COMPLIANCE STACK EMISSION TEST REPORT

ENGINE TEST CELLS (FG-ALLCELLS)

Determination of Nitrogen Oxides and Carbon Monoxide Emissions

Utilizing US EPA Methods 3A, 7E, 10, and 19

Test Date(s): May 7, 2019
State Registration Number: N6327
Source Location: Plymouth, MI
Permit: EGLE ROP No. MI-ROP-N6327-2015

Prepared For:

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Document Number: M049AS-554629-RT-21R0
Document Date: June 5, 2019
Test Plan: 049AS-554629-PP-2-R1

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TO ASTM D7036 ONLY
CERT #3925.01

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REVIEW AND CERTIFICATION

The results of the Compliance Test conducted on May 7, 2019 are a product of the application of the United States Environmental Protection Agency (US EPA) Stationary Source Sampling Methods listed in 40 CFR Part 60, Appendix A, that were in effect at the time of this test.

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: ____________ Date: 7-3-19

Name: Mason Sakshaug Title: Field 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: ____________ P.P Date: 7-3-19

Name: Randal Tysar Title: District Manager

1.0 INTRODUCTION

1.1 SUMMARY OF TEST PROGRAM

Federal-Mogul Powertrain, LLC (State Registration Number: N6327), located in Plymouth, MI, contracted Montrose Air Quality Services, LLC (Montrose) of Detroit, Michigan, to conduct compliance stack emission testing for their Engine Test Cells (FG-ALLCELLS). Testing was performed to satisfy the emissions testing requirements pursuant to the Michigan Department of Environment, Great Lakes and Energy (EGLE) Renewable Operating Permit (ROP) No. MI-ROP-N6327-2015. The testing was performed on May 7, 2019.

Sampling was performed at the Air Injection Control System (AICS) Exhaust Pipe to determine the emissions of nitrogen oxides (NO_x) (as NO_2) and carbon monoxide (CO). Testing was conducted during two different process conditions, Developmental Testing (without the AICS) and Durability Testing (with the AICS), using a single FG-ALLCELLS test cell (Test Cell 12) while a 6.2 L gasoline-powered engine was in operation. During Durability Testing Cycle B, emissions from Test Cell 12 were controlled by an AICS. During Developmental Testing, emissions from the Test Cell 12 were uncontrolled.

The test methods that were conducted during this test were US EPA Methods 3A, 7E, 10, and 19.

1.2 KEY PERSONNEL

The key personnel who coordinated this test program (and their phone numbers) were:

- Terrance Walter, Manager, Technical, Federal-Mogul, 734-254-8291
- Rhiana Dornbos, PE, Project Engineer, NTH, 517-702-2953
- Mason Sakshaug QI, Field Project Manager, Montrose, 248-548-7980

2.0 SUMMARY AND DISCUSSION OF TEST RESULTS

2.1 OBJECTIVES AND TEST MATRIX

The purpose of this test was to determine the emissions of NO_x (as NO_2) and CO at the AICS Exhaust Pipe during two different process conditions. Testing was performed to satisfy the emissions testing requirements pursuant to EGLE ROP No. MI-ROP-N6327-2015, FG-ALLCELLS, Special Condition V.1.

The specific test objectives for this test are as follows:

- Measure the concentration of NO_x, CO, and oxygen (O_2) at the AICS Exhaust Pipe.
- Utilize the above variables to determine the emissions of NO_x (as NO_2) and CO at the AICS Exhaust Pipe during two different process conditions.

Tables 2.1.1 and 2.1.2 present the sampling matrix log for this test.

2.2 FIELD TEST CHANGES AND PROBLEMS

During Developmental Testing, Run 1 was aborted due to a process stop and restart; and during Durability Testing, Run 2 was aborted due to an engine upset condition resulting in several error codes, requiring diagnosis and a restart, consistent with normal operating procedures. The results of these runs are included in the test report, but not included in the emission result average.

2.3 PRESENTATION OF RESULTS

A single sampling train was utilized during each run at the AICS Exhaust Pipe to determine the emissions of NO_x (as NO_2) and CO. This sampling train measured the duct gas concentration of O_2, NO_x, and CO.

Table 2.2 displays the emissions of NO_x (as NO_2) and CO measured at the AICS Exhaust Pipe during two different process conditions.

The graphs that present the raw, uncorrected concentration data measured in the field by the US EPA Method 3A, 7E, and 10 sampling systems at the AICS Exhaust Pipe are located in the Field Data section of the Appendix.

