FINAL REPORT

GENERAL MOTORS LLC

WARREN, MICHIGAN

GM TECHNICAL CENTER: 2024 RELATIVE ACCURACY TESTING AUDIT (RATA) SOURCE TESTING REPORT: EU-BOILER2-107

RWDI #2405820

April 15, 2024

SUBMITTED TO

Jermy Howe
Air Quality Division Technical
Programs Unit (TPU)
Constitution Hall 2nd Floor, South
525 West Allegan Street
Lansing, Michigan 48909-7760

Joyce Zhu
Michigan Department of Environment, Great Lakes and Energy (EGLE) Air Quality Division
Air Quality District Manager
27700 Donald Court
Warren, Michigan 48092-2793

Matthew Perko
Environmental Engineer
Matthew.Perko@gm.com

General Motors LLC
Global Technical Center
30001 VanDyke Avenue
Warren, Michigan 48093

T: 586.506.4046

SUBMITTED BY

Ben Durham
Senior Scientist
Ben.Durham@rwdi.com

Steve Smith, B.Sc., QSTI
Project Manager | Associate
Steve.Smith@rwdi.com

Brad Bergeron, A.Sc.T., d.E.T.
Technical Director | Principal
Brad.Bergeron@rwdi.com

RWDI USA LLC
Consulting Engineers & Scientists
2239 Star Court
Rochester Hills, Michigan 48309

T: 248.841.8442
F: 519.823.1316

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 GM 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) 16 specified by 40 CFR, Part 60, Appendix B. The pollutants tested include oxygen (O_2) and nitrogen oxides (NO_x) from EU-BOILER2-107.

Table i: Summary of Results – EUBOILER2-107

Parameter	EU-BOILER2-107		
	Oxides of Nitrogen (ppm)	Oxides of Nitrogen (lb/MMBTU)	Oxygen (%)
Relative Accuracy (RA) (Mean Difference from RM %)	0.8% ***(Limit 20%)***	2.5% ***(Limit 20%)***	7.0%
Relative Accuracy (RA) (Absolute Difference from RM Concentration)	0.09	0.0006	0.25% **(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 12 runs conducted on each source.

TABLE OF CONTENTS

LIST OF TABLES

(Found Within The Report Text)

LIST OF TABLES

(Found After Report Text)

LIST OF FIGURES

LIST OF APPENDICES

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 GM 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) 16 specified by 40 CFR, Part 60, Appendix B. The pollutants tested include oxygen (O_2) and nitrogen oxides (NO_x) from EU-BOILER2-107.

In accordance with the test plan submitted by RWDI, EU-BOILER1-107, EU-BOILER2-107, and EU-BOILER3-107 were to be tested. When preparing EU-BOILER2-107 for testing, an equipment malfunction occurred, and testing was not able to be completed on EU-BOILER2-107 during the week of February 6th. Testing for EU-BOILER2-107 was conducted on March 27th, 2024. Testing for EU-BOILER1-107 and EU-BOILER3-107 was provided to EGLE under separate cover.

1.1 Location and Dates of Testing

The test program was completed on March 27th, 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-BOILER2.

1.3 Description of Source

GM Technical Center located in Warren, Michigan has three (3) 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.

1.4 Personnel Involved in Testing

Table 1.4.1: Testing Personnel

Matt Perko Environmental Engineer	**General Motors – Global Technical Center** 30001 Van Dyke Ave Warren, MI 48093	(586) 242-6763
Elise Ciak Environmental Engineer		(586) 689-5308
Amanda Kosch Environmental Supervisor		(248) 416-2089
Andrew Riley Air Quality Division	**State of Michigan Department of Environment, Great Lakes & Energy** (EGLE)	(586) 565-7379
Steve Smith Project Manager	**RWDI USA LLC** 2239 Star Court Rochester Hills, MI 48309	(734) 751-9701
Ben Durham Senior Scientist		(734) 474-1731
Roy Zimmer Field Technician		(810) 956-7478

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)
- O_2 concentration (%)

This information can be found in **Appendix A** for EU-BOILER2.

