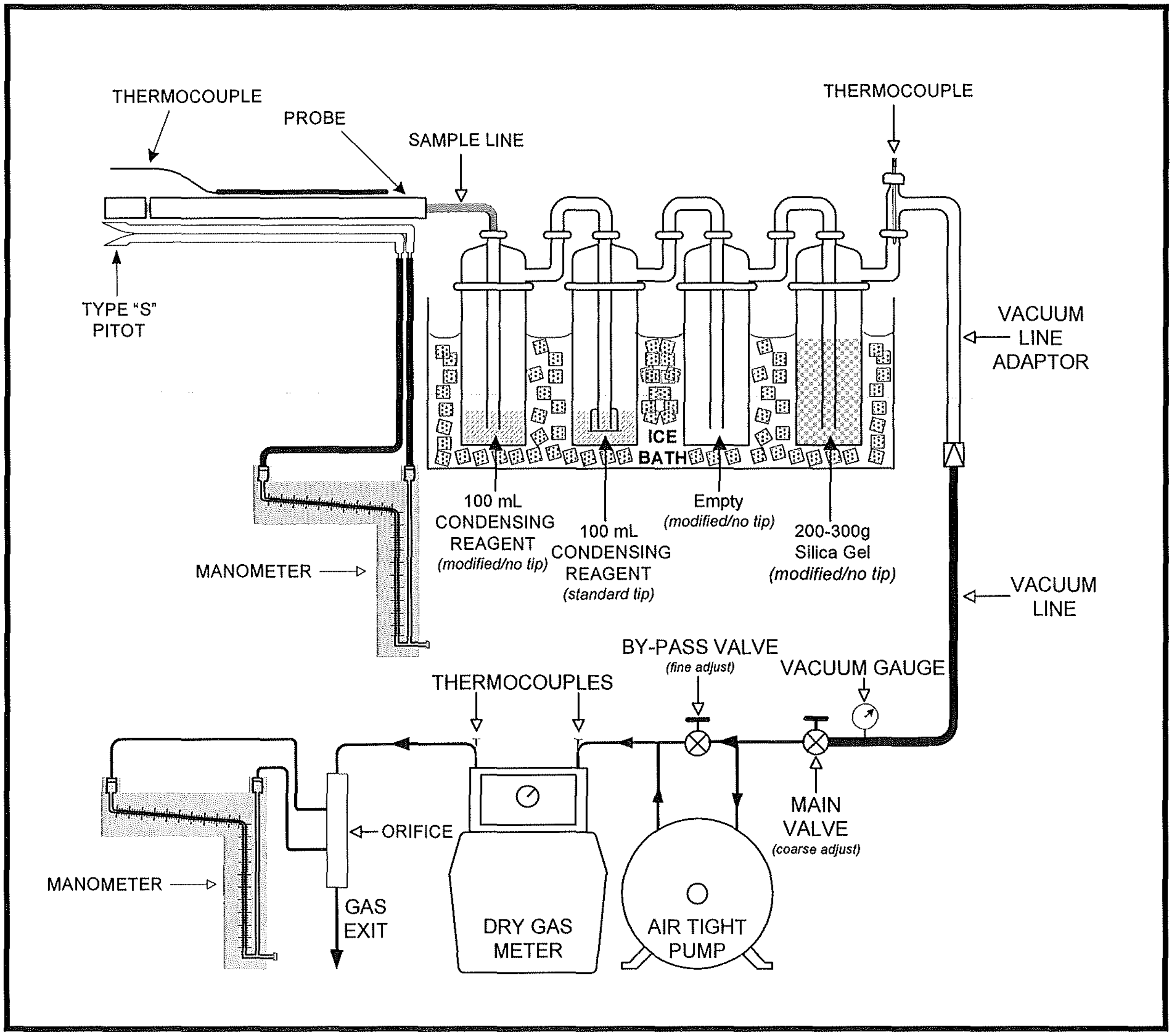
EPA Method 4 is a manual, non-isokinetic method used to measure the moisture content of gas streams. Gas is sampled at a constant sampling rate through a probe and impinger train. Moisture is removed using a series of pre-weighed impingers containing methodology-specific liquids and silica gel immersed in an ice water bath. The impingers are weighed after each run to determine the percent moisture.

Pertinent information regarding the performance of the method is presented below:

- Method Options:
  - Since it is theoretically impossible for measured moisture to be higher than psychrometric moisture, the psychrometric moisture is also calculated, and the lower moisture value is used in the calculations
- Method Exceptions:
  - Moisture sampling is performed as a stand-alone method at a single point in the centroid of the stack
- Target and/or Minimum Required Sample Duration: 60 minutes

The typical sampling system is detailed in Figure 3-2.

