FINAL REPORT

FEDERAL-MOGUL POWERTRAIN, LLC

PLYMOUTH, MICHIGAN

FEDERAL MOGUL POWERTRAIN, LLC:
2024 FG-ALLCELLS EMISSIONS TESTING REPORT

RWDI #2403404

July 15, 2024

SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI USA LLC (RWDI) has been retained by NTH Consultants to perform compliance stack emissions testing for Federal-Mogul Powertrain, LLC located at 47001 Port Street, Plymouth, Michigan. Testing was completed to demonstrate compliance with Michigan Department of Environment, Great Lakes, and Environment (EGLE) ROP No. MI-ROP-N6327-2015, Special Condition V.1 for total oxides of nitrogen (NO_x) and carbon monoxide (CO) on Engine Test Cells (FG-ALLCELLS). To determine compliance, testing included three (3) tests on one (1) 3.6 liter (L) gasoline engine under each of the following conditions:

1) Durability Testing – emissions controlled by the Air Injection Control System (AICS)
2) Developmental Testing – emissions uncontrolled by the Air Injection Control System (AICS)

Executive Table i: Cell 12 Average NO_x and CO Emission Rates

Condition	NO_x		CO	
	Concentration (ppm_{vd})	Emission Rate (lb/lb fuel)	Concentration (ppm_{vd})	Emission Rate (lb/lb fuel)
Durability	382	0.009	9,425.9	0.13
Developmental	1,109.00	0.026	12,762.8	0.18

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1 INTRODUCTION

RWDI USA LLC (RWDI) has been retained by NTH Consultants to perform compliance stack emissions testing for Federal-Mogul Powertrain, LLC located at 47001 Port Street, Plymouth, Michigan. Testing was completed to demonstrate compliance with Michigan Department of Environment, Great Lakes, and Environment (EGLE) ROP No. MI-ROP-N6327-2015, Special Condition V.1 for total oxides of nitrogen (NO_x) and carbon monoxide (CO) on Engine Test Cells (FG-ALLCELLS). To determine compliance, testing included three (3) tests on one (1) 3.6L gasoline engine under each of the following conditions:

1) Durability Testing – emissions controlled by the Air Injection Control System (AICS)
2) Developmental Testing – emissions uncontrolled by the Air Injection Control System (AICS)

1.1 Location and Dates of Testing

The test program took place at the Federal-Mogul facility located at 47001 Port Street, Plymouth, MI on May 21-22, 2024.

1.2 Purpose of Testing

This testing was conducted to show compliance with MI-ROP-N6327-2015, Special Condition V.1.

1.3 Description of Source

Federal-Mogul Powertrain operates sixteen (16) dynamometer test cells. Fifteen (15) of the cells can be used to test gasoline and diesel engines. One (1) cell is used to test small engines. The Air Injection Control System (AICS) is used with durability and deep thermal shock testing for most gasoline engine but is not used with diesel or small engines or during developmental testing. All emissions are released at the AICS Exhaust Pipe. Testing was completed on a 3.6 L Gasoline Engine in Test Cell 12.

1.4 Personnel Involved in Testing

Table 1.4: Testing Personnel

David Thiel David.Thiel@tenneco.com	**Federal-Mogul Powertrain, LLC** 47001 Port Street Plymouth, MI 48170	(724) 954-5329
Chloe Reed Senior Staff Engineer CPalajac@nthconsultants.com	**NTH Consultants, LTD** 3300 Eagle Run Dr #202 Grand Rapids, MI 49525	(313) 600-1191
Jeremy Howe	**State of Michigan Department of Environment, Great Lakes and Energy**	N/A
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Shane Rabideau Field Technician Shane.Rabideau@rwdi.com		(248) 841-8442

2 SUMMARY OF RESULTS

2.1 Operating Data

Operating parameters used to monitor the engine includes the following:

- AICS Air Injection Rate (during Durability testing) – scfm
- Air-to-fuel-ratio
- Temperature before air injection - °F
- Temperature after air injection - °F
- Fuel consumption – lbs
- Average fuel flow rate – lbs/hr

Operating parameters for each test can be found in **Appendix A**.

2.2 Applicable Permit Number

MI-ROP-N6327-2015, Special Condition V.1

3 SOURCE DESCRIPTION

3.1 Description of Process and Emission Control Equipment

Federal-Mogul Powertrain operates sixteen (16) dynamometer test cells. Fifteen (15) of the cells can be used to test gasoline and diesel engines. One (1) cell is used to test small engines. The Air Injection Control System (AICS) is used with durability and deep thermal shock testing for most gasoline engine but is not used with diesel or small engines or during developmental testing. All emissions are released at the AICS Exhaust Pipe. Testing was completed on a 3.6 L Gasoline Engine in Test Cell 12.

