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The Emission Effects of Misfueling Five 1981-82 Model Year Automobiles With 10 Continuous Tankfuls of Leaded Gasoline

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NOTICE

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Table of Contents

Background

Misfueling of catalyst equipped vehicles (the use of leaded gas instead of unleaded) has been known to substantially increase the regulated emissions of pre-1980 model year (MYR) vehicles. Even one tankful of leaded gasoline can cause emission levels to double or triple.(1-3)* The early vehicle catalysts controlled only two of the three major regulated emissions - hydrocarbons (HC) and carbon monoxide (CO). These catalysts are usually referred to as "oxidation catalysts", because they add oxygen to the HC and CO molecules to form H_2O and CO_2. Starting in 1981, most catalysts controlled oxides of nitrogen (NOx) emissions as well as HC and CO. The control of NOx is a "reduction" process, because oxygen is subtracted from the NOx molecules to form N_2. Catalysts which perform both the oxidation and reduction catalyst functions are referred to as three-way catalysts.

Three-way catalysts differ from earlier oxidation catalysts in three main ways. First, three-way catalysts contain a third precious metal for the reduction function, rhodium (Rh), as well as platinum (Pt) and palladium (Pd) which are used in oxidation catalysts. Second, the support material differs in that current three-way catalysts have larger pores and higher surface areas than older catalysts, which affects the chemical reactions. Third, the ratio and amounts of Pt and Pd have often changed.(4) In addition, there are important differences in the vehicles on which three-way and oxidation catalysts are used. Three-way catalysts are most often used in combination with closed-loop fuel control, which results in a different exhaust gas composition than typically enters an oxidation catalyst. Finally, closed-loop fuel systems depend on catalyzed exhaust gas oxygen sensors which themselves may be influenced by misfueling. These differences mean that the effects of misfueling three-way catalyst vehicles require separate quantification from those of misfueling oxidation catalyst vehicles. Because it is likely that most of the vehicles produced in the 1980's will have three-way catalysts, this test program focused mainly on them. There have been previous misfueling studies of three-way catalyst vehicles(1,2) but these were limited to early generation systems or to only one or two current generation vehicles.

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*Numbers in parentheses refer to references at the end of the report.

The rate of misfueling of passenger cars has been recently estimated at about 10%.(5) This is a substantial percentage which has a significant environmental impact. EPA wanted to determine the effect of misfueling on late model vehicles in order to help predict the effect on fleetwide emission levels in the 1980's. A test program was therefore initiated with Automotive Test Laboratories (ATL) in Ohio, which had a contract with EPA to perform work assignments as required. This task was Work Assignment No. 1 to EPA Contract No. 68-03-3157.

Vehicle Types

Five vehicle types were designated by EPA as test vehicles. The 1981 MYR vehicles were to have accumulated at least 25,000 miles prior to testing and the 1982 MYR vehicles at least 15,000 miles. The vehicles recruited are listed in Table 1 (more specific information is given in the Appendix). Each conforms to the types originally designated by EPA, except for the Plymouth Reliant. EPA had desired a three-way catalyst closed-loop emission control system for this vehicle type, but ATL could only obtain a vehicle with the alternate engine size which had an oxidation catalyst. EPA agreed to the use of this vehicle. EPA also agreed to allowing the use of two 1981 MYR vehicles which had less than 25,000 miles.

Vehicle Preparation

All test vehicles had their as-received tank fuels measured for the presence of leaded gas and the tailpipes checked with a lead detection paper. No vehicles appeared to have been misfueled prior to the test program.

Vehicles were thoroughly inspected prior to testing and none were found to require more than minor adjustments. All vehicles were then set to the manufacturer's tune-up specifications. All vehicles were left in this condition for the entire test program and did not appear to change in any manner.

Table 1

MYR	MFR	Make/Model	Engine	Fuel System	Catalyst	Closed-Loop?	Air Injection?	Odometer
1981	GM	Buick Regal	231 CID 6 cyl	Carbureted	3-way	Yes	Pump	25,902
1981	Ford	Mercury Lynx	98 CID 4 cyl	Carbureted	Ox+3-way	No	Pump	24,850
1981	Chrysler	Plymouth Reliant	156 CID 4 cyl	Carbureted	Oxidation	No	Pulse	42,620
1981	VW	Rabbit	105 CID 4 cyl	Port F.I.	3-way	Yes	No	21,657
1982	GM	Chevrolet Citation	151 CID 4 cyl	TBI	3-way	Yes	No	16,934

Definitions:

MYR - Model year
CID - Cubic inch displacement
Port F.I. - Port fuel injection
TBI - Throttle body fuel injection
Closed-Loop - Emission system which senses the exhaust gas and sends the information to a computer which uses the information in controlling the fuel system; sometimes called "feed-back" system.
Ox+3-way - Oxidation catalyst plus three-way catalyst, in two separate containers
Oxidation - Oxidation catalyst
Pump - Air pump driven by the engine
Pulse - Pulse air injection utilizing only suction pulses in the exhaust