FIGURE 3-2
EPA METHOD 4 DETACHED WITH PITOTS SAMPLING TRAIN



3.1.5 EPA Method 205, Verification of Gas Dilutions Systems for Field Instrument Calibrations

EPA Method 205 is used to accurately dilute high-level EPA Protocol 1 calibration gases to intermediate levels for use when calibrating instrumental analyzers. A calibrated gas dilution system is used for these dilutions. The gas dilution system is recalibrated once per calendar year using NIST-traceable primary flow standards with an uncertainty ≤ 0.25 percent. A field evaluation is also performed to verify the dilution ratios for each project.

To perform the field evaluation, two diluted standards are prepared using the high-level supply gas. The diluted gas is alternately introduced in triplicate to a pre-calibrated analyzer, the average instrument response is calculated, and the average predicted concentration is calculated using the dilution ratios. No single injection should differ by more than ± 2% from the average instrument response for that dilution. For each level of dilution, the difference between the average concentration output recorded by the analyzer and the predicted concentration is calculated. The average concentration output from the analyzer should be within ± 2% of the predicted value.

Next, a mid-level supply gas is injected three different times directly into the analyzer while bypassing the dilution system. The average analyzer output is calculated. The difference between the certified concentration of the mid-level supply gas and the average instrument response should be within ± 2%. If the gas dilution system meets the criteria listed above, it may be used throughout the field test.

Pertinent information regarding the performance of the method is presented below:

- Method Options:
  - None
- Method Exceptions:
  - None

3.2 Process Test Methods

The test plan did not require that process samples be collected during this test program; therefore, no process sample data are presented in this test report.

4.0 Test Discussion and Results

4.1 Field Test Deviations and Exceptions

No field deviations or exceptions from the test plan or test methods occurred during this test program.

4.2 Presentation of Results

The average results are compared to the permit limits in Table 1-2. The results of individual compliance test runs performed are presented in Tables 4-1 through 4-4. Emissions are reported in units consistent with those in the applicable regulations or requirements. Additional information is included in the appendices as presented in the Table of Contents.

Table 4-1
CO Emissions and DE Results - RTO 1

Parameter/Units	Run 1	Run 2	Run 3	Average
Date	4/11/2022	4/11/2022	4/11/2022	--
Time	15:40-16:40	17:14-18:14	18:30-19:30	--
Inlet Flue Gas Parameters				
volumetric flow rate, dscfm	19,479	19,930	20,501	19,967
CO_2, % volume dry	0.2	0.2	0.2	0.2
O_2, % volume dry	20.0	20.0	20.0	20.0
Inlet Carbon Monoxide (CO)				
ppmvd	1,429.0	1,592.4	1,799.6	1,607.0
lb/hr	121.4	138.4	160.9	140.2
Outlet Flue Gas Parameters				
flue gas temperature, °F	235	252	234	240
volumetric flow rate, acfm	28,881	30,115	30,122	29,706
volumetric flow rate, scfm	21,039	21,414	21,976	21,476
volumetric flow rate, dscfm	20,504	20,979	21,580	21,021
CO_2, % volume dry	0.7	0.7	0.7	0.7
O_2, % volume dry	19.6	19.5	19.5	19.5
moisture content, % volume	2.6	2.1	1.8	2.2
Outlet Carbon Monoxide (CO)				
ppmvd	30.3	31.1	36.3	32.6
lb/hr	2.7	2.8	3.4	3.0
DE, %	97.8	97.9	97.9	97.9

Table 4-2
CO Emissions and DE Results - RTO 2

Parameter/Units	Run 1	Run 2	Run 3	Average
Date	4/12/2022	4/12/2022	4/12/2022	--
Time	09:25-10:25	10:46-11:46	12:10-13:10	--
Inlet Flue Gas Parameters				
volumetric flow rate, dscfm	19,088	18,437	18,469	18,664
CO_2, % volume dry	0.3	0.4	0.3	0.3
O_2, % volume dry	20.3	20.2	20.2	20.2
Inlet Carbon Monoxide (CO)				
ppmvd	1,832.3	1,565.1	1,516.1	1,637.9
lb/hr	152.6	125.9	122.1	133.5
Outlet Flue Gas Parameters				
flue gas temperature, °F	256	277	303	278
volumetric flow rate, acfm	29,790	29,854	30,696	30,114
volumetric flow rate, scfm	21,323	20,754	20,607	20,895
volumetric flow rate, dscfm	20,093	19,407	19,441	19,647
CO_2, % volume dry	0.6	0.7	0.5	0.6
O_2, % volume dry	19.5	19.4	19.8	19.6
moisture content, % volume	5.8	6.5	5.7	6.0
Outlet Carbon Monoxide (CO)				
ppmvd	41.9	40.5	35.4	39.3
lb/hr	3.7	3.4	3.0	3.4
DE, %	97.6	97.3	97.5	97.5

