

FINAL REPORT



GENERAL MOTORS LLC GM TECHNICAL CENTER

WARREN, MICHIGAN

2024 RELATIVE ACCURACY TESTING AUDIT (RATA) SOURCE TESTING REPORT: EU-BOILER1 AND EU-BOILER3

RWDI #2401924

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SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI USA LLC (RWDI) was retained by General Motors, LLC (GM) to complete the Relative Accuracy Testing Audit (RATA) emission sampling program at the General Motors Technical Center in Warren, Michigan. The test program was conducted to fulfill the requirements of the Michigan Department of Environment, Great Lakes and Energy (EGLE) MI-ROP-B4049-2019 in accordance with Appendix A, 40 CFR, Part 60, Subpart Db, US EPA Reference Methods 3A and 7E found in 40 CFR, Part 60, Appendix A, and Performance Specifications (PS) 2, 3, and 16 specified by 40 CFR, Part 60, Appendix B. The pollutants tested include oxygen (O₂) and nitrogen oxides (NO_x) from EU-BOILER1 and EU-BOILER3

In accordance with the test plan submitted by RWDI, EU-BOILER1, EU-BOILER2, and EU-BOILER3 were to be tested. When preparing EU-BOILER2 for testing, an equipment malfunction occurred, and testing was not able to be completed on EU-BOILER2.

Executive Summary Table i: Summary of Results – EU-BOILER1 – February 7, 2024

Parameter	EU-BOILER1		
	Oxides of Nitrogen (ppm)	Oxides of Nitrogen (lb/MMBTU)	Oxygen (%)
Relative Accuracy (RA) (Mean Difference from RM %)	0.79% <i>(Limit 20%)</i>	1.31% <i>(Limit 20%)</i>	1.92% <i>(Limit 20%)</i>
Relative Accuracy (RA) (Absolute Difference from RM Concentration)	0.09	0.0003	0.07% <i>(Limit 1%)</i>
Bias Present?	No	Yes	Not Applicable
Bias Factor	Not Applicable	1.01	Not Applicable

Notes: The average data is based on 9 of the 10 runs conducted on each source.

Executive Summary Table ii: Summary of Results – EU-BOILER3 – February 6, 2024

Parameter	EU-BOILER3		
	Oxides of Nitrogen (ppm)	Oxides of Nitrogen (lb/MMBTU)	Oxygen (%)
Relative Accuracy (RA) (Mean Difference from RM %)	3.1% <i>(Limit 20%)</i>	2.1% <i>(Limit 20%)</i>	2.7% <i>(Limit 20%)</i>
Relative Accuracy (RA) (Absolute Difference from RM Concentration)	0.61	0.0006	0.01% <i>(Limit 1%)</i>
Bias Present?	No	No	No
Bias Factor	Not Applicable	Not Applicable	Not Applicable

Notes: The average data is based on 9 of the 10 runs conducted on each source.



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1. INTRODUCTION

RWDI USA LLC (RWDI) was retained by General Motors, LLC (GM) to complete the Relative Accuracy Testing Audit (RATA) emission sampling program at the General Motors Technical Center in Warren, Michigan. The test program was conducted to fulfill the requirements of the Michigan Department of Environment, Great Lakes and Energy (EGLE) MI-ROP-B4049-2019 in accordance with Appendix A, 40 CFR, Part 60, Subpart Db, US EPA Reference Methods 3A and 7E found in 40 CFR, Part 60, Appendix A, and Performance Specifications (PS) 2, 3, and 16 specified by 40 CFR, Part 60, Appendix B. The pollutants tested include oxygen (O₂) and nitrogen oxides (NO_x) from EU-BOILER1 and EU-BOILER3

In accordance with the test plan submitted by RWDI, EU-BOILER1, EU-BOILER2, and EU-BOILER3 were to be tested. When preparing EU-BOILER2 for testing, an equipment malfunction occurred, and testing was not able to be completed on EU-BOILER2.

1.1 Location and Dates of Testing

The test program was completed on February 6th and 7th, 2024 at the GM Technical Center located in Warren, MI.

1.2 Purpose of Testing

The emissions test program is required by EGLE permit number MI-ROP-N4049-2019a. The facility SRN number is N4049. This report outlines the results for the 2024 RATA for EU-BOILER1 and EU-BOILER3.

1.3 Description of Source

The General Motors Technical Center located in Warren, Michigan has three boilers that are capable of firing natural gas. Each of the boilers has an input capacity of 108 MMBtu/hr while firing NG. The steam from the boilers is utilized as process steam. Low-NO_x burners minimize the emissions of nitrogen oxides from the boilers.