3.2 Process Flow Sheet or Diagram (if applicable)

A process flow diagram is available upon request.

3.3 Type and Quantity of Raw and Finished Materials

Testing was completed on a 3.6 L Gasoline Engine. Gasoline was used as the raw material.

3.4 Normal Rated Capacity of Process

The dynamometers use a variety of engines and testing was completed on a 3.6 L Gasoline Engine.

3.5 Process Instrumentation Monitored During the Test

No process instrumentation was being monitored for this testing.

4 SAMPLING AND ANALYTICAL PROCEDURES

4.1 Description of Sampling Train and Field Procedures

4.1.1 Oxygen, Oxides of Nitrogen, and Carbon Monoxide

O_2, NO_x, and CO concentrations were determined utilizing RWDI's continuous emissions monitoring (CEM) system in accordance with USEPA Methods 3A, 7E, and 10, respectively. Prior to testing, a 3-point analyzer calibration error check was conducted using USEPA protocol gases. The calibration error check was performed by introducing zero, mid and high-level calibration gases directly into the analyzer. The calibration error check was performed to confirm that the analyzer response was within ±2% of the certified calibration gas introduced. Prior to each test run, a system-bias test was performed where known concentrations of calibration gases were introduced at the probe tip to measure if the analyzers response was within ±5% of the introduced calibration gas concentrations. At the conclusion of each test run a system-bias check was performed to evaluate the percent drift from pre and post-test system bias checks. The system bias checks were used to confirm that the analyzer did not drift greater than ±3% throughout each test run.

Zero and upscale calibration checks were 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 were introduced into the sampling system at the probe outlet so that the calibration gases were 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 measure 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 CEM 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 cools 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 NO_x, CO, and O_2 analyzers. Each of these analyzers measure the respective gas concentrations on a dry volumetric basis.

4.1.2 USEPA Method 19

USEPA Method 19, "Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide and Nitrogen Oxide Emission Rates," was used to calculate a NO_x and CO emission factor based on Oxygen concentrations and appropriate F-factors. Equation 19-1 from the method was used. Table 19-1 was used to determine the conversion factor for concentration. 1.197×10^{-7} was used for NO_x and 7.27×10^{-8} was used for CO. A fuel analysis was completed to determine the F_d factor.

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

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 (%)

4.1.3 USEPA Method 205

Calibration gases were mixed using an Environics 4040 Gas Dilution System. The mass flow controllers are factory calibrated using a primary flow standard traceable to the United States National Institute of Standards and Technology (NIST). Each flow controller utilizes an 11-point calibration table with linear interpolation, to increase accuracy and reduce flow controller nonlinearity. The calibration is done yearly, and the records will be included in the Source Testing Report. A multi-point EPA Method 205 check was executed in the field prior to testing to ensure accurate gas-mixtures. The gas dilution system consists of calibrated orifices or mass flow controllers and dilutes a high-level calibration gas to within ±2% of predicted values. The gas divider is capable of diluting gases at set increments and was evaluated for accuracy in the field in accordance with US EPA Method 205 "*Verification of Gas Dilution Systems for Field Instrument Calibrations*". The gas divider dilutions were measured to evaluate that the responses were within ±2% of predicted values. In addition, a certified mid-level calibration gas within ±10% of one of the tested dilution gases was introduced into the analyzer to ensure the response of the gas calibration is within ±2% of gas divider dilution concentration.

4.2 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.

4.3 Sampling Port Description

A figure of the testing sites is provided in the **Figures** section.

5 SAMPLING RESULTS

The following table give the averages for each permit requirement. The **Tables** section and **Appendix B** provides a detailed breakdown of each test.

Table 4.4: Cell 12 Average NO_x and CO Emission Rates

Condition	NO_x		CO	
	Concentration (ppm_{vd})	Emission Rate (lb/lb fuel)	Concentration (ppm_{vd})	Emission Rate (lb/lb fuel)
Durability	382	0.009	9,425.9	0.13
Developmental	1,109.00	0.026	12,762.8	0.18

5.1 Discussion of Results

The emission rate (lb of pollutant/lb of fuel) is used as an emission factor.

5.2 Variations in Testing Procedures

All testing was completed as per the respective USEPA method.

5.3 Process Upset Conditions During Testing

During Test 3 of the developmental testing, the process data was being collected at a lower-than-desired frequency; therefore, Test 3 was aborted to update the frequency of collecting process data as approved by EGLE on site during testing. Test 3 concentrations are included in the report but not included in the average results. Test 4 was completed for a total of three (3) 60-minute sampling runs.

