7.5-22

An Evaluation of Rolfite Company's Gasoline Fuel Additive "Upgrade"

March 1975

Technology Assessment and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Environmental Protection Agency

Background

The Rolfite Company, of Stamford, Connecticut, first contacted the Emission Control Technology Division (ECTD) in the Spring of 1973 concerning a fuel additive for gasoline which they had developed and were marketing under the name of "Upgrade". The additive was evaluated in the Spring of 1974 by an independent testing laboratory. A test program was conducted following several suggestions from EPA which involved testing a vehicle for emissions and fuel economy at baseline conditions without the additive, at three different mileage points with the additive, and then again without the additive. Results of that program indicated significant pollutant emission reductions after Upgrade was added to the fuel and about 500 miles had been accumulated on the vehicle with the treated fuel. No significant changes in fuel economy were seen. On the basis of the emission reductions that occurred during the tests, EPA agreed to test the additive. The test program began in December 1974 and ended in March 1975.

The Environmental Protection Agency receives information about many devices and additives for which emission reduction or fuel economy improvement claims are made. In some cases, both claims are made for a single device or additive. In most cases, these products are being recommended or promoted for retrofit to existing vehicles although some represent advanced systems for meeting future standards.

The EPA is interested in evaluating the validity of the claims for all such devices or additives because of the obvious benefits to the Nation of identifying products that live up to their claims. For that reason the EPA invites proponents of such products to provide to the EPA complete technical data on the product's principle of operation, together with test data on the product made by independent laboratories. In those cases in which review by EPA technical staff suggests that the data submitted show promise of confirming the claims made for the product, confirmatory tests are scheduled at the EPA Emissions Laboratory at Ann Arbor, Michigan. The results of all such confirmatory test projects are set forth in a series of Technology Assessment and Evaluation Reports, of which this report is one.

The conclusions drawn from the EPA confirmatory tests are necessarily of limited applicability. A complete evaluation of the effectiveness of a product in achieving its claimed performance improvements on the many different types of vehicles that are in actual use requires a much larger sample of test vehicles than is economically feasible in the confirmatory test projects conducted by EPA. 1/ For promising products it is necessary that more extensive test programs be carried out.

The conclusions from the EPA confirmatory test can be considered to be quantitatively valid only for the specific type of vehicle used in the EPA confirmatory test program. Although it is reasonable to

---

1/ See Federal Register 38 FR 11334, 3/27/74, for a description of the test protocols proposed for definitive evaluations of the effectiveness of retrofit devices.

extrapolate the results from the EPA confirmatory test to other types of vehicles in a directional or qualitative manner, i.e., to suggest that similar results are likely to be achieved on other types of vehicles, tests of the product on such other vehicles would be required to reliably quantify results on other types of vehicles.

In summary, a device or additive that lives up to its claims in the EPA confirmatory test must be further tested according to protocols described in footnote 1/, to quantify its beneficial effects on a broad range of vehicles. A product which when tested by EPA does not meet the claimed results would not appear to be a worthwhile candidate for such further testing from the standpoint of the likelihood of ultimately validating the claims made. However, a definitive quantitative evaluation of its effectiveness on a broad range of vehicle types would equally require further tests in accordance with footnote 1/.

Description of Additive

The Rolfite Company claims that Upgrade is designed to improve combustion in spark ignition internal combustion engines to yield the desired benefits of greater power, increased fuel economy, and reduced pollutant emissions. It is mixed with gasoline in the amount of one ounce (approximately 30 ml) per five gallons of gasoline (1:640 ratio).

Upgrade is a manganous-amine complex - an organic nitrogen compound containing about 3 ppm manganese - and is soluble in gasoline. According to a consultant to the Rolfite Company, Upgrade acts as a catalyst in the combustion process which increases the flame front velocity and the rate of development of pressure, and the pressure-versus-crank-angle curve is optimized which increases power output. Optimizing the combustion process would lead to increased fuel economy by converting more heat energy into useful work.