1.4 Personnel Involved in Testing

Table 1.4.1: Testing Personnel

<p>Matt Perko Environmental Engineer</p>	<p>General Motors – Global Technical Center 30001 Van Dyke Ave Warren, MI 48093</p>	<p>(586) 242-6763</p>
<p>Andrew Riley Air Quality Division</p>	<p>State of Michigan Department of Environment, Great Lakes & Energy (EGLE)</p>	<p>(586) 565-7379</p>
<p>Steve Smith Project Manager</p>	<p>RWDI USA LLC 2239 Star Court Rochester Hills, MI 48309</p>	<p>(734) 751-9701</p>
<p>Mason Sakshaug Supervisor, Source</p>		<p>(989) 323-0355</p>
<p>Kate Strang Field Technician</p>		<p>(518) 257-0117</p>

2. SUMMARY OF RESULTS

2.1 Operating Data

Operational data collected during the testing includes:

- Heat Input (MMBTU/hr)
- Boiler steam load (klbs/hr)
- NO_x concentration (ppm_{vd})
- NO_x emission rate (lbs/MMBTU)
- O₂ concentration (%)

This information can be found in **Appendices A and B**, respectively for EU-BOILER1 and EU-BOILER3.

2.2 Applicable Permit Number

MI-ROP-N4049-2019a



3. SOURCE DESCRIPTION

3.1 Description of Process and Emission Control Equipment

The General Motors Technical Center located in Warren, Michigan has three boilers that are capable of firing natural gas. Each of the boilers has an input capacity of 108 MMBtu/hr while firing NG. The steam from the boilers is utilized as process steam. Low-NOx burners minimize the emissions of nitrogen oxides from the boilers.

3.2 Predictive Emission Monitors (PEMS) Specifications

The SmartCEMS 60 Predictive Emissions Monitoring System (PEMS) provides continuous data recording and report generation for compliance with 40 CFR Part 60 regulations. The data acquisition system provides a secure and reliable means of collecting and retrieving compliance data. This application has been customized to meet the requirements of gas-fired boiler under 40 CFR Part 60, Subpart Db; and as a PEMS, an alternative to continuous emissions monitoring under 40 CFR Part 60, Performance Specification 16 for Predictive Emissions Monitoring Systems (PS-16).

Table 3.2.1: Summary of PEMS Units

	EU-BOILER1, EU-BOILER3
NOx (PS-2) Limit	Less than 20% of RM or 10% of AS – ppmvd Less than 20% of RM or 10% of AS – lb/MMBtu
O₂ (PS-3) Limit	Less than 20% of RM or 1% Difference
PEMS Unit O₂	CMC Solutions – SmartCEMS-60 – GMBL 122042
PEMS Unit NOx	CMC Solutions – SmartCEMS-60 – GMBL 122041

3.3 Process Flow Sheet or Diagram

Each boiler has a single outlet. A process flow diagram can be provided if requested.

3.4 Type and Quantity of Raw and Finished Materials

Each boiler is fired by natural gas.

3.5 Normal Rated Capacity of Process

Each boiler has a maximum heat input rating of 108 MMBTU/hr. Each test was completed with the boilers (EU-BOILER1 and EU-BOILER3) operating at greater than 50% capacity for each test. Process data is provided in **Appendices A and B.**



3.6 Process Instrumentation Monitored During the Test

The following process instrumentation data was monitored during each test:

- Heat Input (MMBTU/hr)
- Boiler steam load (klbs/hr)
- NO_x concentration (ppm_{vd})
- NO_x emission rate (lbs/MMBTU)
- O₂ concentration (%)

This information can be found in **Appendices A and B**, respectively for EU-BOILER1 and EU-BOILER3.

4. SAMPLING AND ANALYTICAL PROCEDURES

The following test methods were referenced in the test program. These methods can be found in 40 CFR, Part 60, Appendix A and B.

- **Method 3A:** Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources
- **Method 7E:** Determination of Nitrogen Oxides Emissions from Stationary Sources
- **Method 19:** Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide and Nitrogen Oxide Emission Rates
- **Performance Specification 2:** Specifications and Test Procedures for SO₂ and NO_x Continuous Emission Monitoring Systems in Stationary Sources
- **Performance Specification 16:** Specifications and Test Procedures for Predictive Emission Monitoring Systems in Stationary Sources

4.1 Relative Accuracy Testing Audit (RATA) NO_x and O₂

To satisfy the NO_x data accuracy requirement, the relative accuracy results of a minimum of nine performance test runs must meet the criteria outlined in section 8.4.4 of the US EPA PS 2 for NO_x and PS 3 for O₂. A 21-minute period was used for each run. A complete stratification check was completed for EU-BOILER3 and the gas stream was found to be non-stratified. One sampling point was used for the duration of testing. As per Performance Specification 2, traverse points were located at 16.7, 50.0, and 83.3 percent of the stack diameter for EU-BOILER1. Each point was sampled at for 7 minutes in duration for each RATA run.

Prior to the RATA, a NO₂-to-NO conversion efficiency check was performed. It met the criteria of ≥ 90%. Also prior to the RATA, an interference response test was performed on the analyzer used for this test program. The heated sample lines were operated at 250°F to avoid a buildup of condensation.



