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BTEC Inc.

NOx
Emissions Test Summary Report

Prepared for:

General Motors

Pontiac Powertrain
823 Joslyn Ave.
Pontiac, Michigan 48340

Project No. 16-4867.00
September 19, 2016

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073
(248) 548-8070

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EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by General Motors (GM) to conduct a compliance emissions test program on the exhaust of a single racing dynamometer at the GM facility in Pontiac, Michigan. The testing program evaluated oxides of nitrogen (NOx) and oxygen (O_2) from high performance engines. The emissions test program was conducted on July 26, 2016.

Testing of the dynamometer consisted of triplicate 60-minute test runs. The emissions test program was required by MDEQ Air Quality Division Renewable Operating Permit (ROP) No. MI-ROP-B4032-2014b. The results of the emission test program are summarized by Table I.

Table I
Overall Emission Summary
Test Date: July 26, 2016

Pollutant	Average Emission Rate
NOx	3.18 lb/hr
	1.15 lb/mmbtu
	0.13 lb/gal

BTEC Inc.

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BTEC Inc.

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by General Motors (GM) to conduct a compliance emissions test program on the exhaust of a single racing dynamometer at the GM facility in Pontiac, Michigan. The testing program evaluated oxides of nitrogen (NOx) and oxygen (O_2) from high performance engines. The emissions test program was conducted on July 26, 2016. The purpose of this report is to document the results of the test program.

AQD has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (December 2013). The following is a summary of the emissions test program and results in the format suggested by the aforementioned document.

1.a Identification, Location, and Dates of Test

Sampling and analysis for the emission test program was conducted on July 26, 2016 at the GM facility located in Pontiac, Michigan. The test program included evaluation of NOx and O_2 emissions from a single racing dynamometer.

1.b Purpose of Testing

AQD issued Renewable Operating Permit No. MI-ROP-B4032-2014b to GM. The permits limit emissions from the oxidizers as summarized by Table 1.

Table 1
NOx Emission Limitations
General Motors

Pollutant	Emission Limit
NOx	73.9 lb/hr[1]
	1.38 lb/mmbtu[2]

1: Combined for all dynamometers in FG-RACINGTCS
2: for spark-ignited fuels

1.c Source Description

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 mandated by the United States Environmental Protection Agency (U.S. EPA). Depending on the engine type, the engines can be fueled by unleaded gasoline, leaded gasoline, and other fuels running a variety of tests on engines and engine components. A variety of test cycles are used depending on the purpose of the test program and the type of the engine. The engines are tested with or without control equipment, such as catalytic converters and particulate traps.

1.d Test Program Contacts

The contact for the source and test report is:

Ms. Lisa M. Parks
Staff Environmental Engineer
General Motors LLC
GECS
30400 Mound Road, B Mfg. B
Mail Code: 480-109- MB1
Warren, Michigan 48092
(248) 410-2591

Names and affiliations for personnel who were present during the testing program are summarized by Table 2.

Table 2
Test Personnel

Name and Title	Affiliation	Telephone
Mr. Barry P. Boulianne Senior Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Todd Wessel Senior Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070
Mr. Mason Sakshaug Environmental Technician	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070

2. Summary of Results

Sections 2.a through 2.d summarize the results of the emissions compliance test program.

2.a Operating Data

The racing test dynamometers consist of three engine test cells which are used for the testing of internal combustion high performance engines for automotive motor vehicles. The engine sizes vary and the engines tested are currently only fueled by unleaded gasoline, unleaded gasoline blends, leaded gasoline, ethanol, with the potential to run on methanol fuel bends as well.

2.b Applicable Permit

Renewable Operating Permit No. MI-ROP-B4032-2014b.

2.c Results

NOx emissions from the race engine was 3.18 lb/hr, 1.15 lb/mmbtu, and 0.13 lb/gal.

3. Source Description

Sections 3.a through 3.e provide a detailed description of the process.

3.a Process Description

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 mandated by the United States Environmental Protection Agency (U.S. EPA). Depending on the engine type, the engines can be fueled by unleaded gasoline, leaded gasoline, and other fuels running a variety of tests on engines and engine components. A variety of test cycles are used depending on the purpose of the test program and the type of the engine. The engines are tested with or without control equipment, such as catalytic converters and particulate traps.

3.b Process Flow Diagram

Due to the simplicity of the internal combustion engine, a process flow diagram is not necessary.

3.c Raw and Finished Materials

The facility is designed to supply unleaded gasoline, leaded gasoline, ethanol, natural gas, methanol, propane, liquefied petroleum gas, and hydrogen for engine testing. The engine fuel used during the emissions test program was commercial E-20 gasoline only. The racing dynamometers are not set up to run diesel engines at this time. No catalytic converters or particulate traps were used during the emissions test program.

3.d Process Capacity

The total combined spark-ignited fuel usage for FG-RACINGTCS is limited to 3,616 MMBTU per 12-month rolling time period and of the 3,616 MMBTU, the permittee is limited to 767 MMBTU of leaded gasoline per 12-month rolling time period.