5.4 Maintenance Performed in Last Three Months

Regular maintenance is performed monthly.

5.5 Re-Test

This was not a retest.

5.6 Audit Samples

A sample of gasoline being used for the testing was collected and hand-delivered to Paragon Laboratories to analyze for the necessary compounds to determine the F_d factor in accordance with USEPA Method 19.

5.7 Field Data Sheets

Field data sheets can be found in **Appendix C**.

5.8 Calibration Data

Calibration data can be found in **Appendix D**.

5.9 Example Calculations

Example calculations can be found in **Appendix E**.

5.10 Laboratory Data

A sample of gasoline being used for the testing was collected and hand-delivered to Paragon Laboratories to analyze for the necessary compounds to determine the F_d factor in accordance with USEPA Method 19. The analysis can be found in **Appendix F.**

5.11 Test Plan and EGLE Correspondence

The test plan and all EGLE correspondence can be found in **Appendix G**.

TABLES

Table 1: Summary of Sampling Parameters and Methodology

Source Location	No. of Tests	Condition	Sampling Parameter	Sampling Method
Cell 12	3	Durability	Oxygen	U.S. EPA [1] Method 3A
			Nitrogen Oxides	U.S. EPA [1] Method 7E
			Carbon Monoxide	U.S. EPA [1] Method 10
	4	Developmental	Oxygen	U.S. EPA [1] Method 3A
			Nitrogen Oxides	U.S. EPA [1] Method 7E
			Carbon Monoxide	U.S. EPA [1] Method 10

Test 3 for the developmental was aborted and the test data is not used in the average emissions

Notes:

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

Table 2: Cell 12 Sampling Summary

Condition	Test #	Sampling Date	Start Time	End Time
Durability	Test #1	21-May-24	1:21 PM	2:20 PM
	Test #2	21-May-24	2:35 PM	3:34 PM
	Test #3	21-May-24	3:46 PM	4:45 PM
Developmental	Test #1	22-May-24	9:06 AM	10:05 AM
	Test #2	22-May-24	10:16 AM	11:15 AM
	Test #3	*22-May-24*	*11:28 AM*	*11:56 AM*
	Test #4	22-May-24	12:02 PM	1:01 PM

Test 3 for the developmental was aborted and the test data is not used in the average emissions

Table 3: Durability - NO_x Testing Summary

RWDI Project #2403404

Durability				O_2	NO_x	NOx (as NO_2)	NO_x Emission Rate			Gas Used			NO_x Emission Rate
Test ID	Date	Start	End	%	ppm	mg/m3	lb/dscf	lb/hr	lb/lb fuel	lb/hr	MMBTU/hr	Gross Calorie Value	lb/MMBTU
1	2024-05-21	13:21	14:20	1.09	407.1	765.6	4.78E-05	0.944	0.009	103.4	2.0233	19,568	0.47
2	2024-05-21	14:35	15:34	1.03	337.1	634.0	3.96E-05	0.809	0.008	107.4	2.1016	19,568	0.39
3	2024-05-21	15:46	16:45	1.13	401.8	755.7	4.72E-05	0.952	0.009	105.5	2.0644	19,568	0.46
		Average		1.08	382.0	718.4	4.49E-05	0.902	0.009	105.4	2.0631	19,568	0.44

Caloric value for natural gas used 19568 btu/ft^3

Conversion for ppm to lbs/scf (U.S. EPA Method 19) 1.197E-07

Fd - 9073 dscf/10^6 BTU

$E = (1.194\times10^{-7}) \times C_d \times F_d \times ((20.9/(20.9-\%O_{2d}))$

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 (%)

Table 4: Durability - CO Testing Summary

RWDI Project #2403404

Durability				O_2	CO	CO Emission Rate	CO Emission Rate			Gas Used			CO Emission Rate
Test ID	**Date**	**Start**	**End**	**%**	**ppm**	**mg/m3**	**lb/dscf**	**lb/hr**	**lb/lb of fuel**	**lb/hr**	**MMBTU/hr**	**Gross Calorie Value**	**lb/MMBTU**
1	2024-05-21	13:21	14:20	1.09	9087.55	10531.9	6.57E-04	12.79	0.12	103.4	2.0233	19568	6.32
2	2024-05-21	14:35	15:34	1.03	9366.11	10854.8	6.78E-04	13.88	0.13	109.2	2.1368	19568	6.50
3	2024-05-21	15:46	16:45	1.13	9824.12	11385.6	7.11E-04	14.02	0.13	104.6	2.0468	19568	6.85
		Average		1.08	9425.93	10924.1	6.82E-04	13.57	0.13	105.7	2.0690	19568	6.56
							Limit						