4.2 EPA Method 3A, and 7E (O₂, and NO_x)

A three-point (zero, mid-, and high-range) analyzer calibration error check was conducted on each reference analyzer before initiating the relative accuracy testing. This check was conducted (after final calibration adjustments are made) by injecting the calibration gases directly into each gas analyzer and recording the responses.

Zero and upscale calibration checks are conducted both before and after each test run to quantify measurement system calibration drift and sampling system bias. Upscale is either the mid- or high-range gas, whichever most closely approximates the flue gas level. During these checks, the calibration gases are introduced into the sampling system at the probe outlet so that the calibration gases are analyzed in the same manner as the flue gas samples.

A gas sample was continuously extracted from the stack and delivered to a series of gas analyzers, which measured the pollutant or diluent concentrations in the gas. The analyzers were calibrated on-site using EPA Protocol No. 1 certified calibration mixtures. The probe tip was equipped with a sintered stainless-steel filter for particulate removal. The end of the probe was connected to a heated Teflon sample line, which delivered the sample gases from the stack to the CEMs system. The heated sample line was designed to maintain the gas temperature above 250°F to prevent condensation of stack gas moisture within the line.

Before entering the analyzers, the gas sample passed directly into a refrigerated condenser, which cooled the gas to approximately 35°F to remove the stack gas moisture. After passing through the condenser, the dry gas entered a Teflon-head diaphragm pump and a flow control panel, which delivered the gas in series to the O₂ and NO_x analyzer. This analyzer measured the respective gas concentrations on a dry volumetric basis.

4.3 Nitrogen Oxides Emission Rate Calculation (US EPA Methods 19)

USEPA Method 19, "Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide and Nitrogen Oxide Emission Rates," was utilized to calculate a NO_x emission factor based on Oxygen concentrations and appropriate F-factors. Equation 19-1 from the method was used. Table 19-1 was also used to determine the conversion factor for concentration (1.194x10⁻⁷) for NO_x. Table 19-2 was used for the F-Factor (natural gas 8,710 dscf/10⁶ BTU).

$$E = (1.194 \times 10^{-7}) \times C_d \times F_d \times ((20.9 / (20.9 - \%O_{2d}))$$

Where:

E = Pollutant Emission Rate (lb/10⁶ BTU)

C_d = Pollutant Concentration, Dry Basis (ppm)

F_d = Fuel Factor, Dry Basis (dscf/10⁶ BTU)

%O_{2d} = Oxygen Concentration, Dry Basis (%)



4.4 Description of Recovery and Analytical Procedures

There were no samples to recover during this test program. All testing used real time data from the analyzers.

4.5 Sampling Port Description

All sampling ports meet USEPA Method 1 locations, flow measurements were not taken as emissions were determined via US EPA Method 19.

4.6 Internal Quality Assurance

Quality control procedures specific to the CEMS includes linearity checks to determine the instrument performance and reproducibility prior to its use in the testing program. Regular performance checks on the analyzers were also carried out during the testing program by performing zero and span calibration checks using EPA Protocol 1 gas standards. Sample system bias checks were also conducted. These checks were used to verify the ongoing precision of the monitor and sampling system over time. Pollutant-free nitrogen was introduced to perform the zero checks, followed by a known calibration (span) gas into the monitor. The response of the monitor to pollutant-free air and the corresponding sensitivity to the span gas was be recorded regularly during the tests. These records can be found in **Appendix A and B**.



5. TEST RESULTS AND DISCUSSION

5.1 Results Summary

Table 5.1.1: Summary of Results – EUBOILER1 – February 7, 2024

Parameter	EU-BOILER1		
	Oxides of Nitrogen (ppm)	Oxides of Nitrogen (lb/MMBTU)	Oxygen (%)
Relative Accuracy (RA) (Mean Difference from RM %)	0.79% (Limit 20%)	1.31% (Limit 20%)	1.92% (Limit 20%)
Relative Accuracy (RA) (Absolute Difference from RM Concentration)	0.09	0.0003	0.07% (Limit 1%)
Bias Present?	No	Yes	Not Applicable
Bias Factor	Not Applicable	1.01	Not Applicable

Notes: The average data is based on 9 of the 10 runs conducted on each source.

Table 5.1.2: Summary of Results – EUBOILER3 – February 6, 2024

Parameter	EU-BOILER3		
	Oxides of Nitrogen (ppm)	Oxides of Nitrogen (lb/MMBTU)	Oxygen (%)
Relative Accuracy (RA) (Mean Difference from RM %)	3.1% (Limit 20%)	2.1% (Limit 20%)	2.7% (Limit 20%)
Relative Accuracy (RA) (Absolute Difference from RM Concentration)	0.61	0.0006	0.01% (Limit 1%)
Bias Present?	No	No	No
Bias Factor	Not Applicable	Not Applicable	Not Applicable

Notes: The average data is based on 9 of the 10 runs conducted on each source.



5.2 Discussion of Results

Detailed results for each unit can be found in **Appendices A and B**. Calibration documentation can be found in **Appendix C**. The calibration records for the Teledyne T200H NO_x and O₂ analyzer, in compliance with USEPA Methods 3A and 7E, can be found in **Appendix A, B, and C**.