Typical Properties of Upgrade

Form	Liquid
Color	Amber
Specific Gravity	.92
Viscosity-SSU @ 100°F	130
Cleveland Open Cup Flash Point	320
Pour Point	-20°F

Test Procedure

Exhaust emissions tests were conducted according to the 1975 Federal Test Procedure described in the Federal Register of November 15, 1972. Additional tests included the EPA Highway Cycle. All tests were conducted using an inertia weight of 4000 pounds (1814 kg) with a road load setting of 12.0 horsepower (8.95 kW) at 50 miles per hour (80.5 km/hr). The vehicle used in the test program was a 1970 Chevrolet Impala with a 350 CID (5700 cc) engine and automatic transmission (a complete vehicle description is given on the following page).

The test vehicle was first tuned to manufacturer's specifications, in accordance with which the fuel-air mixture was set using the lean idle speed roll-off method, since exhaust CO concentration is not specified. Ignition timing was set at, 4^{o} BTDC; exhaust CO concentration at idle was 0.6%. Exhaust emissions tests were conducted at the conditions and mileage intervals shown below. As a reference, the point at which the additive was first used is termed zero miles.

Test Program	Miles with Additive in Fuel
1. Baseline tests (without additive)	-550
2. Accumulate 300 miles on AMA cycle (without additive)	
3. More baseline tests (without additive)	-050
4. Tests with additive at low mileage	100
5. Accumulate 300 miles on AMA cycle	
6. Tests (with additive)	560
7. Accumulate 300 miles on AMA cycle	
8. Tests (with additive)	1000
9. Accumulate 500 miles on AMA cycle	
10. Tests (with additive)	1670

Because the vehicle was driven to and from the test track (about 50 miles each way) and because of vehicle preparation before testing, the total mileage accumulated between emissions tests was higher than that accumulated at the test track on the AMA cycle.

Steps No. 2 and 3 were done because the vehicle had not been subjected to the AMA cycle for a period of time and it was felt necessary to establish a baseline after some driving on this cycle. Originally, step No. 8 was to be the last, but after this step a stabilized level of emissions and fuel economy was not evident so the final two steps were added.

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1970 Chevrolet Impala

Engine

type	4 stroke Otto Cycle, OHV, V-8
bore x stroke	4.00 x 3.48 in/102 x 88 mm
displacement	350 CID/5700 cc
compression ratio	9.00/1
maximum power @ rpm	250 HP/186 kW @ 4800 RPM
fuel metering	2 barrel carburetor
fuel requirement	94 RON

Drive Train

transmission type	automatic
final drive ratio	2.73

Chassis

type	body/frame, front engine, rear wheel drive, 4 door sedan
tire size	G 78 x 15
curb weight	3888 lbs/1765 kg
inertia weight	4000 lb
passenger capacity	six

Emission Control System

basic type	engine modifications, PCV

Engine Specifications (at Idle in Drive)

rpm	620
dwell	30^{o}
CO	Initial Setting: .6% (air cleaner removed) (∿2.5% with air cleaner attached) Final: .3% (air cleaner removed) (∿2.0% with air cleaner attached)
timing	4^{o} BTDC
manifold vacuum	15" Hg

Two valid '75 FTP's and two valid EPA Highway Cycles were run at each of the above points with two exceptions: only one FTP was run at the second baseline point (Step 3) and only one Highway Cycle was run during the last test sequence (Step 10).

The fuel used for all testing, with and without the additive, was Indolene Clear Gasoline.

Test Results

Exhaust emissions and fuel economy data are summarized in Tables 1 and 2 below. A complete listing of all emission and fuel economy results obtained during the program can be found in Tables 1-A through 3-A of the Appendix.

Idle CO and spark timing settings remained constant except before the final test series. At that point idle CO and ignition timing had both decreased slightly, to .3% and 2° BTDC respectively. One test was run at this condition. Timing was then increased to the original 4° BTDC setting and another test run. Since the timing had only been 2° low (retarded) when the vehicle was first tested at this mileage, and this is within the acceptable tolerance range, that test was deemed valid along with the last one. The slight change in timing was the only difference between the two.