Table 4-3
CO Emissions and DE Results -
RTO 4

Parameter/Units	Run 1	Run 2	Run 3	Average
Date	4/13/2022	4/13/2022	4/13/2022	--
Time	09:17-10:17	10:35-11:35	11:56-12:56	--
Inlet Flue Gas Parameters				
flue gas temperature, °F	94	131	110	112
volumetric flow rate, acfm	21,814	23,156	22,274	22,414
volumetric flow rate, scfm	19,282	19,182	19,121	19,195
volumetric flow rate, dscfm	18,846	18,537	18,504	18,629
CO_2, % volume dry	1.2	1.3	0.7	1.1
O_2, % volume dry	18.8	18.7	19.4	19.0
moisture content, % volume	2.3	3.4	3.3	3.0
Inlet Carbon Monoxide (CO)				
ppmvd	3,473.9	3,176.0	3,674.0	3,441.3
lb/hr	285.6	256.8	296.5	279.6
Outlet Flue Gas Parameters				
flue gas temperature, °F	280	275	297	284
volumetric flow rate, acfm	31,798	31,691	32,009	31,833
volumetric flow rate, scfm	21,758	21,834	21,409	21,667
volumetric flow rate, dscfm	20,969	20,930	20,608	20,835
CO_2, % volume dry	1.8	1.0	1.1	1.3
O_2, % volume dry	18.3	19.2	19.1	18.9
moisture content, % volume	3.7	4.2	3.8	3.9
Outlet Carbon Monoxide (CO)				
ppmvd	56.3	51.3	57.3	55.0
lb/hr	5.2	4.7	5.2	5.0
DE, %	98.2	98.2	98.3	98.2

Table 4-4
CO Emissions and DE Results - RTO 3

Parameter/Units	Run 1	Run 2	Run 3	Average
Date	4/28/2022	4/28/2022	4/28/2022	--
Time	09:53-10:53	11:24-12:24	12:43-13:43	--
Inlet Flue Gas Parameters				
flue gas temperature, °F	87	55	97	80
volumetric flow rate, acfm	21,252	19,974	20,907	20,711
volumetric flow rate, scfm	19,387	19,373	18,732	19,164
volumetric flow rate, dscfm	18,508	19,101	18,364	18,658
CO_2, % volume dry	1.0	1.0	1.2	1.1
O_2, % volume dry	19.1	19.4	19.3	19.3
moisture content, % volume	4.6	1.4	2.0	2.7
Inlet Carbon Monoxide (CO)				
ppmvd	1,952.5	2,096.4	1,998.8	2,015.9
lb/hr	157.6	174.7	160.1	164.1
Outlet Flue Gas Parameters				
flue gas temperature, °F	273	263	283	273
volumetric flow rate, acfm	32,374	30,240	32,210	31,608
volumetric flow rate, scfm	22,837	21,623	22,402	22,287
volumetric flow rate, dscfm	21,773	21,231	22,090	21,698
CO_2, % volume dry	1.5	1.6	1.5	1.5
O_2, % volume dry	18.9	18.7	18.8	18.8
moisture content, % volume	4.7	1.9	1.4	2.7
Outlet Carbon Monoxide (CO)				
ppmvd	33.4	43.2	41.0	39.2
lb/hr	3.2	4.0	4.0	3.7
DE, %	98.0	97.9	97.5	97.8

5.0 Internal QA/QC Activities

5.1 QA/QC Audits

The meter boxes and sampling trains used during sampling performed within the requirements of their respective methods. All post-test leak checks, minimum metered volumes, minimum sample durations met the applicable QA/QC criteria.

EPA Methods 3A and 10 calibration audits were all within the measurement system performance specifications for the calibration drift checks, system calibration bias checks, and calibration error checks.

An EPA Method 205 field evaluation of the calibration gas dilution system was conducted. The dilution accuracy and precision QA specifications were met.

5.2 QA/QC Discussion

All QA/QC criteria were met during this test program.

5.3 Quality Statement

Montrose is qualified to conduct this test program and has established a quality management system that led to accreditation with ASTM Standard D7036-04 (Standard Practice for Competence of Air Emission Testing Bodies). Montrose participates in annual functional assessments for conformance with D7036-04 which are conducted by the American Association for Laboratory Accreditation (A2LA). All testing performed by Montrose is supervised on site by at least one QI as defined in D7036-04 Section 8.3.2. Data quality objectives for estimating measurement uncertainty within the documented limits in the test methods are met by using approved test protocols for each project as defined in D7036-04 Sections 7.2.1 and 12.10. Additional quality assurance information is included in the report appendices. The content of this report is modeled after the EPA Emission Measurement Center Guideline Document (GD-043).

Appendix A
Field Data and Calculations