Operating conditions during the sampling were monitored by GM personnel. Testing was performed while each of the boilers operated at greater than 50% load. Contact was kept between RWDT and boiler operators to ensure the boiler was running at all times during the testing.

5.3 Variations in Testing Procedures

Accordance with the test plan submitted by RWDT EU-BOILER1, EU-BOILER2, and EU-BOILER3 were to be tested. EU-BOILER2 was not tested due to a malfunction in critical equipment.

5.4 Process Upset Conditions During Testing

There were normal operation of each boiler during the testing.

5.5 Maintenance Performed in Last Three Months

Normal general maintenance to boilers were completed.

5.6 Re-Test

This was not a retest.

5.7 Audit Samples

This test did not require any audit samples.

5.8 Calibration Data

Calibration data can be found in **Appendices A, B, and C**.

5.9 Process Data

Process data can be found in **Appendices A and B**.

5.10 Example Calculations

Example calculations can be found in **Section 4.3 and Appendix E**.



5.11 Laboratory Data

There was no laboratory data from this testing program.

6. CONCLUSIONS

The purpose of the study was to perform 2024 RATA on the PEMS for EU-BOILER1 and EU-BOILER3. PEMS determine concentrations for NO_x and O₂ and NO_x emission rate. All analyzers meet the relative accuracy requirements set out in Performance Specification in 40 CFR 60, Appendix B.

