EPA/AA/CTAB/87-07

Technical Report

Evaluation of M85-Fueled 1987 Turbo Buick Regals

by

David M. Blair

December 1987

NOTICE

Technical Reports do not necessarily represent final EPA decisions or positions. They are intended to present technical analysis of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position or regulatory action.

U. S. Environmental Protection Agency
Office of Air and Radiation
Office of Mobile Sources
Emission Control Technology Division
Control Technology and Applications Branch
2565 Plymouth Road
Ann Arbor, Michigan 48105

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR AND RADIATION

December 7, 1987

MEMORANDUM

SUBJECT: Exemption From Peer and Administrative Review

FROM: Karl H. Hellman, Chief
Control Technology and Applications Branch

TO: Charles L. Gray, Jr., Director
Emission Control Technology Division

The attached report entitled "Evaluation of M85-Fueled 1987 Turbo Buick Regals," (EPA/AA/CTAB/87-07) describes emissions testing conducted at the motor vehicle emission laboratory on two turbocharged Buick Regals which were converted to use M-85 fuel.

Since this report is concerned only with the presentation of data and its analysis and does not involve matters of policy or regulations, your concurrence is requested to waive administrative review according to the policy outlined in your directive of April 22, 1982.

Approved: _____ Date: 3-10-88
Charles L. Gray, Jr., Dir., ECTD

Attachment

Introduction

Section 211 of the Clean Air Act[1] requires that the United States Environmental Protection Agency (EPA) play a key role in the introduction of new motor vehicle fuels. The Emission Control Technology Division (ECTD), of the Office of Mobile Sources, EPA, assesses technology that could be used to reduce mobile source emissions, including evaluation of alternate-fueled vehicles.

Two 1987 turbocharged Buick Regals were emission tested at the U.S. EPA Motor Vehicle Emissions Laboratory located in Ann Arbor, MI. These vehicles which were converted to use methanol (M85) fuel have the potential to create a consumer interest in methanol-fueled or flexible-fueled vehicles due to the increased performance possible when using methanol fuel in a turbocharged engine.

Project Summary

Oak Ridge National Laboratory (ORNL), which is operated for the Department of Energy (DOE) by Martin Marietta Energy Systems, Inc., leased ten 1987 turbocharged Buick Regals for fleet use. Five of these vehicles were modified for use with M85 fuel (85 percent methanol/15 percent gasoline) by Michigan Automotive Research Corporation (MARCO) at their Ann Arbor facilities. Arrangements were made with ORNL and MARCO to supply EPA with two of the converted vehicles for emission testing prior to delivery to the ORNL fleet.

An informal cooperative effort between EPA and ORNL has been established to generate emission and performance data on these vehicles. The EPA will perform emission and fuel economy testing on these two vehicles and ORNL will supply basic performance and driver response data after the vehicles have been driven a few thousand miles.

The two Buick Regals arrived at the Ann Arbor Motor Vehicle Emissions Laboratory on November 10, 1987 and were subsequently tested on November 12, 13, and 17, 1987. The vehicles were returned to MARCO on November 23, 1987. MARCO transferred all five of the methanol-converted Regals to ORNL on December 7, 1987. The vehicles began accumulating mileage in the Oak Ridge National Laboratory fleet shortly after this date. ORNL will keep records of vehicle maintenance and driver response. EPA is particularly interested in driver performance ratings of the methanol-fueled versus gasoline-fueled vehicles.

Contact will be maintained with ORNL to obtain the performance data. Phase II emission testing of the M-85 vehicles is a possibility after the vehicles have accumulated mileage. This testing would be conducted to evaluate emission control degradation with mileage accumulation.

Testing Summary

The stock gasoline-fueled Regals were emissions certified at an equivalent test weight (ETW) of 3,625 pounds. The methanol-fueled (M85) Regals were also tested at this weight, even though the larger 30-gallon fuel tank and additional fuel in the methanol vehicles could have moved the ETW up to 3,750 pounds. This was done to allow direct comparison of gasoline-vehicle emissions to methanol-vehicle emissions.

