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Low-Altitude and Low-Temperature Exhaust Emissions Tests of Four Vehicles on Oxygenated Gasoline Blends and Gasoline Fuels

by

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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.

Test and Evaluation Branch
Emission Control Technology Division
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U.S. Environmental Protection Agency

Background

The Coordinating Research Council (CRC) addresses technical issues of mutual interest to both the automotive and petroleum industries. The group initiated CRC Project No. CM-129-87, Wintertime Exhaust Emissions, to study the effect of altitude and the use of oxygenated gasoline blends on vehicle exhaust emissions at 75°F and at low temperature . Sixteen vehicles representing three different control technologies were tested: six vehicles with closed-loop, three-way catalyst control systems and adaptive learning devices representing the most advanced emission control systems; six closed-loop, three-way catalyst vehicles; and four open-loop carbureted vehicles representing older control technology. The test temperatures were 75°F, 50°F, and 35°F.

To support this effort, EPA provided the four open-loop carbureted vehicles and conducted the low-altitude tests on these vehicles at the EPA Motor Vehicle Emission Laboratory (MVEL) in Ann Arbor, MI. CRC selected the twelve closed-loop vehicles to be close to or meet the emission standards rather than to represent typical in-use vehicle emissions. The low-altitude tests on the twelve closed-loop vehicles were conducted at the National Institute for Petroleum and Energy Research (NIPER) in Bartlesville, Oklahoma. The high-altitude testing of all sixteen vehicles was conducted at the Environmental Testing Corporation (ETC) laboratory in Denver, Colorado.

Only the EPA tests of the four open-loop carbureted vehicles are given here. This report is essentially a data report of these tests without detailed analysis of the effects. The ETC and NIPER tests are covered in CRC reports for project CM-129-87.

Discussion

Each of the four vehicles had single FTP tests at 35°F and 50°F for each of the three CRC fuels (six tests total per vehicle). At 75°F there were single FTP tests using each of the four EPA fuels. The tests were conducted in the EPA Environmental Test Facility using the large (48 inch) single roll electric chassis dynamometer. The EPA lab altitude is 894.6 Ft. A summary of the exceptions to the standard FTP is given below:

FTP tests only, no evaporative emissions tests or heat builds.

EPA did not have the capability to store fuel at fuel temperatures lower than 60°F. Also, vehicle preps and soaks were limited to a lower temperature

of 50°F. Therefore, EPA decided to chill the CRC fuels to only 50°F in the fuel dispensing cart. Thus, when transferring fuel to the refrigerated fuel dispensing cart, some light ends may have been lost and the fuel may not have been totally representative of a similar fuel which was handled at 30-35°F.

CRC conditioning cycle was used after changing fuel type (CRC conditioning cycle is given at end of report).

CRC conditioning cycle served as vehicle prep.

Vehicles were tested with prep fuel. Therefore, there was no fuel drain and refill to 40 percent level with chilled fuel immediately prior to the FTP tests.

Vehicle prep - at 75°F for 75°F tests
at 50°F for 35°F and 50°F tests

Vehicle soaks - at 75°F for 75°F tests
at 50°F for 35°F and 50°F tests
Note: For 35°F tests, vehicle was force cooled from 50°F soak temperature to 35°F temperature prior to testing. Test was started after engine oil stabilized at 35°F.

Only single tests were conducted for each vehicle/fuel type/temperature combination. To minimize test variability, all tests, including those at 75°F, were conducted in the EPA Environmental Test Cell.

Fuel/Temperature FTP Test Matrix for Each Vehicle

Fuels	Temperature 35°F	50°F	75°F
CRC Fuels			
Gasoline, 12.8 psi RVP Howell batch 129-1	X	X	
Gasohol, 13.5 psi RVP 10% ethanol by Vol. Howell batch 129-3	X	X	
MTBE gasoline, 13.5 psi RVP 10.8% MTBE by Vol. Howell batch 129-4	X	X	

Fuel/Temperature FTP Test Matrix for Each Vehicle cont'd

Fuels	Temperature 35°F	50°F	75°F
EPA Emission Factors Fuels			
Gasoline, 11.9 psi RVP			X
Gasohol, 10.0 psi RVP 9.6% ethanol by Vol			X
MTBE gasoline, 9.3 psi RVP, 14.3% MTBE by Vol.			X
Certification 9.1 psi RVP gasoline			X

NOTE: CRC/Howell would have provided EPA the fuels for 75°F testing. However, due to limited EPA on-site storage for fuels in barrels, EPA elected to use its own fuels from bulk storage for these 75°F reference blends. At the time testing was orginally scheduled, EPA gasohol was about 11.5 psi RVP and 10% ethanol and the EPA MTBE was about 12.2 psi RVP and 11% MTBE. These lower RVP reference fuels were to be used for the 75°F testing since they were representative of RVP's at 75°F and the use of 13.5-12.8 RVP winter fuels at 75°F occurs rarely during the winter months. Furthermore, in the few cases this does occur, ambient CO levels are usually low.