TABLE 2.1.1
SAMPLING MATRIX OF TEST METHODS UTILIZED - DEVELOPMENTAL TESTING

Date	Run No.	Sampling Location	US EPA METHOD 3A (O_2/CO_2) Sampling Time / Duration (min)	US EPA METHOD 7E (NO_x) Sampling Time / Duration (min)	US EPA METHOD 10 (CO) Sampling Time / Duration (min)
5/7/2019	*1	AICS Exhaust Pipe	9:15 - 9:28 / 13	9:15 - 9:28 / 13	9:15 - 9:28 / 13
5/7/2019	2	AICS Exhaust Pipe	9:33 - 10:33 / 60	9:33 - 10:33 / 60	9:33 - 10:33 / 60
5/7/2019	3	AICS Exhaust Pipe	10:55 - 11:55 / 60	10:55 - 11:55 / 60	10:55 - 11:55 / 60
5/7/2019	4	AICS Exhaust Pipe	12:12 - 13:12 / 60	12:12 - 13:12 / 60	12:12 - 13:12 / 60

* Aborted Run
All times are Eastern Daylight Time.

TABLE 2.1.2
SAMPLING MATRIX OF TEST METHODS UTILIZED - DURABILITY TESTING

Date	Run No.	Sampling Location	US EPA METHOD 3A (O_2/CO_2) Sampling Time / Duration (min)	US EPA METHOD 7E (NO_x) Sampling Time / Duration (min)	US EPA METHOD 10 (CO) Sampling Time / Duration (min)
5/7/2019	1	AICS Exhaust Pipe	13:37 - 14:37 / 60	13:37 - 14:37 / 60	13:37 - 14:37 / 60
5/7/2019	*2	AICS Exhaust Pipe	15:06 - 15:27 / 21	15:06 - 15:27 / 21	15:06 - 15:27 / 21
5/7/2019	3	AICS Exhaust Pipe	16:02 - 17:02 / 60	16:02 - 17:02 / 60	16:02 - 17:02 / 60
5/7/2019	4	AICS Exhaust Pipe	17:12 - 18:12 / 60	17:12 - 18:12 / 60	17:12 - 18:12 / 60

* Aborted Run
All times are Eastern Daylight Time.

TABLE 2.2
EMISSION RESULTS

Parameter	AICS Exhaust Pipe-DEVELOPMENTAL					AICS Exhaust Pipe-DURABILITY				
	Run 1*	Run 2	Run 3	Run 4	Average	Run 1	Run 2*	Run 3	Run 4	Average
Fuel Flow (lb/hr)†	14.05	19.46	20.06	21.37	20.29	138.12	157.18	130.93	128.24	132.43
Nitrogen Oxides Emissions (ton/year) (as NO_2)‡	3.9	3.2	2.8	2.8	2.9	1.2	0.9	1.9	2.5	1.9
Nitrogen Oxides Emissions (lb/lb of fuel) (as NO_2)	0.014	0.011	0.010	0.010	0.010	0.0042	0.0033	0.0066	0.0088	0.0065
Nitrogen Oxides Emissions (lb/hr) (as NO_2)§	0.19	0.22	0.20	0.21	0.21	0.58	0.52	0.86	1.13	0.86
Nitrogen Oxides Concentration (ppmvd)	577.9	462.2	402.5	398.6	421.1	196.4	154.0	300.4	404.6	300.5
Carbon Monoxide Emissions (ton/year)‡	84.8	88.6	91.9	92.7	91.0	75.3	240.9	37.3	19.5	44.0
Carbon Monoxide Emissions (lb/lb of fuel)	0.30	0.31	0.32	0.33	0.32	0.27	0.85	0.13	0.069	0.16
Carbon Monoxide Emissions (lb/hr)§	4.20	6.07	6.49	6.98	6.52	36.7	133.4	17.2	8.8	20.9
Carbon Monoxide Concentration (ppmvd)	20,460	21,078	21,530	21,814	21,474	20,244	64,482	9,885	5,183	11,771
Percent by Volume Oxygen in Stack Gas (%-dry)	2.38	2.62	2.90	2.83	2.79	0.27	0.34	0.55	0.50	0.44

* Developmental Testing Run 1 and Durability Testing Run 2 were aborted and are not included in the average.
† Process data was provided by Federal Mogul personnel.
‡ Based on the 2018 fuel flow of 567,368 lbs gasoline per year.
§ Emissions were calculated utilizing the gasolilne sample's Gross Heating Value (19,741 BTU/lb) in the US EPA Method 19 lb/hr calculation.