Table 1
'75 FTP Composite Mass Emissions
grams per mile
(grams per kilometre)

	HC	CO	NOx	Fuel Economy (Fuel Consumption)
Baseline - avg. of 3 tests	2.20 (1.37)	31.7 (19.7)	3.65 (2.26)	13.0 miles/gal (18.1 litres/100 km)
Additive - avg. of last 6 tests	2.20 (1.37)	32.2 (20.0)	2.64 (2.26)	13.5 miles/gal (17.4 litres/100 km)
% Change	0%	+1.6%	0%	+4% in miles/gal (-4% in litres/100 km)

Table 2
EPA Highway Cycle
grams per mile
(grams per kilometre)

	HC	CO	NOx	Fuel Economy (Fuel Consumption)
Baseline - avg. of 4 tests	1.15 (.71)	13.94 (8.64)	4.24 (2.63)	20.6 miles/gal (11.4 litres/100 km)
Additive - avg. of last 5 tests	1.13 (.70)	13.28 (8.23)	4.73 (2.93)	20.8 miles/gal (11.3 litres/100 km)
% Change	-2%	-5%	+12%	+1% in miles/gal) (-1% in litres/100 km)

Perhaps a more significant summary of the test results is shown in Figures 1 and 2. These figures plot the emissions and fuel economy history of the test car during the program. No clear trends in either emissions or fuel economy are apparent. A comparison of the Highway Cycle and '75 FTP urban cycle economy data tends to indicate that the drop in idle CO noted before the last phase of the program may have more likely been the results of a shift in carburetor calibration than some effect the Rolfite additive was having on the combustion process. On the highway cycle, where the carburetor's idle circuit has essentially no effect, the last fuel economy value recorded was equal to the first baseline value. The final 75 FTP (urban cycle) economy values, however, were 5% higher than the initial baseline results. A change in idle CO adjustment would tend to improve urban cycle fuel economy rather than Highway Cycle fuel economy, where as an increase in combustion efficiency would be expected to more uniformly improve economy, with some benefit on the Highway Cycle being apparent.

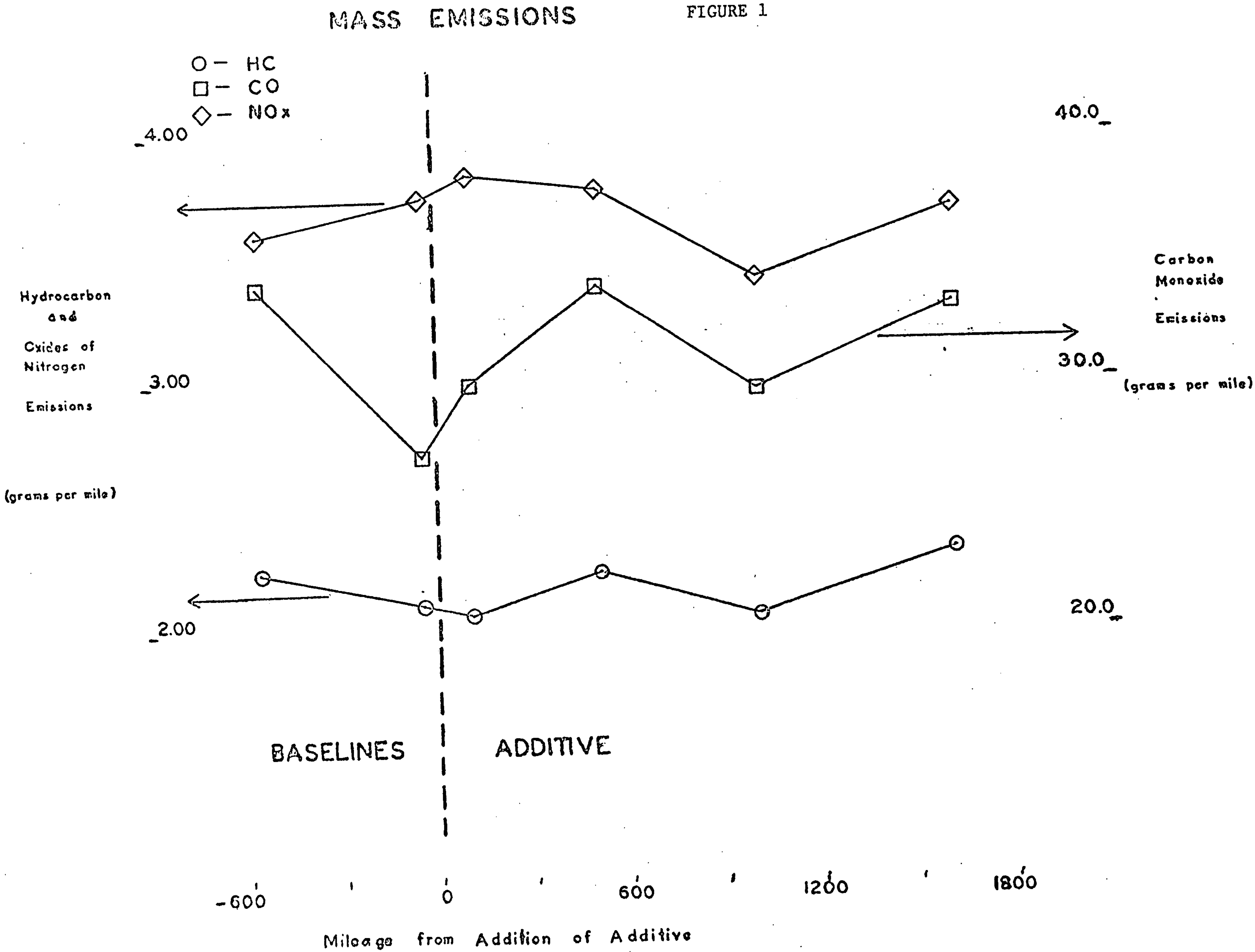
A statistical "t" test was performed on both the '75 FTP and the Highway Cycle tests which compared the baseline tests with the last 6 additive tests (5 additive tests in the case of the Highway Cycle tests) to determine if the two series were from different populations. The first two additive tests were not used because the vehicle had not yet accumulated any AMA driving cycle mileage. At the 90% confidence level there were no significant differences in either emissions or fuel economy, with or without the additive. The same test was performed using the baseline tests and only the last test series, in which the vehicle had accumulated over 1600 miles with the additive, and the results were the same.