TABLES

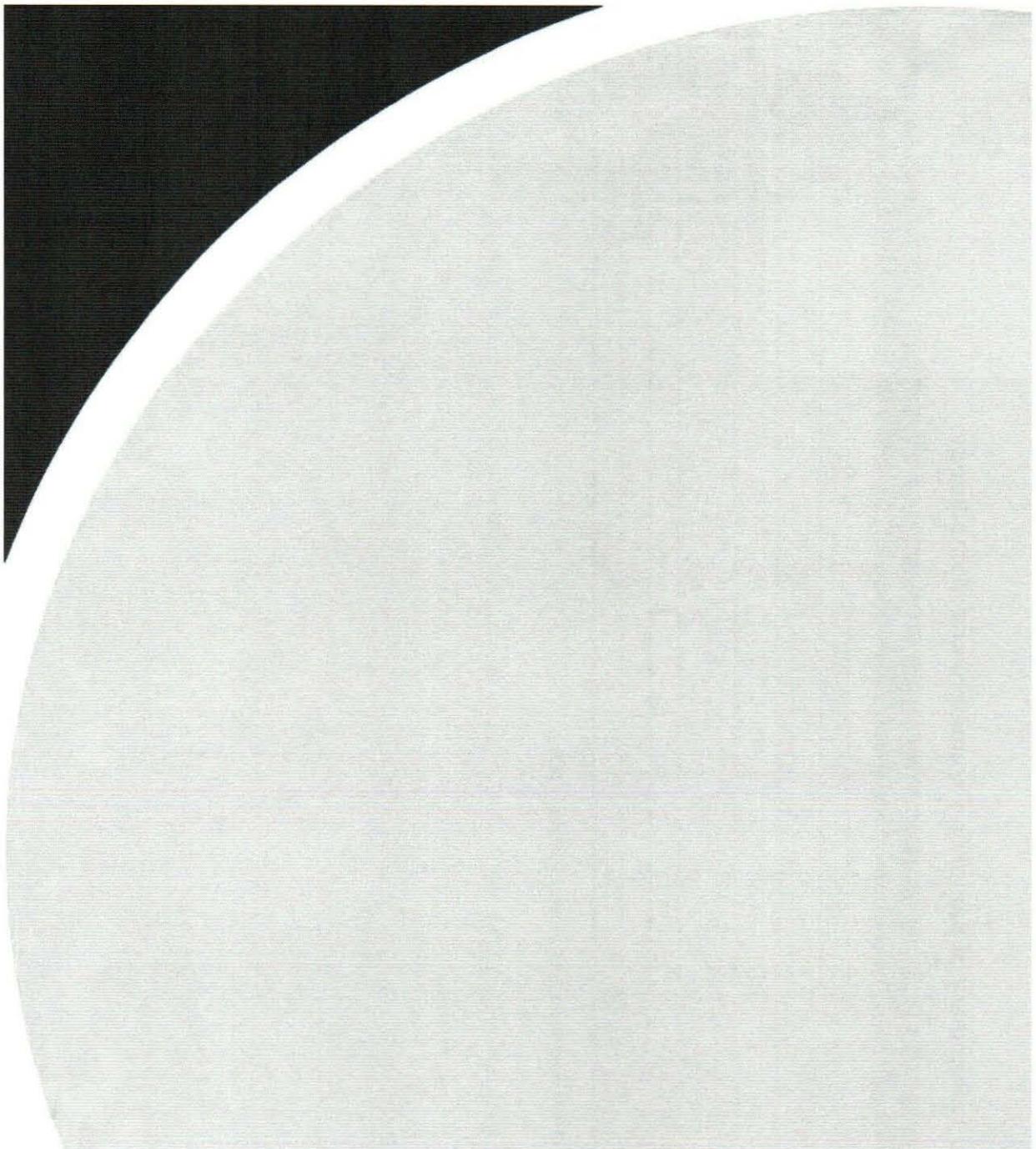


Table 1: Summary of Sampling Parameters and Methodology

Source Location	No. of Tests per Stack	Sampling Parameter	Sampling Method
EU-BOILER1	10	O ₂	U.S. EPA [1] Method 3A
	10	NO _x	U.S. EPA [1] Method 7E
	10	lb/mmbtu	U.S. EPA [1] Method 19
	10	O ₂	Performance Specification 3
	10	NO _x	Performance Specification 16
EU-BOILER3	10	O ₂	U.S. EPA [1] Method 3A
	10	NO _x	U.S. EPA [1] Method 7E
	10	lb/mmbtu	U.S. EPA [1] Method 19
	10	O ₂	Performance Specification 3
	10	NO _x	Performance Specification 16

Notes:

[1] U.S. EPA - United States Environmental Protection Agency

Table 2A: Sampling Summary - EU-BOILER1

Test #	Sampling Date	Start Time	End Time
1	7-Feb-24	7:42	8:02
2		8:11	8:31
3		8:40	9:00
4		9:09	9:29
5		9:37	9:57
6		10:11	10:31
7		10:38	10:58
8		11:05	11:25
9		11:33	11:53
10		12:00	12:20

Table 2B: Sampling Summary - EU-BOILER3

Test #	Sampling Date	Start Time	End Time
1	6-Feb-24	7:27	7:47
2		8:03	8:23
3		8:33	8:53
4		9:04	9:24
5		9:35	9:55
6		10:05	10:25
7		10:35	10:55
8		11:06	11:26
9		11:36	11:56
10		12:06	12:26

Table 3: EU-BOILER1: RATA Results

Date: Wednesday, February 7, 2024

Test	RWDI Time		NOx				O ₂				Emission Rate			Load Steam (klb/hr)	Heat Input (MMBTU/hr)
	Start Time	End Time	RM (dppm)	RM cor	PEMS (ppm)	d _i (ppm)	RM (d%)	RM (cor%)	PEMS (%)	d _i (%)	RM (lb/MMBTU)	PEMS (lb/MMBTU)	d _j (lb/min)		
1	7:42	8:02	19.35	19.56	19.67	-0.11	4.05	4.05	4.00	0.05	0.0252	0.0250	0.0002	53.85	58.60
2	8:11	8:31	19.30	19.56	19.75	-0.19	4.03	4.08	4.00	0.08	0.0253	0.0250	0.0003	53.78	58.69
3	8:40	9:00	19.35	19.54	19.74	-0.20	4.02	4.06	4.00	0.06	0.0252	0.0250	0.0002	54.02	58.63
4	9:09	9:29	19.24	19.45	19.64	-0.19	4.04	4.08	4.00	0.08	0.0251	0.0250	0.0001	54.21	58.66
5	9:37	9:57	19.27	19.57	19.64	-0.07	4.03	4.07	4.00	0.07	0.0253	0.0250	0.0003	54.10	58.70
6	10:11	10:31	19.31	19.63	19.57	0.06	4.04	4.09	4.00	0.09	0.0254	0.0250	0.0004	54.10	58.60
7	10:38	10:58	19.26	19.59	19.75	-0.16	4.03	4.07	4.00	0.07	0.0253	0.0250	0.0003	54.28	58.60
8	11:05	11:25	19.20	19.55	19.66	-0.11	4.04	4.09	4.00	0.09	0.0253	0.0250	0.0003	54.42	58.56
9	11:33	11:53	19.31	19.66	19.62	0.04	4.03	4.07	4.00	0.07	0.0254	0.0250	0.0004	54.34	58.59
10	12:00	12:20	19.31	19.65	19.70	-0.05	4.03	4.07	4.00	0.07	0.0254	0.0250	0.0004	54.30	58.58
AVERAGE			–	19.58	19.67	-0.09	–	4.07	4.00	0.07	0.0253	0.0250	0.0003	54.14	58.62
STDS			–	0.06	0.06	0.09	–	0.01	0.00	0.01	0.00008	0.00000	0.00008	–	–
n			9				9				9				
Full Scale			51.6				21.16				-				
t_{0.975}			2.306				2.306				2.306				
 d 			0.09				0.07				0.0003				
 cc 			0.07				0.01				0.0001				
Bias present? (d_{avg} > cc)			no bias				bias present				bias present				
Bias Factor			Not Applicable				Not Applicable				1.01				
Relative Accuracy (20% limit)			0.79% = Pass				1.92% = Pass				1.31% = Pass				

Notes:

RM = Reference Method (RWDI measurements)