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 PS-16 Limits and PEMS Units

	EU-BOILER2-107
NOx (PS-16) Limit	Less than 20% of RM Less than 20% of RM – lb/MMBtu
O_2 (PS-16) Limit	1% Difference
PEMS Unit O_2	CMC Solutions – SmartCEMS-60 – GMBL 122042
PEMS Unit NOx	CMC Solutions – SmartCEMS-60 – GMBL 122041

3.3 Process Flow Sheet or Diagram

EU-BOILER2-107 has a single outlet. A process flow diagram can be provided if requested.

3.4 Type and Quantity of Raw and Finished Materials

EU-BOILER2-107 boiler is fired by natural gas.

3.5 Normal Rated Capacity of Process

EU-BOILER2-107 has a maximum heat input rating of 108 MMBTU/hr. Each test was completed with the boiler operating at greater than 50% capacity for each test. Process data is provided in **Appendix A**.

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)
- O_2 concentration (%)

This information can be found in **Appendix A** for EU-BOILER2-107.

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 16:** Specifications and Test Procedures for Predictive Emission Monitoring Systems in Stationary Sources

4.1 Relative Accuracy Testing Audit (RATA) NO_x and O_2

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 13.1 of the US EPA PS 16 for NO_x for O_2. A 21-minute period was used for each run. Three (3) points were taken at 7-minute intervals at 16.7%, 50% and 83.3% of stack diameter for EU-BOILER2-107.

Prior to the RATA, a NO_2-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.

Table 4.1: NO/NO_2 Converter Efficiency

Certified Calibration Gas Value (ppmv)	Boiler	Analyzer Response Peak Value (ppmv)	NO_2 to NO Converter Efficiency (%)	Efficiency: Pass/Fail
49.6	EU-BOILER2-107	45.665	92%	PASS

Note: *Converter Efficiency must be >90%*

4.2 EPA Method 3A, and 7E (O_2, 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 O_2 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 (1.194×10^{-7}) for NO_x. Table 19-2 was used for the F-Factor (natural gas 8,710 dscf/10^6 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/10^6 BTU)

C_d = Pollutant Concentration, Dry Basis (ppm)

F_d = Fuel Factor, Dry Basis (dscf/10^6 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 assurance measures were implemented during the sampling program to ensure the integrity of the results. These measures included detailed documentation of field data, and equipment calibrations for all measured parameters.

Quality control procedures specific to the CEM monitoring included linearity checks, to determine the instrument performance, and reproducibility checks prior to its use in the field. Regular performance checks on the analyzer was 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 (zero) air 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 were recorded regularly during the tests. The tables below outline the QA/QC procedures and calibration gas summary.

Table 4.6.1: Summary of QA/QC Procedures

Summary of QA/QC Procedures				
Test Method	**QA/QC Procedure**	**QA/QC Objective**	**QA/QC Results**	**Status of QA/QC**
US EPA 3A & 7E	Initial Calibration Error Test	< ±2%	< ±2%	Acceptable
	System Bias Test	< ±5%	< ±5%	Acceptable
	Drift Test	< ±3%	< ±3%	Acceptable
US EPA 7E	NOx Converter Checks	>90% conversion efficiency	>90%	Acceptable

Table 4.6.2: Reference Method Calibration Gas Values

Reference Method Calibration Gas Values			
Parameter	**Span Level**	**Calibration Gas Value**	**Calibration Gas Serial Number**
Oxygen	Mid	10%	Environics 9405
	High	21.05%	EB0001454
Nitrogen Oxides	Mid	25 ppm	Environics 9405
	High	51.6 ppm	EB0022638
Nitrogen Dioxide	Converter Gas	49.6 ppm	DT0018386

5. TEST RESULTS AND DISCUSSION

5.1 Results Summary

Table 5.1.1: Summary of Results – EU-BOILER2-107

Parameter	EU-BOILER2-107		
	Oxides of Nitrogen (ppm)	Oxides of Nitrogen (lb/MMBTU)	Oxygen (%)
Relative Accuracy (RA) (Mean Difference from RM %)	0.8% ***(Limit 20%)***	2.5% ***(Limit 20%)***	7.0%
Relative Accuracy (RA) (Absolute Difference from RM Concentration)	0.09	0.0006	0.25% **(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 12 runs conducted on each source.