The vehicles were LA-4 prepped then driven over the Federal Test Procedure (FTP) and Highway Fuel Economy Test (HFET) cycles at standard test conditions. Emissions of all regulated pollutants, along with formaldehyde, were sampled and measured. The two vehicles were each tested over three FTP/HFET cycles and the average values are reported. One evaporative loss test was conducted to determine the effect of the larger 30-gallon tank and the use of M85 fuel on evaporative emissions. The tailpipe emission values were fairly large; both vehicles would fail the 1.0 gram per mile new vehicle NOx standard and one vehicle would fail the 3.4 gram per mile new vehicle CO standard.

Turbocharger boost pressure was observed to be negligible over all portions of the FTP and HFET driving cycles. Dynamometer drivers reported both vehicles as responding identically during the test sequences, although one vehicle (#565) did have a false start at the beginning of the third FTP cycle.

Discussion

Vehicle description data is given in Table 1. It is interesting to note that the engine and drivetrain in the methanol-fueled Regals are relatively stock. The changes made by MARCO to the stock vehicles to increase vehicle performance and operating range included: modified fuel delivery system with larger Bosch injectors, slight cylinder head cleanup and installation of hardened valve seats, increased fuel tank capacity to 30 gallons, slightly increased maximum turbo boost pressure, and modified onboard computer software including a special PROM chip.[2]

Data concerning the evaporative loss test indicates that the underhood temperature of the Regal is relatively hot, probably due to underhood turbo and exhaust plumbing. As seen in the Table 3 data, the stock evaporative emission system can effectively handle the hydrocarbon vapors emitted from the 12 gallons of M85 fuel. Although the total loss was .30 grams greater with the M85-fueled Regal compared to the stock gasoline-fueled Regal, the total loss was less than the 2.0 gram/test new vehicle certification standards.

Table 1

Vehicle Description

1987 Turbocharged Buick Regals
Modified to Use M85 Fuel by MARCO*

Vehicle Identification Numbers (VIN):

G4GJ1172HP448039: referred to as #039

G4GJ1171HP448565: referred to as #565

Engine:

Type	4-stroke Otto cycle, 60 degree V-6
Bore x stroke	3.76 x 3.40 inches
Displacement	231 cubic inches
Compression ratio	8.0:1
Fuel metering	Bosch sequential port-fuel injection
Turbocharger	Garrett AiResearch
Horsepower	Estimated at 300**

Drivetrain:

Transmission	Four-speed automatic with lock-up converter
Axle Ratio	3.42

Chassis:

Type	Two-door Sedan
Tires	Goodyear Eagle GT P215/65R15
Curb weight	3,433 lbs (before modification)
Test weight (ETW)	3,625 lbs
Actual dynamometer horsepower	9.6

Table 1 (cont'd)

Vehicle Description

1987 Turbocharged Buick Regals
Modified to Use M85 Fuel by MARCO*

Other:

Fuel tank	20-gallon, stainless steel construction***
Exhaust	Dual-side exhaust, one three-way catalytic converter
Feedback	Closed loop A/F ratio control
Odometer reading when returned to MARCO	#039: 780 miles (approx.) #565: 445 miles (approx.)

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* Michigan Automotive Research Corporation, 1254 N. Main, Ann Arbor, MI, 48197, Phone (313) 995-2544

** Stock vehicle was rated at 235 hp.

*** Stock vehicle uses an 18.1-gallon tank.

Exhaust emission values and fuel economy values for stock 1987 turbocharged Buick Regals are presented in Table 2. A fuel mileage comparison between the methanol-fueled Regals and the stock gasoline-fueled vehicles, presented in Table 4, show that while the methanol vehicles' miles per gallon (MPG) and energy equivalent MPG are both lower than the gasoline-fueled vehicle MPG, the range of both vehicles is comparable due to the methanol-fueled vehicles larger 30-gallon fuel tank.

Exhaust emission results obtained over the FTP and HFET are presented using the proposed methanol vehicle procedures in Tables 5-7. The calculations for the data presented in these tables were based on the new proposed test procedures for methanol-fueled vehicles.[3] These calculation procedures differ considerably from the gasoline calculations and are discussed briefly in Appendix B.[4] Tables 8-10 present the emissions results using the current gasoline-fueled vehicle procedures for reference purposes.