Conclusions

In tests conducted according to the '75 FTP at intervals during 1600 miles of mileage accumulation, the Rolfite "Upgrade" gasoline additive produced no significant changes in either exhaust emissions or fuel economy. On the Highway Cycle test slight decreases in HC and CO emissions were accompanied by a small increase in NOx emissions, with no change in fuel economy.

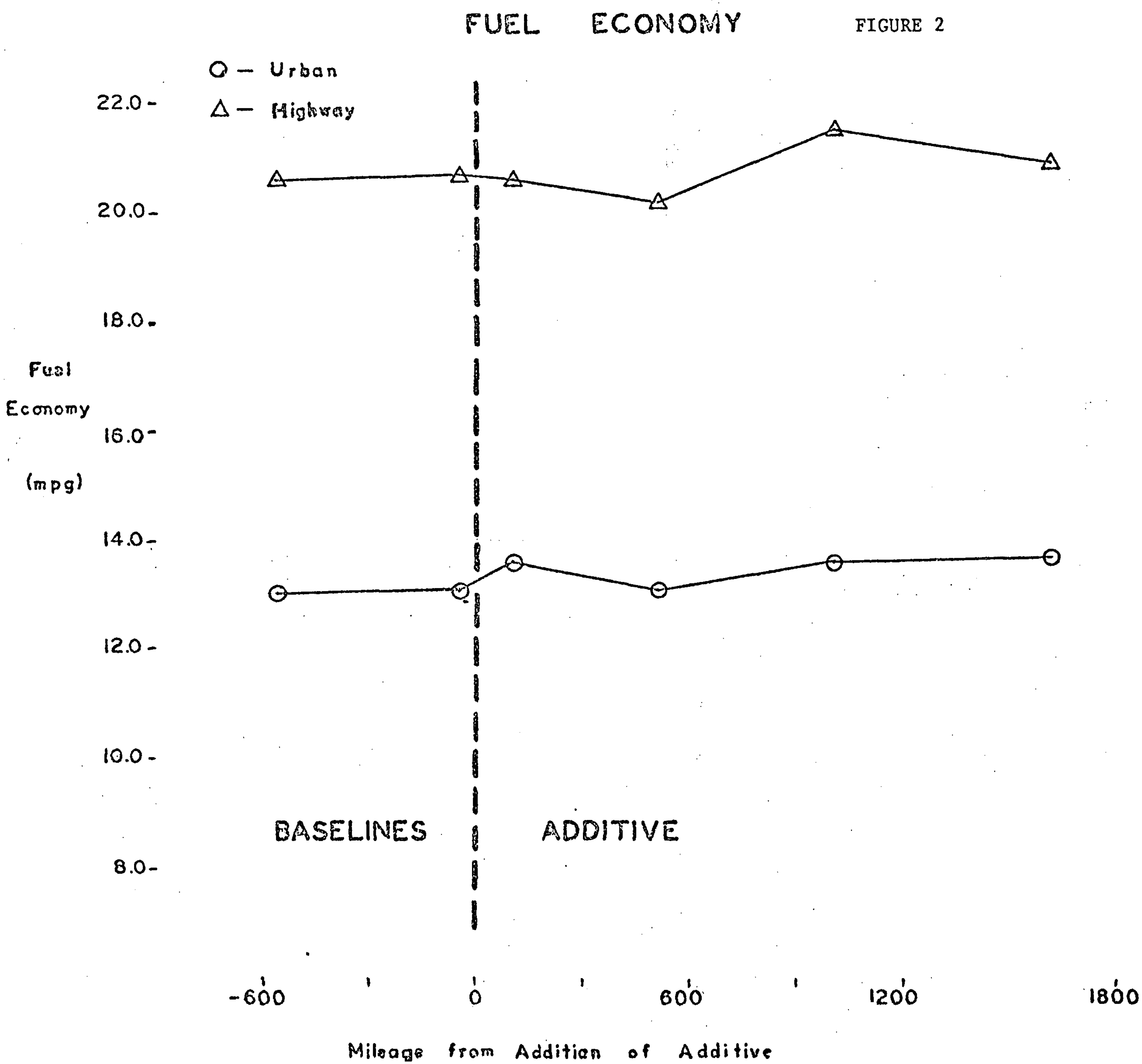
The EPA test results did not confirm the emission reduction claims made for the additive based upon the results of testing using Federal exhaust emissions test procedures by an independent commercial laboratory. No explanation for the discrepancy has been determined.

FIGURE 1



MASS EMISSIONS
O — HC
□ — CO
◇ — NOx
4.00
3.00
2.00
Hydrocarbon and Oxides of Nitrogen Emissions
(grams per mile)
40.0
30.0
20.0
Carbon Monoxide Emissions
(grams per mile)
BASELINES
ADDITIVE
-600
0
600
1200
1800
Mileage from Addition of Additive

FIGURE 2


FUEL ECONOMY
O — Urban
Δ — Highway
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
Fuel Economy (mpg)
BASELINES
ADDITIVE
-600
0
600
1200
1800
Mileage from Addition of Additive