However, the start of testing was delayed six months to support several higher priority programs. In the interim EPA changed the specifications for the gasohol and MTBE fuels to the specifications in the table to obtain a better test matrix for emission factors testing. Therefore, the EPA fuels do not match the CRC high altitude test fuels at 75°F as well as originally intended. CRC was informed of the changes in these fuels during the test program.

The Reid Vapor Pressures (RVP) and blends for the three CRC fuels were preliminary values provided by CRC and Howell Hydrocarbons Inc. The RVP values for the EPA fuels represent the average of 8 to 14 replicate analyses of the fuel batch at the time that the fuel was used for this program.

The vehicles are described at the end of this report. The dynamometer inertia weights and horsepower settings used were the same used at ETC.

Results

The composite FTP test results are tabulated at the end of this report. Because the tests were processed using the same software program used to process tests at standard temperatures, there are several cautions that apply to these data.

1. Below 66°F, the software program did not calculate the NOx humidity correction factor, but used 1.0 as the correction factor.

2. The calculations for HC and mpg were done using the properties of Indolene (the standard reference gasoline). They were not corrected for carbon-hydrogen ratio, FID response, oxygen content or the density of each fuel.

3. The dry bulb temperatures given in the tabulation were the average temperature observed during the FTP.

To facilitate the testing process, the vehicles were first tested at 75°F using the EPA fuels. Then, to minimize fuel requirements, all eight tests on each CRC fuel were conducted before using the next CRC fuel.

Originally, 40 tests were scheduled with no repeats. After reviewing the data from the EPA test fuels, it was felt four of the tests should be rerun. Only the reruns are reported here. The Citation test at 50°F on 12.8 RVP gasoline and the Pinto test at 35°F on 13.5 RVP gasohol were not rerun due to a lack of the CRC fuels.

Conclusions:

For this data report, there was no attempt to analyze the results or compare them to the corresponding tests at high altitude. Furthermore, vehicles within a given technology group vary in their response to fuel oxygen content. Thus, a sample of four open-loop oxidation catalyst vehicles may not give data with much statistical significance (or representative of the fleet as a whole). In other words, due to the size of this test program relative to the large emissions data base currently available at FTP temperatures, the data will probably be used by EPA only as a rough indicator of the relative effects of oxygenate at low temperature and/or high altitude compared to the effects at FTP temperature and low altitude.

Test Sequence

Drain vehicle fuel tank and fuel lines including any fuel tank return lines.

Add three gallons of new test fuel.

Start vehicle and idle for five minutes.

Drain vehicle fuel tank and fuel lines including any fuel tank return lines.

40 percent fill with new test fuel at 50°F or lower.

Put vehicle on dyno. Vehicle may be driven to dyno but not more than two minutes.

Vehicle may not be used to set dyno horsepower.

NOTE: For 35°F and 50°F tests, the prep must be done at 50°F.

CRC Prep/Vehicle Fuel Conditioning

LA-4

Key-off five minute soak,

Start and one minute idle

Key-off, one minute soak

Start and one minute idle

Key-off, one minute soak

LA-4

12 to 18 hour soak

FTP

EPA Test Vehicles

MANU-FACTURER	Ply.	Chev.	Olds.	Ford
MODEL	VOLARE	CITATION	CUTLASS	PINTO
EPA LICENSE#	EPA-1170	EPA-1172	EPA-1176	EPA-1177
V.I.N.	HL29C9B217336	1X687AQ139507	3R47A9M5232BO	9T11Y186165
MODEL YEAR	1979	1980	1979	1979
ENGINE	225 CID/6 CYL.	2.8L/V-6	3.8L/V-6	2.3L/I-4
INERTIA WEIGHT	3500	3000	3500	2750
H.P.@ 50	11.3	7.3	12.2	9.7
TRANS-MISSION	AUTO	AUTO	AUTO	AUTO
TIRES	P195/75 R14	P185/80 R13	P195/75 R14	P175/80 D13