The total combined diesel fuel usage for FG-RACINGTCS is limited to 767 MMBTU per 12-month rolling time period, however, the racing test cells are currently not configured to be able to run diesel engines and therefore diesel engines will not be included in this test cycle.

3.e Process Instrumentation

GM collected fuel flow, fuel specifications, air fuel ratio, exhaust temperatures, specific gravity of the fuel, RPM, fuel type, and cell atmospheric pressure.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used.

4.a Sampling Train and Field Procedures

The emissions test program utilized the following test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A):

- Method 3A - "Determination of Oxygen and Carbon Dioxide Concentrations in emissions from stationary sources" (Instrumental Analyzer Procedure)
- Method 7E - "Determination of Nitrogen Oxide Emissions from Stationary Sources"
- Method 19 - "Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates"

The Molecular Weight of the gas stream was evaluated according to procedures outlined in Title 40, Part 60, Appendix A, Method 3A.

40 CFR 60, Appendix A, Method 3A, *"Determination of Oxygen and Carbon Dioxide Concentrations in emissions from stationary sources (Instrumental Analyzer Procedure)"* and Method 7E, *"Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)"* will be used to measure O_2 and NO_x concentrations and calculate emission rates (see Figure 1 for a schematic of the sampling train).

The gas stream was drawn through a stainless-steel probe with a heated in-line filter to remove any particulate, a heated Teflon® sample line, through a refrigerated sample conditioner with a peristaltic pump to remove the moisture from the sample before it enters the analyzers. Data will be recorded on a PC equipped with Labview® II data acquisition software. Recorded O_2 and NO_x concentrations were averaged and reported for the duration of each test (as drift corrected per Method 7E).

In accordance with Method 7E, a 3-point (zero, mid, and high) calibration check was performed on each analyzer. Calibration drift checks were performed at the completion of each run.

For analyzer calibrations, calibration gases were mixed to desired concentrations using an Environics Series 4040 Computerized Gas Dilution System. The Series 4040 consists of a single chassis with four mass flow controllers. 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. A field quality assurance check of the system will be performed pursuant to Method 205 by setting the diluted concentration to a value identical to a Protocol 1 calibration gas and then verifying that the analyzer response is the same with the diluted gas as with the Protocol 1 gas.

The accuracy of the gas dilution system was verified using the procedures detailed by Method 205 and the NOx converter efficiency was verified as specified by Method 7E.

4.b Recovery and Analytical Procedures

A fuel sample was sent to Paragon Laboratories for sampling.

4.c Sampling Ports

N/A

4.d Traverse Points

N/A

5. Test Results and Discussion

Sections 5.a through 5.k provide a summary of the test results.

5.a Results Tabulation

The overall results of the emissions test program are summarized by Table 3. Detailed results for the emissions test program are summarized by Table 4.

Table 3
Overall Emission Summary
Test Date: July 26, 2016

Pollutant	Average Emission Rate
NOx	3.18 lb/hr
	1.15 lb/mmbtu
	0.13 lb/gal

5.b Discussion of Results

NOx emissions from the race engine was 3.18 lb/hr, 1.15 lb/mmbtu, and 0.13 lb/gal. The NOx emission rate of 1.15 lb/mmbtu is below the permit limit of 1.38 lb/mmbtu.

5.c Sampling Procedure Variations

There were no sampling variations used during the emission compliance test program.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

There was no control equipment maintenance performed during the emissions test program.

5.f Re-Test

The emissions test program was not a re-test.

5.g Audit Sample Analyses

No audit samples were collected as part of the test program.

5.h Calibration Sheets

Relevant equipment calibration documents are provided in Appendix B.

5.i Sample Calculations

Sample calculations are provided in Appendix C.

5.j Field Data Sheets

Field documents relevant to the emissions test program are presented in Appendix A.

5.k Laboratory Data

Laboratory data can be found in Appendix D. Raw CEM data is provided electronically in Appendix E.

Table 4
General Motors
Pontiac, Michigan
Racing Dynomometer NOx Emission Rates
July 25, 2016

									Run 1	Run 2	Run 3	Average
equation 19-13		Racing Fuel	Fuel F-Factor (dscf/MMBtu):	9075		Average Fuel Flow	g/s		18.69	18.65	18.67	
			Fuel Heating Value (Btu/lb):	18592								
Fd =	9,075	scf/(10^6 Btu)				NOx	ppm		780.96	773.26	894.47	
						O2	%		4.9	4.85	4.84	
K	1000000	10^6										
Khd	3.64	(scf/lb)/%					NOx emission rate	lb/hr	3.05	3.00	3.47	3.18
Kc	1.53	(scf/lb)/%			Average		NOx emission rate	lb/mmbtu	1.11	1.09	1.26	1.15
Ks	0.57	(scf/lb)/%					NOx emission rate	lb/gallon	0.12	0.12	0.14	0.13
Kn	0.14	(scf/lb)/%										
Ko	0.46	(scf/lb)/%										
%H	14.16											
%C	78.73											
%S	0.00007											
%N	0											
%O	7.11											
GCV	18592	btu/lb										