3.0 PLANT AND SAMPLING LOCATION DESCRIPTIONS

3.1 PROCESS DESCRIPTION AND OPERATION

Federal-Mogul Corporation tests engines and engine components in dynamometer cells and is permitted to operate sixteen (16) engine test cells. Fifteen (15) of the test cells can be used to conduct testing on gasoline or diesel engines. One cell is used to test small engines. The engines are connected to a dynamometer that simulates a vehicle load on the engine. The tests include durability, deep thermal shock, and developmental cycles. Each is designed to test specific components, or overall performance, of an engine. When gasoline is used as a fuel and during durability and deep thermal shock testing, it is required that an Air Injection Control System (AICS) be utilized to control emissions. No controls are required for diesel fuel testing, small engines, or during developmental testing. A single FG-ALLCELLS engine test cell (Test Cell 12) was in operation during testing, running a 6.2-L gasoline engine in developmental and durability-cycle B testing.

Figure 3.1 depicts sampling location schematic.

3.2 CONTROL EQUIPMENT DESCRIPTION

During Durability Testing, emissions from Test Cell 12 were controlled by an AICS. During Developmental Testing Cycle B, emissions from the Test Cell 12 were uncontrolled. The AICS was installed in 2004 to control CO and volatile organic compound (VOC) emissions from the test cells. The AICS works by injecting a measured stream of air, hotter than the auto-ignition point of CO, into the exhaust gas which causes the CO to oxidize in the exhaust pipe.

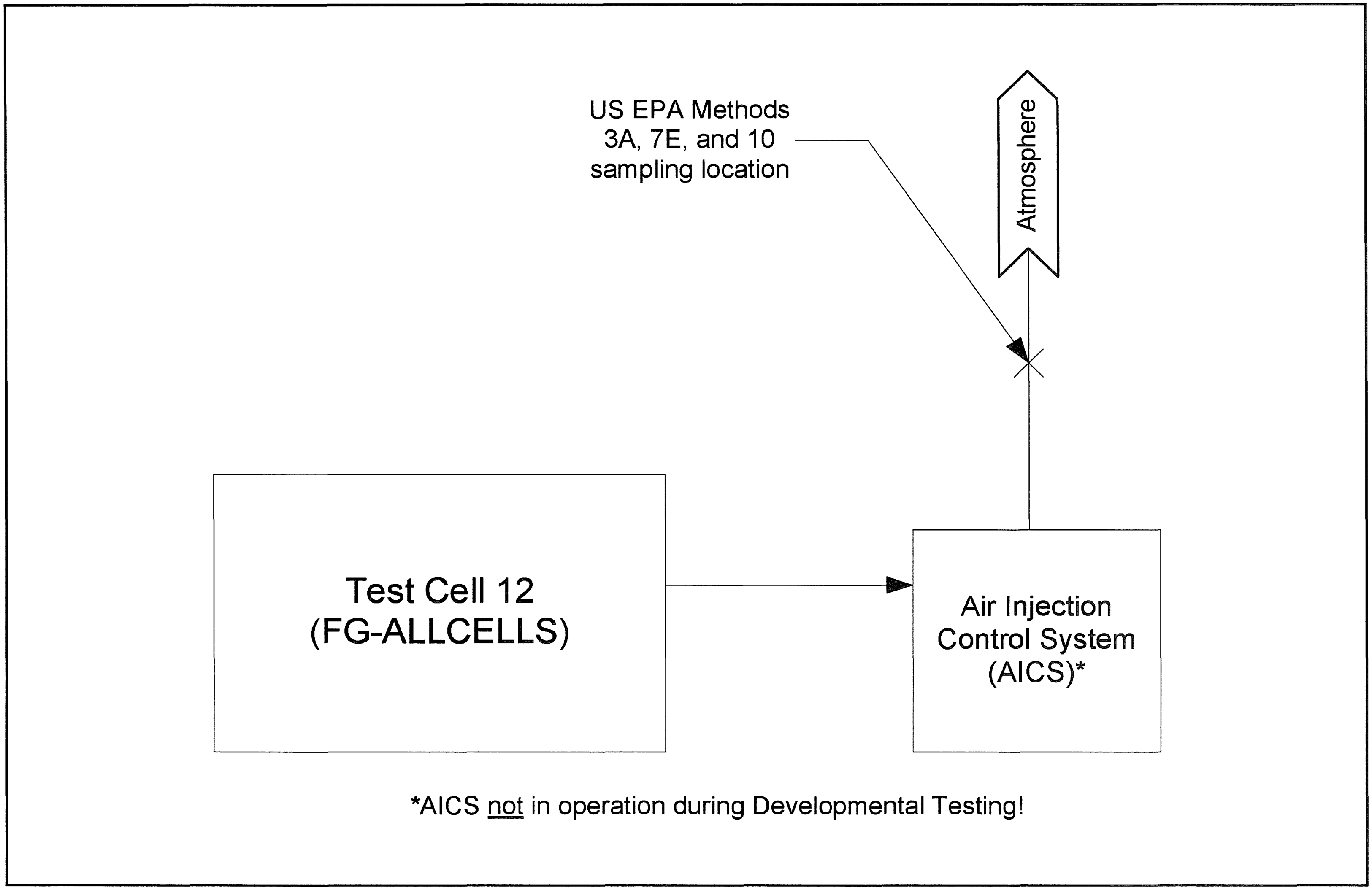
3.3 SAMPLING LOCATION(S)