5.2 Discussion of Results

Detailed results for EU-BOILER2-107 can be found in **Appendix A**. Calibration documentation can be found in **Appendix B**. The calibration records for the Teledyne T200H NO_x and O_2 analyzer, in compliance with USEPA Methods 3A and 7E, can be found in **Appendices A and B**.

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 RWDI 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 RWDI EU-BOILER1-107, EU-BOILER2-107, and EU-BOILER3-107 were to be tested during the same sampling event. EU-BOILER2-107 was tested on March 27th, 2024 due to an equipment malfunction with the boiler. EU-BOILER2-107 was tested as soon as practicable once the repairs were completed.

5.4 Process Upset Conditions During Testing

There were normal operation of the 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 **Appendix B**.

5.9 Process Data

Process data can be found in **Appendix A2**.

5.10 Example Calculations

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

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-BOILER2-107. PEMS determine concentrations for NO_X and O_2 and NO_x emission rate. All analyzers meet the relative accuracy requirements set out in Performance Specification in 40 CFR 60, Appendix B.

TABLES

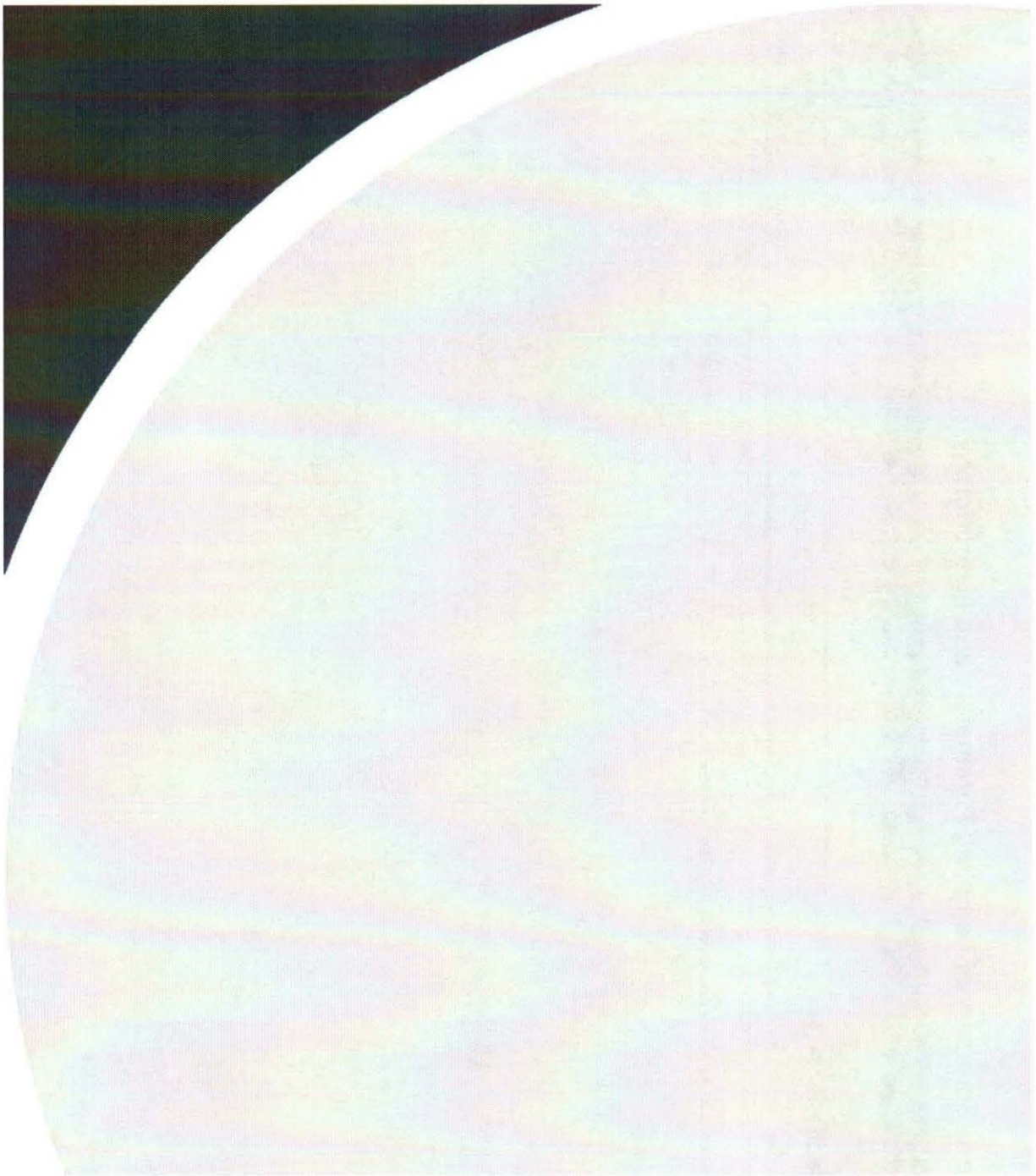


Table 1: Summary of Sampling Parameters and Methodology

Source Location	No. of Tests per Stack	Sampling Parameter	Sampling Method
EU-BOILER2-107	12	O_2	U.S. EPA [1] Method 3A
	12	NO_x	U.S. EPA [1] Method 7E
	12	lb/mmbtu	U.S. EPA [1] Method 19
	12	O_2	Performance Specification 16
	12	NO_x	Performance Specification 16

Notes:

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

Table 2: Sampling Summary - EU-BOILER2-107

Test #	Sampling Date	Start Time	End Time
1	27-Mar-24	7:37	7:57
2		8:09	8:29
3		8:40	9:00
4		9:12	9:32
5		9:42	10:02
6		10:12	10:32
7		10:42	11:02
8		11:11	11:31
9		11:40	12:00
10		12:10	12:30
11		12:39	12:59
12		13:09	13:29