Exhaust emissions over the FTP sequences remained fairly constant for each vehicle, except for CO emission from vehicle #565 which was 3.72 g/mile for test 1 and rose steadily to 6.00 g/mile for test 3. These individual test results can be found in Appendix A. This rising CO emission problem of vehicle #565, coupled with the fact that this vehicle produced consistently high emissions levels compared to vehicle #039, could indicate that vehicle #565 is experiencing a problem that is not present with vehicle #039. The CO problem of vehicle #565 seems to be limited to Bags 2 and 3. The Bag 2 CO output of vehicle #565 is 4.2 times greater than vehicle #039, Bag 3 CO is 2.2 times greater while bag 1 CO is only 1.1 times greater. Thus CO formation of vehicle #565 is only a problem at the higher operating temperatures encountered during Bags 2 and 3. The high emissions could also be caused by a fuel enrichment modification programmed into the software to compensate for a hesitation when moderately accelerating. MARCO thoroughly checked vehicle #565's computer system before the car was returned to the ORNL, but no problems were found. It must be realized, however, that vehicle #565 had less than 445 miles on the odometer when tested, compared to 780 miles on vehicle #039.

Both vehicles exhibited higher than expected NOx values for methanol, which are spread throughout the entire FTP. MARCO revised the exhaust gas recirculation (EGR) function and reduced total EGR in the vehicle calibrations. This would be expected to have the effect of increasing NOx output.

Table 8 and Table 10 present data that indicates the methanol-fueled Regals produce less hydrocarbon (HC) emissions than the comparable gasoline-fueled vehicles. The formaldehyde emission values of 32.54 milligrams per mile for vehicle #039 and 33.59 milligrams per mile for vehicle #565 over the FTP, as presented in Table 8, are comparable to the formaldehyde outputs of other methanol-fueled vehicles. For a gasoline-fueled vehicle, formaldehyde levels would be in the 5-10 milligram per mile range.

Table 2

Certification Data

Gasoline-Fueled 1987
Turbocharged Buick Regals 231 Cubic Inches V-6

FTP Emissions:

	HC (g/mi)	CO (g/mi)	NOx (g/mi)	City/HWY MPG*
50K miles**	.30	3.2	.39	--
4K miles***	.312	2.47	.48	19.3/31.6
0K miles****	.183	2.09	.18	15.9/--
4K miles (HWY)***	.026	.51	.13	--/31.6

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* Gas Mileage Guide, fuel economy = 17.0/25.0

** Certification data.

*** Data gathered from 1987 EPA Test Car List, vehicle ID B55107-FEC.

**** Data from EPA audit from December 8 through December 13, 1986.

Table 3

Evaporative Emission Data
1987 Turbocharged Buick Regals

Evaporative Family: 7B0-ZE
Evaporative Code: 401

M85-fueled vehicle
I.D.#565
(30-gallon tank)
1.21 gram/test total loss
0.62 gram diurnal
0.59 gram heat soak

Gasoline-fueled vehicle
certification data
(18.1-gallon tank)
.91* gram/test total loss

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* 4K miles certification value: test #854872.

Table 4

Fuel Mileage

1987 Turbocharged Buick Regals

	M85 (City/HWY) Methanol (MPG)	EMPG*	Range (mi)
#039	10.2/15.9	17.7/27.8	306/477
#565	10.2/16.0	17.8/27.9	306/480

	Gasoline-Fueled Vehicle (City/HWY)	
	Gasoline MPG	Range (mi)
0K	15.9/--	288/--
4K	19.3/31.6	349/572
Gas Mileage Guide	17.0/25.0	308/452

* EMPG is the energy equivalent gasoline fuel economy.