Caloric value for natural gas used 19568 btu/ft^3

Conversion for ppm to lbs/scf (U.S. EPA Method 19) 7.270E-08

Fd - 9073 dscf/10^6 BTU

$E = (7.27 \times 10^{-8}) \times C_d \times F_d \times ((20.9/(20.9 - \%O_{2d}))$

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 (%)

Table 5: Developmental - NO_x Testing Summary

RWDI Project #2403404

Durability				O_2	NO_x	NOx (as NO_2)	NO_x Emission Rate			Gas Used			NO_x Emission Rate
Test ID	Date	Start	End	%	ppm	mg/m3	lb/dscf	lb/hr	lb/lb fuel	lb/hr	MMBTU/hr	Gross Calorie Value	lb/MMBTU
1	2024-05-22	9:06	10:05	1.64	1,058.2	1990.1	1.24E-04	0.342	0.024	14.0	0.2740	19,568	1.25
2	2024-05-22	10:16	11:15	1.83	1,118.6	2103.6	1.31E-04	0.365	0.026	14.0	0.2743	19,568	1.33
3	*2024-05-22*	*11:28*	*11:56*	*1.83*	*1,135.8*	*2136.0*	-	-	-	-	-	-	-
4	2024-05-22	12:02	13:01	1.77	1,150.1	2162.9	1.35E-04	0.368	0.027	13.8	0.2696	19,567	1.36
		Average		1.75	1,109.0	2085.5	1.30E-04	0.358	0.026	13.9	0.2726	19,568	1.31

Test 3 was aborted due to the process data not being properly recorded and is not included in the average

Caloric value for natural gas used 19568 btu/ft^3

Conversion for ppm to lbs/scf (U.S. EPA Method 19) 1.197E-07

Fd - 9073 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 (%)

Table 6: Developmental - CO Testing Summary

RWDI Project #2403404

Durability				O_2	CO	CO Emission Rate	CO Emission Rate			Gas Used			CO Emission Rate
Test ID	Date	Start	End	%	ppm	mg/m3	lb/dscf	lb/hr	lb/lb of fuel	lb/hr	MMBTU/hr	Gross Calorie Value	lb/MMBTU
1	2024-05-22	13:21	14:20	1.64	13831.30	16029.7	1.00E-03	2.74	0.20	14.0	0.2764	19741	9.90
2	2024-05-22	10:16	11:15	1.83	13461.86	15601.5	9.74E-04	2.69	0.19	14.0	0.2768	19741	9.73
3	*2024-05-22*	*11:28*	*11:56*	*1.83*	*11980.96*	*13885.2*	-	-	-	-	-	-	-
4	2024-05-22	12:02	13:01	1.77	10995.12	12742.7	7.95E-04	2.16	0.16	13.8	0.2720	19741	7.92
		Average		1.75	12762.76	14791.3	9.23E-04	2.53	0.18	13.93	0.2751	19741	9.18

Test 3 was aborted due to the process data not being properly recorded and is not included in the average

Caloric value for natural gas used 19568 btu/ft^3

Conversion for ppm to lbs/scf (U.S. EPA Method 19) 7.270E-08

Fd - 9073 dscf/10^6 BTU

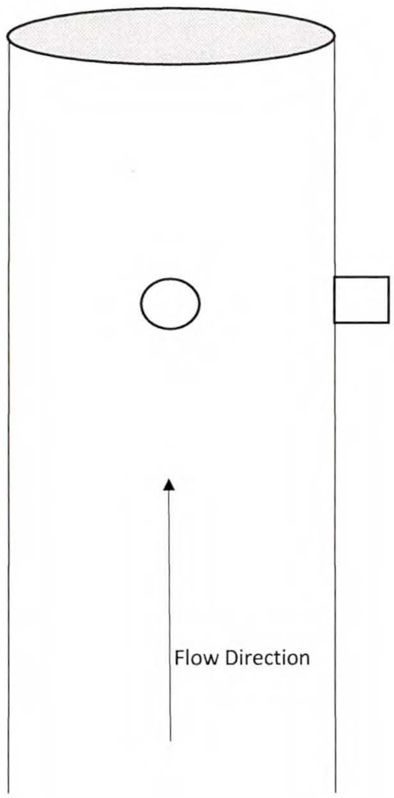
$$E = (7.27\times10^{-8}) \times C_d \times F_d \times ((20.9/(20.9-\%O_{2d}))$$

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 (%)