The AICS Exhaust Pipe had a measured inner diameter 6.0-inches and was oriented in the vertical plane. During emissions sampling, a single point was utilized to determine O_2, NO_x, and CO concentration determinations.

3.4 PROCESS SAMPLING LOCATION(S)

A process sample (gasoline) was taken during the test event by Federal-Mogul Powertrain, LLC personnel. The gasoline sample was subsequently analyzed for proximate and ultimate fuel analysis.

FIGURE 3.1
FG-ALLCELLS SAMPLING LOCATION SCHEMATIC



4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 TEST METHODS

4.1.1 US EPA Method 3A: "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)"

Principle: A gas sample is continuously extracted from the effluent stream. A portion of the sample stream is conveyed to an instrumental analyzer(s) for determination of O_2 and CO_2 concentration(s). Performance specifications and test procedures are provided to ensure reliable data. This method was utilized in its entirety as per the procedures outlined in 40 CFR Part 60, Appendix A.

4.1.2 US EPA Method 7E: "Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)"

Principle: A gas sample is continuously extracted from the effluent stream. A portion of the sample stream is conveyed to an instrumental analyzer for the determination of NO_x concentration. NO and NO_2 may be measured separately or simultaneously. For the purposes of this method, NO_x is the sum of NO and NO_2. Performance specifications and test procedures are provided to ensure reliable data. This method was utilized in its entirety as per the procedures outlined in 40 CFR Part 60, Appendix A.

4.1.3 US EPA Method 10: "Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)"

Principle: A gas sample is continuously extracted from the effluent stream. A portion of the sample stream is conveyed to an instrumental analyzer for determination of CO concentration. Performance specifications and test procedures are provided to ensure reliable data. This method was utilized in its entirety as per the procedures outlined in 40 CFR Part 60, Appendix A.

4.1.4 US EPA Method 19: "Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxides Emission Rates"

Principle: Oxygen (O_2) or carbon dioxide (CO_2) concentrations and appropriate F-factors (ratios of combustion gas volumes to heat inputs) are used to calculate pollutant emission rates from pollutant concentrations. For this test, the appropriate F-Factor was calculated based on the fuel heating value obtained from the analysis of a gasoline sample.

The sampling train utilized during this testing project is depicted in Figure 4.1.

4.2 PROCEDURES FOR OBTAINING PROCESS DATA

Process data was recorded by Federal-Mogul Powertrain, LLC personnel utilizing their typical record keeping procedures. Recorded process data was provided to Montrose personnel at the conclusion of this test event. The process data is located in Table 2.2 and in the Appendix.

5.0 INTERNAL QA/QC ACTIVITIES

5.1 QA AUDITS

Tables 5.1 to 5.5 illustrate the QA audits that were performed during this test.

Tables 5.1.1 to 5.3.2 illustrate the O_2, NO_x, and CO calibration audits which were performed during this test (and integral to performing US EPA Method 3A, 7E, and 10 correctly) were all within the Measurement System Performance Specifications of ±3% of span for the Zero and Calibration Drift Checks, ±5% of span for the System Calibration Bias Checks, and ±2% of span for the Calibration Error Checks.

Table 5.4 displays the NO_2 to NO Converter Efficiency Check. The Converter Efficiency Check was conducted as per the procedures contained in US EPA Method 7E, Section 8.2.4.2 and 16.2.2 (Tedlar Bag Procedure) which requires a mid-level gas be recorded for at least 30-minutes and the final NO_x value to be within 2% of the peak NO_x value. As shown, a post-test difference of 1.56% was achieved. Therefore, the NO_x Converter Efficiency was acceptable.

Table 5.5 displays the US EPA Method 205 field evaluation of the calibration gas dilution system utilized during this test event. As shown, the average concentration output at each dilution level was within ±2% of the predicted value. The average concentration output of the mid-level gas was also within ±2% of the certified concentration.

5.2 QA/QC PROBLEMS

No QA/QC problems occurred during this test event.

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 Qualified Individual (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 presented in the report appendices.