PEMS = Predictive Emission Monitor System (GM data)

d_i = Difference between PEMS and RM for each point

n = number of tests

| d | = Absolute mean difference between the PEMS and RM results

| cc | = Confidence coefficient

F-Factor = 8710

Bolded test runs were not used in the RA calculation

Table 4: EU-BOILER3 - RATA Results

Date: Tuesday, February 6, 2024

Test	RWDI Time		NOx				O ₂				Emission Rate			Load Steam (klb/hr)	Heat Input (MMBTU/hr)
	Start Time	End Time	RM (dppm)	RM (corppm)	PEMS (ppm)	di (ppm)	RM (d%)	RM (cor%)	PEMS (%)	di (%)	RM (lb/MMBTU)	PEMS (lb/MMBTU)	di (lb/MMBTU)		
1	7:27	7:47	36.38	36.18	37.56	-1.38	4.04	4.08	4.00	0.1	0.0468	0.0480	-0.0012	62.72	72.42
2	8:03	8:23	36.45	35.91	37.56	-1.65	4.07	4.12	4.00	0.1	0.0465	0.0480	-0.0015	62.97	72.48
3	8:33	8:53	36.57	36.11	37.56	-1.45	4.05	4.10	4.00	0.1	0.0467	0.0480	-0.0013	63.02	72.43
4	9:04	9:24	36.68	36.34	37.56	-1.22	4.08	4.13	4.00	0.1	0.0471	0.0480	-0.0009	62.82	72.41
5	9:35	9:55	36.81	36.46	37.56	-1.10	4.06	4.11	4.00	0.1	0.0472	0.0480	-0.0008	62.88	72.44
6	10:05	10:25	36.91	36.58	37.07	-0.49	3.80	3.85	3.90	-0.1	0.0466	0.0470	-0.0004	59.91	68.50
7	10:35	10:55	37.11	36.66	37.05	-0.39	3.77	3.82	3.90	-0.1	0.0467	0.0470	-0.0003	60.06	68.53
8	11:06	11:26	37.36	36.92	36.95	-0.03	3.56	3.60	3.80	-0.2	0.0464	0.0470	-0.0006	58.44	66.03
9	11:36	11:56	37.56	37.17	36.95	0.22	3.55	3.60	3.80	-0.2	0.0467	0.0470	-0.0003	58.42	65.97
10	12:06	12:26	37.62	37.28	36.95	0.33	3.62	3.67	3.80	-0.1	0.0470	0.0470	0.0000	58.41	66.03
AVERAGE			--	36.63	37.25	-0.61	--	3.94	3.93	0.0	0.0468	0.0474	-0.0006	60.97	69.72
STDS			--	0.42	0.30	0.70	--	0.21	0.09	0.13	0.00026	0.00053	0.00045	--	--
n			9				9				9				
Full Scale			51.6				21.16				-				
t_{0.975}			2.306				2.306				2.306				
l d l			0.61				0.01				0.0006				
l cc l			0.54				0.10				0.0003				
Bias present? (ldl > lcc l)			no bias				no bias				no bias				
Bias Factor			N/A				N/A				N/A				
Relative Accuracy (20% limit)			3.1%				2.7%				2.1%				

Notes:
 RM = Reference Method (RWDI measurements)
 PEMS = Predictive Emission Monitor System (GM data)
 di = Difference between PEMS and RM for each point
 n = number of tests
 l d l = Absolute mean difference between the PEMS and RM results
 l cc l = Confidence coefficient
 F-Factor = 8710
Bolded test runs were not used in the RA calculation