Appendix

TABLE 1-A

'75 FTP Composite Results
Mass Emissions, gpm
Fuel Economy, mpg

1. Without Additive

Date	Test No.	Test Type	HC	CO	CO_2	NOx	Fuel Economy	Odom.
12-19	15-7124	Baseline	2.21	35.1	618	3.42	13.0	18569
12-24	9-7154	Baseline	2.29	32.9	622	3.77	13.0	18627
		Average	2.25	34.0	620	3.60	13.0	
After 300-mile AMA Cycle								
12-31	16-7158	Baseline	2.11	27.1	628	3.75	13.1	19067

2. With Additive

Date	Test No.	Test Type	HC	CO	CO_2	NOx	Fuel Economy	Odom.
1-11	16-7280	Additive	2.27	32.5	609	3.60	13.3	19213
1-14	9-7334	Additive	1.87	27.5	584	4.07	14.0	19261
		Average	2.07	30.0	597	3.84	13.6	
After 300-mile AMA Cycle								
1-24	16-7479	Additive	2.28	34.8	609	3.72	13.2	19673
1-28	16-7516	Additive	2.20	33.0	617	3.84	13.1	19734
		Average	2.24	33.9	613	3.78	13.1	
After Second 300-mile AMA Cycle								
2-13	15-7749	Additive	2.00	30.0	588	3.36	13.8	20120
2-14	16-7774	Additive	2.11	29.4	603	3.49	13.5	20150
		Average	2.06	29.7	596	3.43	13.6	
After 500-mile AMA Cycle								
3-04	16-8036	Additive	2.36	32.1	588	4.01	13.7	20768
3-07	15-8095	Additive	2.28	34.0	585	3.39	13.7	20859
		Average	2.32	33.1	587	3.70	13.7	