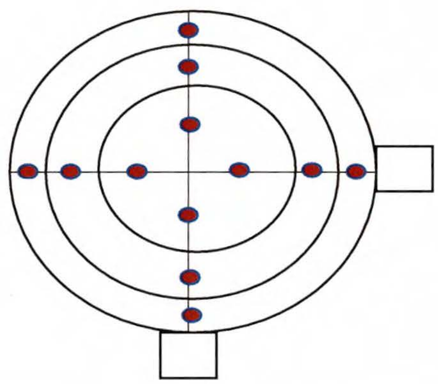
FIGURES

Figure No. 1: Cell 12 Emissions Stack Diagram



Diameter: 8

Sampling Points (in.)	
1	1.28
2	4.00
3	6.66



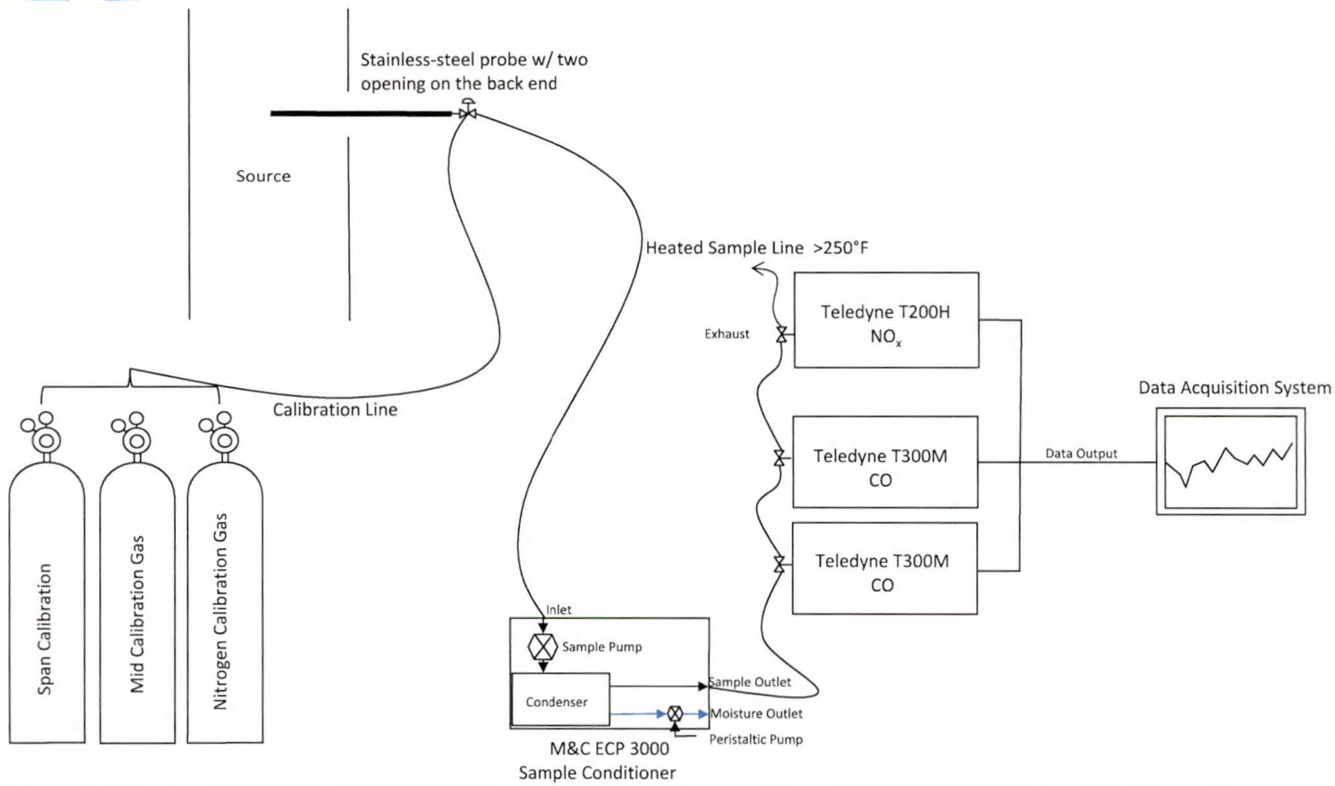
Not to scale

Cell 12
Federal Mogul
Dynamometer Test Cells
Plymouth, Michigan

Date:
May 21-22, 2024

RWDI USA LLC
2239 Star Court
Rochester Hills, MI 48309

Figure No. 2: USEPA Method 3A,7E,10 Schematic



USEPA Method 3A,7E,10

Cell 12

Federal Mogul

Plymouth, Michigan

Project# 2403404

Date: May 21-22, 2024