FIGURE

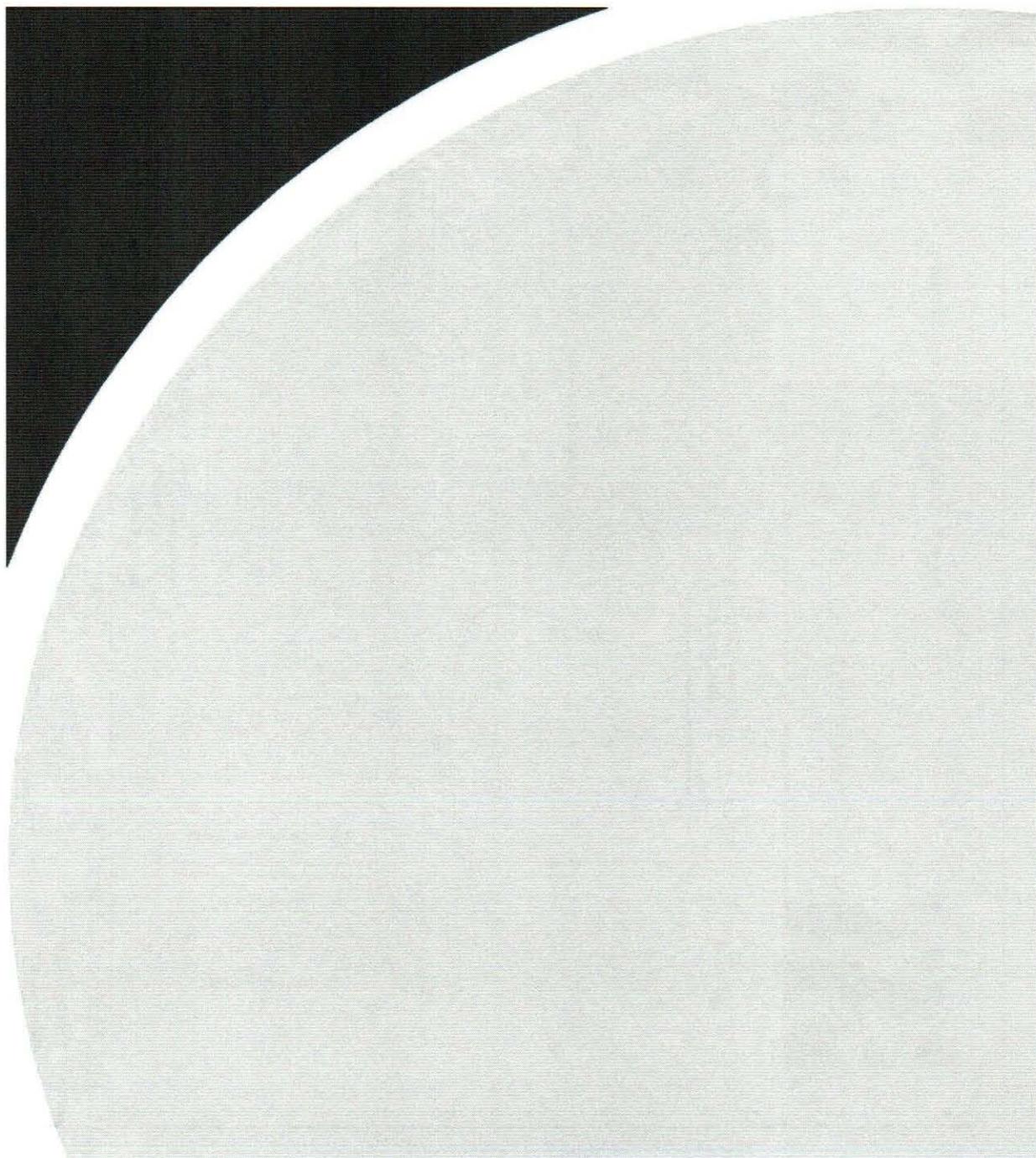
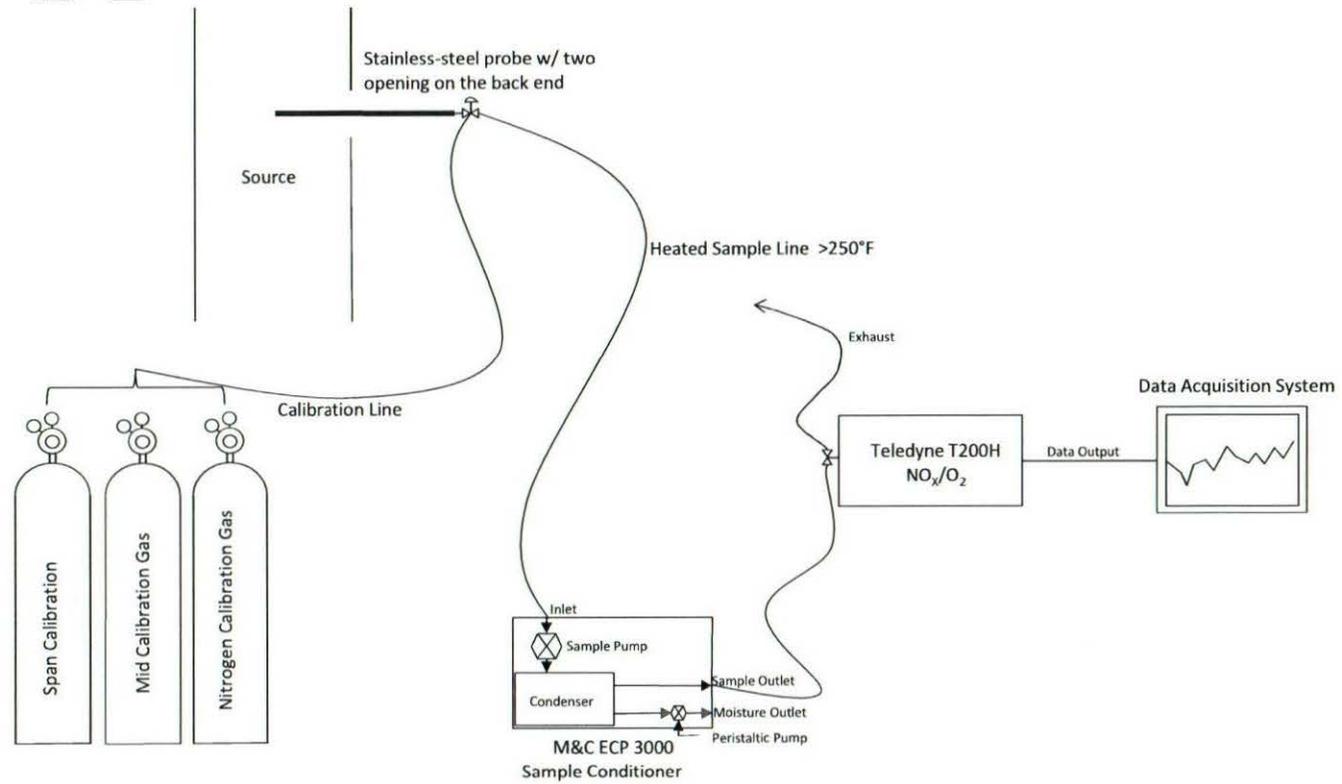