Table 3: EU-BOILER2-107 - RATA Results

Date: Wednesday, March 27, 2024

Test	RWDI Time		NOx				O_2				Emission Rate			Load Steam	Heat Input
	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)	(klb/hr)	(MMBTU/hr)
1	7:37	7:57	24.85	25.14	25.15	-0.01	3.93	3.92	4.10	-0.18	0.0322	0.0330	-0.0008	49.41	55.51
2	8:09	8:29	25.09	25.12	25.15	-0.03	3.88	3.87	4.10	-0.23	0.0321	0.0330	-0.0009	49.10	55.53
3	8:40	9:00	25.12	25.46	25.16	0.30	3.86	3.84	4.10	-0.26	0.0324	0.0330	-0.0006	49.29	55.52
4	9:12	9:32	24.75	25.16	25.16	0.00	3.87	3.84	4.10	-0.26	0.0321	0.0330	-0.0009	49.07	55.49
5	9:42	10:02	24.80	25.14	25.16	-0.02	~~3.86~~	~~3.82~~	~~4.10~~	~~-0.28~~	~~0.0320~~	~~0.0330~~	~~-0.0010~~	49.20	55.50
6	10:12	10:32	24.83	25.16	25.16	0.00	~~3.86~~	~~3.83~~	~~4.10~~	~~-0.27~~	~~0.0320~~	~~0.0330~~	~~-0.0010~~	48.95	55.50
7	10:42	11:02	24.78	25.20	25.15	0.05	~~3.83~~	~~3.82~~	~~4.10~~	~~-0.28~~	~~0.0321~~	~~0.0330~~	~~-0.0009~~	49.30	55.50
8	11:11	11:31	24.85	25.26	25.16	0.10	3.83	3.83	4.10	-0.27	0.0322	0.0330	-0.0008	49.41	55.46
9	11:40	12:00	25.13	25.55	25.15	0.40	3.84	3.85	4.10	-0.25	0.0326	0.0330	-0.0004	49.17	55.53
10	12:10	12:30	~~25.24~~	~~25.75~~	~~25.15~~	~~0.60~~	3.84	3.84	4.10	-0.26	0.0328	0.0330	-0.0002	49.34	55.54
11	12:39	12:59	~~25.19~~	~~25.76~~	~~25.16~~	~~0.60~~	3.83	3.84	4.10	-0.26	0.0328	0.0330	-0.0002	49.65	55.42
12	13:09	13:29	~~25.27~~	~~25.87~~	~~25.16~~	~~0.71~~	3.83	3.83	4.10	-0.27	0.0329	0.0330	-0.0001	49.62	55.47
		AVERAGE	–	25.24	25.16	0.09	–	3.85	4.10	-0.25	0.0324	0.0330	-0.0006	49.29	55.50
		STDS	–	0.16	0.01	0.16	–	0.03	0.00	0.03	0.00035	0.00000	0.00035	–	–
		n	9				9				9				
		Full Scale	51.6				21.16				-				
		$t_{0.975}$	2.306				2.306				2.306				
		l d l	0.09				0.25				0.0006				
		l cc l	0.12				0.02				0.0003				
		Bias present? (davg > lccl)	**no bias**				**no bias**				**no bias**				
		Bias Factor	**N/A**				**N/A**				**N/A**				
		Relative Accuracy (20% limit)	**0.8%**				**7.0%**				**2.5%**				