Table 5

FTP Emission Results*

1987 Turbocharged Buick Regal M85-Fueled Vehicle

ID	Fuel	HC (g/mi)	HCHO (g/mi)	CO (g/mi)	NOx (g/mi)	OMHCE (g/mi)	CH3OH (g/mi)
#039	M85	.040	.03460	2.809	1.116	.215	.368
#565	M85	.048	.03338	4.951	1.181	.256	.444
CERT**	Gasoline	.18-.31	--	2.1-3.2	.18-.48	--	--

* Calculated using proposed methanol procedure.

** Certification data on the gasoline-fueled turbocharged Regal using gasoline-vehicle procedures is shown for comparison (see Table 2).

Table 6

Bag-By-Bag Emission Results*

1987 Turbocharged Buick Regal M85-Fueled Vehicle

Vehicle #039:

	Bag 1	Bag 2	Bag 3
HC(g)	.498	.051	.053
HCHO (mg)	386.95	61.73	49.81
CO (g)	33.985	3.394	4.954
NOx (g)	4.797	3.840	4.167
OMHCE (g)	2.668	.285	.287
CH_3OH (g)	4.597	.473	.487

Vehicle #565:

	Bag 1	Bag 2	Bag 3
HC(g)	.563	.081	.060
HCHO (mg)	323.93	68.05	72.05
CO (g)	38.419	14.126	10.868
NOx (g)	5.117	3.990	4.557
OMHCE (g)	2.962	.438	.335
CH_3OH (g)	5.197	.751	.557

* Calculated using proposed methanol procedures.

Table 7

Highway Emission Data*

1987 Turbocharged Buick Regal M85-Fueled Vehicle

Vehicle	HC (g/mi)	HCHO (g/mi)	CO (g/mi)	NOx (g/mi)	OMHCE (g/mi)	CH_3OH (g/mi)
#039	.004	.00868	.154	1.110	.024	.037
#565	.005	.01618	.492	1.410	.031	.044
CERT**	.026	--	.51	.13	--	--

* Calculated using proposed methanol procedures.

** Certification data on a gasoline-fueled turbocharged Regal using gasoline-vehicle procedures, shown for comparison (see Table 2).

Table 8

FTP Emission Results*

1987 Turbocharged Buick Regals

ID	Fuel	HC (g/mi)	CO (g/mi)	NOx (g/mi)	HCHO (mg/mi)
#039	M85	.159	2.81	1.12	32.54
#565	M85	.192	4.95	1.18	33.59
CERT**	Gasoline	.18-.31	2.1-3.2	.18-.48	--

* Calculated using current gasoline procedures.

** Certification data on the gasoline-fueled turbocharged Regal shown for comparison (see Table 2).

Table 9

Bag-By-Bag Emission Results*

1987 Turbocharged Buick Regal M85-Fueled Vehicle

Vehicle #039:

	Bag 1	Bag 2	Bag 3
HC(g)	1.99	.20	.21
CO (g)	33.99	3.39	4.95
NOx (g)	4.80	3.84	4.17
HCHO (mg)	387.05	45.98	50.23

Vehicle #565:

	Bag 1	Bag 2	Bag 3
HC(g)	2.25	.33	.24
CO (g)	38.42	14.13	10.87
NOx (g)	5.12	3.99	4.56
HCHO (mg)	324.20	68.93	72.46

* Calculated using current gasoline procedures.

Table 10

Highway Emission Data*

1987 Turbocharged Buick Regal

Vehicle	HC (g/mi)	CO (g/mi)	NOx (g/mi)	HCHO (mg/mi)
#039	.016	.15	1.11	8.74
#565	.019	.49	1.41	16.23
Cert**	.026	.51	.13	--

* Calculated using current gasoline procedures.

** Certification data on a gasoline-fueled turbocharged Regal shown for comparison (see Table 2).

The highway formaldehyde data, presented in Table 10, again indicates a problem with vehicle #565's ability to reduce regulated emission outputs at higher operating temperatures. Vehicle #565's highway formaldehyde emission was 16.23 milligrams per mile, compared to vehicle #039's output of 8.74 milligrams per mile.