Table 2-A

'75 FTP Individual Bag Results
Mass emissions, grams per mile
Fuel economy, miles per gallon

	Bag 1 Cold Transient					Bag 2 Hot Stabilized					Bag 3 Hot Transient				
Test Number	HC	CO	CO_2	NOx	Fuel Economy	HC	CO	CO_2	NOx	Fuel Economy	HC	CO	CO_2	NOx	Fuel Econom
15-7124	2.72	56.29	615	4.07	12.5	2.23	32.19	646	2.76	12.6	1.77	24.82	566	4.20	14.5
9-7154	2.50	44.87	609	4.33	12.9	2.43	33.34	652	3.03	12.5	1.87	23.00	577	4.75	14.3
16-7158	2.64	44.00	616	4.23	12.8	2.12	25.74	662	3.01	12.5	1.68	17.02	572	4.81	14.7
16-7280	3.08	51.54	605	4.24	12.8	2.24	32.47	639	2.83	12.7	1.72	18.33	554	4.60	15.1
9-7334	2.40	45.97	569	4.55	13.7	1.84	24.97	619	3.34	13.4	1.54	18.32	526	5.09	15.8
16-7479	2.65	51.64	595	4.20	13.0	2.33	34.76	641	2.94	12.6	1.89	22.13	557	4.85	14.8
16-7516	2.80	58.94	604	4.37	12.6	2.14	28.94	649	3.02	12.6	1.85	21.28	565	500	14.7
15-7749	2.45	46.57	572	3.78	13.6	1.98	30.01	623	2.58	13.1	1.71	17.32	532	4.53	15.7
16-7774	2.50	43.19	590	3.88	13.3	1.99	28.67	637	2.64	12.9	2.02	20.41	547	4.81	15.1
16-8036	3.02	55.37	588	4.65	13.0	2.30	36.25	613	3.21	13.1	1.98	6.66	540	5.04	15.9
15-8095	3.08	51.87	605	4.17	12.7	2.25	32.98	599	2.54	13.5	1.74	22.53	542	4.41	15.2

TABLE 3-A

EPA Highway Cycle
Mass Emissions, gpm
Fuel Economy, mpg

1. Without Additive

Date	Test No.	Test Type	HC	CO	CO_2	NOx	Fuel Economy	Odom.
12-19	15-7124	Baseline	1.15	15.05	398	3.64	20.9	18,591
12-24	9-7154	Baseline	1.21	13.24	412	4.39	20.3	18,646
		Average	1.18	14.15	405	4.02	20.6	
Following 300-mile AMA Cycle								
12-31	16-7158	Baseline	1.10	13.31	403	4.42	20.8	19,079
1-03	16-7166	Baseline	1.14	14.17	405	4.53	20.6	19,126
		Average	1.12	13.74	404	4.48	20.7	

2. With Additive

Date	Test No.	Test Type	HC	CO	CO_2	NOx	Fuel Economy	Odom.
1-10	9-7280	Additive	1.10	12.92	384	4.28	21.8	19,193
1-14	19-7334	Additive	0.55	15.10	428	5.01	19.6	19,286
		Average	0.83	14.01	406	4.65	20.6	
After First 300-mile AMA Cycle								
1-24	16-7479	Additive	1.25	17.83	405	4.44	20.3	19,673
1-27	16-7516	Additive	1.13	11.65	418	4.92	20.2	19.724
		Average	1.19	14.74	412	4.68	20.2	
After Second 300-mile AMA Cycle								
2-13	15-7749	Additive	1.00	11.13	377	4.13	22.3	20,134
2-14	16-7774	Additive	1.12	11.83	405	5.19	20.8	20,161
		Average	1.06	11.38	391	5.10	21.5	
After 500-mile AMA Cycle								
3-04	16-8036	Additive	1.16	13.95	399	4.96	20.9	20,768