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

FIGURES

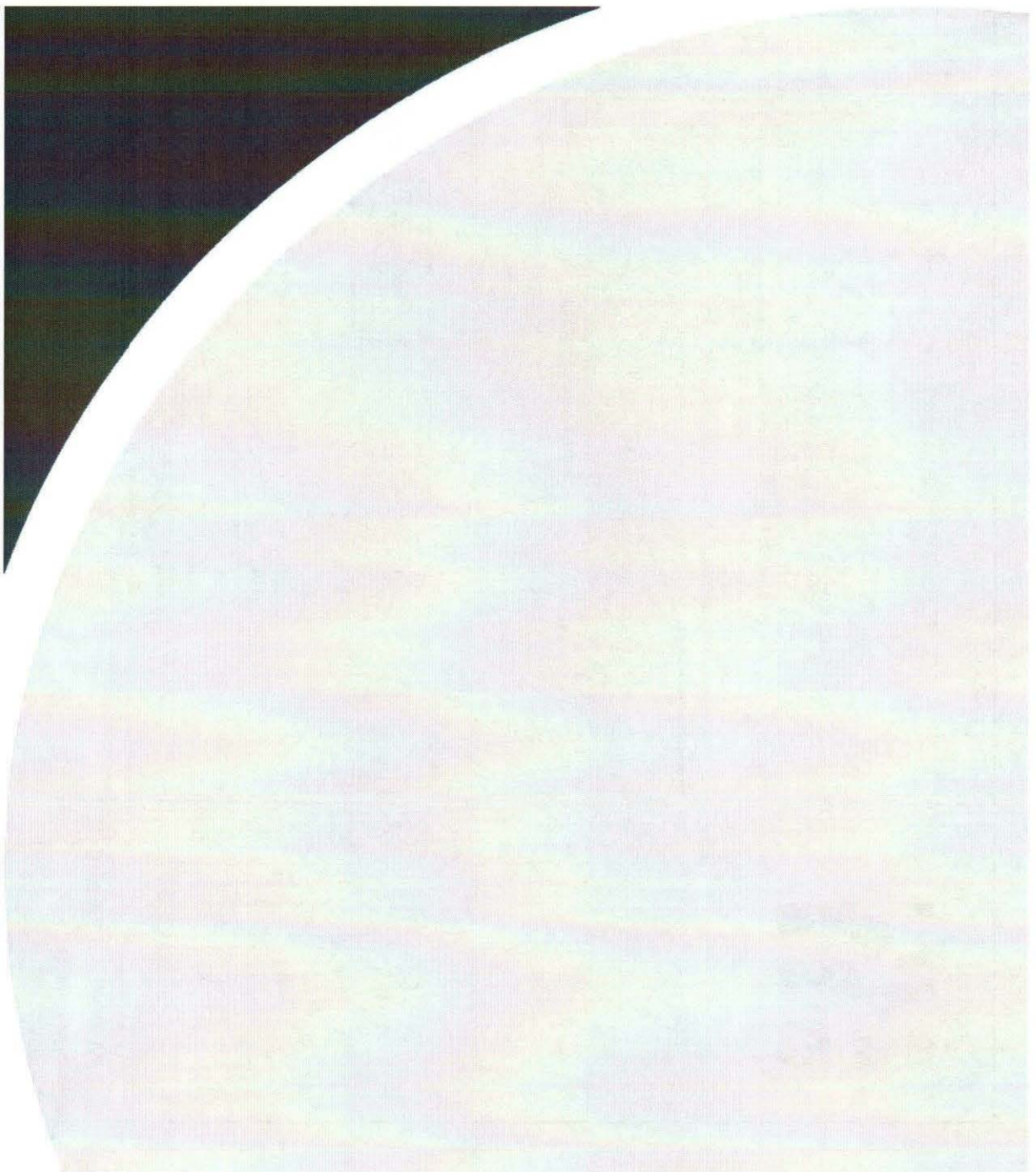
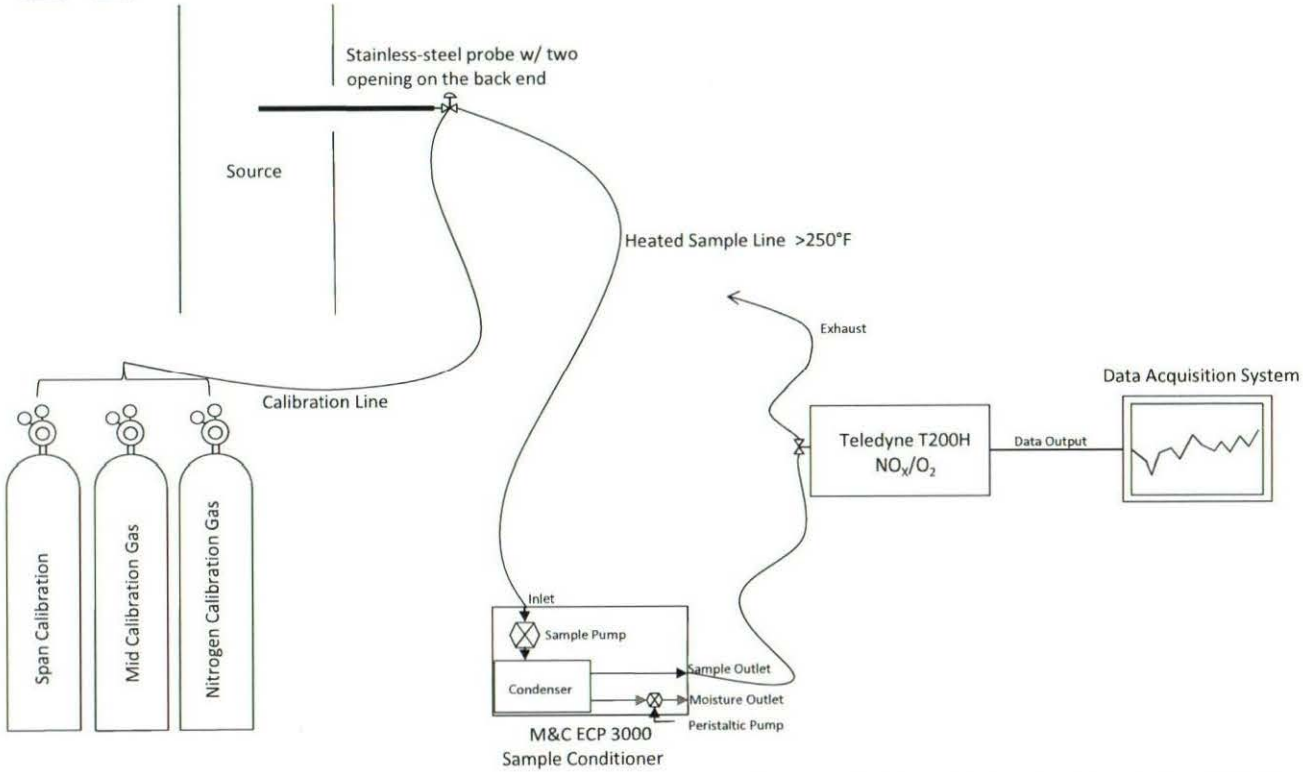


Figure No. 1: USEPA Method 3A and 7E Schematic



USEPA Method 3A and 7E

General Motors, LLC

GM Technical Center

Warren, Michigan

Project# 2405820

Date: March 27, 2024