Street performance of the vehicles can only be rated as excellent. Although cold starting was difficult after the vehicles had been stored outdoors for four days at approximately 45°F, indoor (68°F) starting was generally not a problem, except for the one false start by vehicle #565. The vehicles handle well, although a person not accustomed to driving a high-performance vehicle may have problems controlling wheelspin and maneuvering corners under acceleration. The vehicles were not equipped with antispin rearaxles (positraction), the deletion of which can lead to excessive off-line wheelspin and cornering wheelhop. Drivers should be informed of the increased performance nature of these vehicles, especially if these vehicles will see everyday service in rain and snow.

References

1. The Clean Air Act as amended through July 1981, Section 211(C)(1).

2. "Conversion of 1984 Buick Turbo Regal to Use Methanol (M85) As a Motor Fuel," Yee, G., Woodward, B., and Yuille, R., SAE Paper 861592, presented at the International Fuels and Lubricants Meeting and Exposition, Philadelphia, PA, October 6-9, 1986.

3. "Proposed Emission Standards and Test Procedures for Methanol-Fueled Vehicles, Draft Regulation" U.S. EPA, Summer 1986.

4. "Calculation of Emissions and Fuel Economy When Using Alternate Fuels," EPA 460/3-83-009, Urban, Charles M., March 1983.

5. "Interim Report on the Evaluation of a Methanol-Fueled LTD Crown Victoria", EPA/AA/CTAB/87-03, Piotrowski, G. P., Heavenrich, R. M., Bruetsch, R. I., Cheng, J. P., March, 1987.

APPENDIX A

Individual FTP Test Results*

Date	Test Number		Exhaust Emissions HC	CO	NOx	HCHO	MPG**
Vehicle #039:							
11/12/87	880631	Bag 1 (g)	1.96	30.95	4.79	.364	
		Bag 2 (g)	0.22	2.61	3.81	.041	
		Bag 3 (g)	0.20	4.84	4.10	.069	
		Composite (g/mi)	0.16	2.51	1.10	.032	10.12
11/13/87	880633	Bag 1 (g)	2.11	37.37	4.64	.439	
		Bag 2 (g)	0.19	3.72	3.73	.048	
		Bag 3 (g)	0.20	4.68	4.13	.021	
		Composite (g/mi)	0.16	3.03	1.09	.034	10.21
11/17/87	880638	Bag 1 (g)	1.90	33.63	4.96	.358	
		Bag 2 (g)	0.21	3.85	3.98	.048	
		Bag 3 (g)	0.23	5.35	4.27	.060	
		Composite (g/mi)	0.16	2.89	1.16	.032	10.17
Vehicle #565:							
11/12/87	880634	Bag 1 (g)	1.78	34.98	5.30	.315	
		Bag 2 (g)	0.23	7.53	3.97	.058	
		Bag 3 (g)	0.20	8.93	4.45	.069	
		Composite (g/mi)	0.15	3.72	1.18	.031	10.24
11/13/87	880637	Bag 1 (g)	1.87	35.69	5.18	.327	
		Bag 2 (g)	0.35	16.10	3.77	.059	
		Bag 3 (g)	0.29	11.71	4.82	.044	
		Composite (g/mi)	0.18	5.13	1.18	.030	10.20
11/17/87	880694	Bag 1 (g)	3.10	44.59	4.87	.330	
		Bag 2 (g)	0.39	18.75	4.23	.089	
		Bag 3 (g)	0.23	11.97	4.40	.105	
		Composite (g/mi)	0.25	6.00	1.19	.039	10.17

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* Calculated using current gasoline vehicle procedures.

** Methanol miles per gallon calculated using methanol-fueled vehicle procedures.

APPENDIX B

Calculation of HC, Methanol, and HCHO

As proposed, the regulations in reference 3 require the measurement of methanol CH_3OH and formaldehyde, HCHO. Methanol emissions are especially important since the dilution factor equation includes CH_3OH emissions. At the time the test results reported here were made, the EPA lab did not measure CH_3OH. Therefore, the results shown here were computed with a FID response factor of 0.75 and an assumed HC ppm to methanol ppm factor of xx/.85, where xx is the fraction of methanol in a methanol gasoline blend. HC results were then computed using the procedures specified in the draft regulations.[report ref.5]