CRC/EPA LOW ALTITUDE TESTING

DATE	TEST	TEMP	FUEL	HC ftp	CO ftp	NOx ftp	CO2 ftp	MPG*
1980 Chevrolet Citation EPA 1172								
1/11/89	1432	73.3	9.0 INDO/EPA	0.51	3.68	0.96	453.8	19.22
1/18/89	1433	74.9	GASOHOL/EPA	0.50	2.66	0.92	441.2	19.85
1/19/89	1434	74.3	11.5 UNLD/EPA	0.58	3.88	0.86	435.1	20.02
1/20/89	1435	72.6	14.3% MTBE/EPA	0.49	2.51	0.94	441.8	19.82
2/10/89	1436	51.0	13.5 RVP MTBE	1.66	17.77	1.04	460.6	17.94
2/15/89	1437	35.7	13.5 RVP MTBE	2.19	22.65	1.03	463.0	17.54
2/17/89	1438	36.0	12.8 RVP	2.07	24.45	1.04	475.7	17.02
2/24/89	1439	51.7	12.8 RVP	This test requires further analysis.				
3/1/89	1440	35.2	13.5 RVP GASO	1.94	20.02	1.07	473.5	17.36
3/3/89	1441	51.5	13.5 RVP GASO	1.44	14.85	1.06	462.5	18.07
1979 Ford Pinto EPA 1177								
3/8/89	2198	76.3	9.0 INDO/EPA	1.78	18.52	1.62	386.5	21.08
1/27/89	1454	74.9	GASOHOL/EPA	1.54	14.29	1.47	389.9	21.25
3/9/89	2199	74.8	11.5 UNLD/EPA	1.45	16.81	1.75	378.1	21.68
2/1/89	1456	74.8	14.3% MTBE/EPA	1.50	14.15	1.51	384.1	21.58
2/14/89	1457	51.0	13.5 RVP MTBE	2.10	24.38	2.32	397.0	20.06
2/15/89	1458	34.1	13.5 RVP MTBE	2.12	24.85	3.32	405.4	19.67
2/17/89	1459	35.4	12.8 RVP	1.91	24.29	3.06	409.6	19.52
2/21/89	1460	51.8	12.8 RVP	2.00	30.80	2.53	378.5	20.49
3/2/89	1461	36.1	13.5 RVP GASO	This test requires further analysis.				
3/3/89	2197	50.4	13.5 RVP GASO	2.05	27.24	2.88	413.0	19.18

NOTE: Temperatures below 66 degrees use NOx factor of 1.0 to calculate NOx.

NOTE: These calculations have been carried out using the properties of Indolene. They have not been corrected for carbon-hydrogen ratio, etc. associated with the oxygenated fuels or the densities of each fuel.

TEST RESULTS

CRC/EPA LOW ALTITUDE TESTING

DATE	TEST	TEMP	FUEL	HC ftp	CO ftp	NOx ftp	CO2 ftp	MPG*
1979 Oldsmobile Cutlass EPA 1176								
3/8/89	2193	75.5	9.0 INDO/EPA	0.53	4.86	1.47	439.0	19.77
3/9/89	2194	74.5	11.5 UNLD/EPA	0.47	4.28	1.50	430.3	20.24
3/10/89	2195	75.0	GASOHOL/EPA	0.47	2.47	1.26	442.1	19.82
2/2/89	1446	75.9	14.3% MTBE/EPA	0.50	4.96	1.34	449.3	19.34
2/9/89	1447	37.0	13.5 RVP MTBE	1.04	14.10	1.67	449.4	18.69
2/14/89	1448	49.6	13.5 RVP MTBE	1.01	12.55	1.52	439.9	19.16
2/16/89	1449	49.8	12.8 RVP	1.01	10.97	1.25	414.9	20.36
2/17/89	1450	35.3	12.8 RVP	1.66	19.42	1.79	447.2	18.37
3/2/89	1451	35.7	13.5 RVP GASO	1.58	19.80	1.67	444.3	18.47
3/3/89	2192	52.4	13.5 RVP GASO	0.99	12.42	1.46	436.1	19.34
1979 Plymouth Volare EPA 1170								
1/13/89	1422	73.0	9.0 INDO/EPA	0.68	9.67	1.32	457.7	18.65
1/18/89	1423	75.5	GASOHOL/EPA	0.82	8.83	1.04	444.5	19.26
1/19/89	1424	74.1	11.5 UNLD/EPA	This test requires further analysis.				
1/25/89	1425	72.2	14.3% MTBE/EPA	0.51	5.71	1.35	442.7	19.55
2/9/89	1426	35.6	13.5 RVP MTBE	1.40	20.42	1.63	474.2	17.37
2/14/89	1427	50.9	13.5 RVP MTBE	0.98	17.58	1.67	491.3	17.00
2/17/89	1428	36.6	12.8 RVP	1.50	22.19	1.81	493.1	16.65
2/27/89	1430	50.8	12.8 RVP	1.39	22.43	1.43	474.1	17.26
3/2/89	1431	36.4	13.5 RVP GASO	1.20	19.81	1.85	493.6	16.77
3/3/89	2196	50.9	13.5 RVP GASO	1.50	12.17	1.81	487.0	17.36

NOTE: Temperatures below 66 degrees use NOx factor of 1.0 to calculate NOx.

NOTE: These calculations have been carried out using the properties of Indolene. They have not been corrected for carbon-hydrogen ratio, etc. associated with the oxygenated fuels or the densities of each fuel.

TEST RESULTS