Figure No. 1: USEPA Method 3A and 7E Schematic



USEPA Method 3A and 7E

General Motors, LLC
GM Technical Center

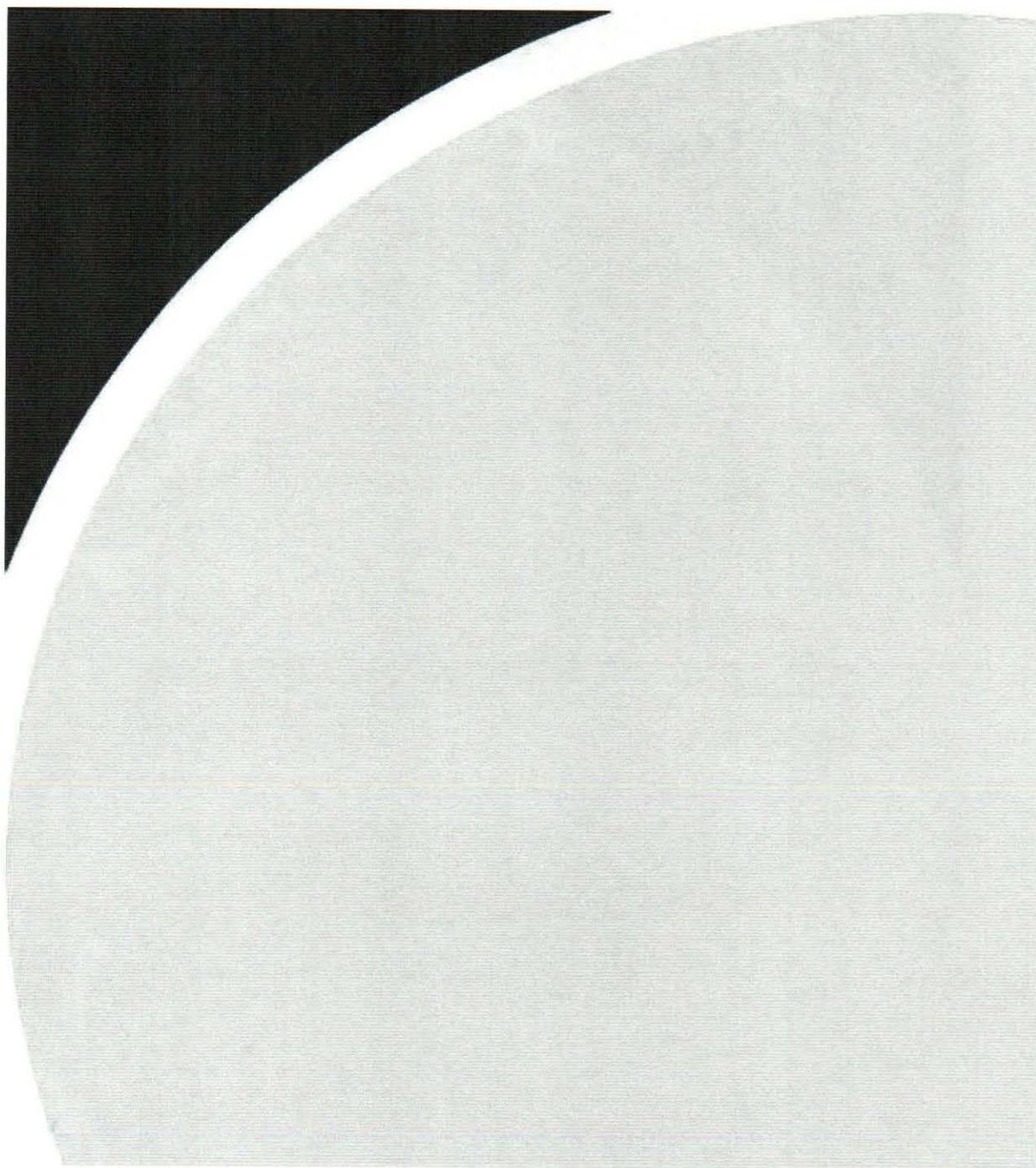
Warren, Michigan

Project# 2401924

Date: February 6 - 7, 2024



APPENDIX A: EU-BOILER1: RATA Results



APPENDIX A1: Reference Method CEM Results - EU-BOILER1