Fuels Used

All emissions testing was performed with Indolene unleaded test fuel. The leaded fuel used for mileage accumulation was a commercially obtained fuel with a lead content of 1.02 grams per gallon. This closely matches the national average lead content of leaded regular gasoline which was recently measured at 0.99 grams per gallon.(6)

Mileage Accumulation

Vehicles were driven on the test track at the Transportation Research Center (TRC) for all mileage accumulation. This is the test track in Liberty, Ohio where ATL has its laboratory. The mileage accumulation speed averaged about 50 mph and the vehicles were driven up to 16 hours per day. The driving cycle consisted of driving at 55 mph with a stop every 10 miles. Because the test intervals were separated by numbers of tankfuls, rather than specific mileages, and this process involved estimation, the mileage between test points varied slightly, and was different for each vehicle. The average mileage for each tankful varied between 250-360 miles for the different vehicles. Table 2 shows the total miles driven on leaded fuel, and the estimated numbers of gallons used with the associated amounts of lead, for each vehicle.

The total number of gallons of lead used by each vehicle had to be estimated, due to the fact that between each test each vehicle was driven for two approximate tankfuls, and the exact amount of fuel used during only the first tankful was known. A method was used to approximate the number of gallons used in the second tank. Because the vehicle was filled at the beginning of the mileage accumulation interval and refilled after one tank of driving, it was known exactly how many gallons were used during the first tank. Miles per gallon (mpg) were then calculated for that tank. After the second tank, the tank was not refilled, and therefore the amount of fuel consumed was not known, but the number of miles driven was known. The same mpg was assumed as during the first tank, and the number of gallons used was estimated. This calculation was performed separately at each interval for each vehicle. Due to the type of driving being consistent during both tanks, it is estimated that the number of gallons calculated is very accurate.

Table 2

Miles Driven and Amounts of Leaded Fuel
Used During the 10 Tankfuls of Misfueling

Vehicle	Miles Driven	No. of Gallons Leaded	No. of Grams Lead
Regal	3010	133.7	136.4
Lynx	2914	87.2	88.9
Reliant	2514	103.1	105.2
Rabbit	2979	91.2	93.0
Citation	3597	112.4	114.6

Emission Tests Conducted

The following test sequence was performed on each vehicle at each test stage.

1. Federal Test Procedure
2. 50 mph Cruise Test
3. Highway Fuel Economy Test
4. Four-Speed Idle Test
5. Loaded Two-Mode Test
6. Engine Restart Idle Test (Ford Idle Test)

Test Conditions

Emission Test sequences were performed at the following conditions:

Vehicle Condition	No. Test Sequences
Baseline	2
Catalyst removed (with straight pipe)	1
After 2 tankfuls leaded (catalyst on)	1
After 2 more tankfuls leaded (4 total)	1
After 2 more tankfuls leaded (6 total)	1
After 2 more tankfuls leaded (8 total)	1
After 2 more tankfuls leaded (10 total)	2
With new catalyst	1
With new oxygen sensor (when applicable)	1

Results

All vehicles generally produced increasingly more FTP HC, CO and NOx emissions as they were exposed to more leaded fuel. Table 3 shows the average FTP emissions at each test stage for the five vehicles. Table 4 shows the average emission levels for the three closed-loop 3-way catalyst vehicles (which have oxygen sensors). The degree of emission increase varied considerably from vehicle to vehicle, however. For example, the CO emissions of the five vehicles after 10 tankfuls of leaded gasoline were approximately 300%, 240%, 60%, 10% and 290% greater than the baseline levels. Data from the tests with the catalyst removed also show considerable variation in emission levels, particularly for CO. The vehicles with closed-loop, three-way catalysts, though, all emitted relatively low CO levels with the catalyst removed. This indicates the generally good CO control associated with closed-loop sytems.

Figure 1 graphically shows the HC, CO and NOx emissions at each stage for each vehicle, along with graphs showing the conversion loss at each test stage. The percent conversion loss was determined by dividing the change in emissions from baseline by the difference between the baseline emission level and the level with the catalyst removed. HC emissions increased fairly steadily for all five vehicles, although not to the same degree. CO emissions increased for only four of the five vehicles, and often leveled off after a few tankfuls of leaded, rather than continually increasing. NOx emissions increased for all five vehicles to varying degrees. The HC increases are more dramatic than those of CO and NOx, similarly to past observances. This is because the catalysts generally are more negatively affected by misfueling in their HC conversion efficiency than their CO and NOx conversion. (Individual test scores are shown in the Appendix.)

It is not possible to predict the emission increases from observing just the amount of lead passing through the catalyst, even if the catalyst volume and size of the vehicle are considered. For example, the two vehicles which used the most leaded fuel (the Regal and Citation) had very different emission increases. Their catalyst and emission control designs are similar, yet the Regal's HC emissions increased much more than the Citation's. It may be possible, though, that a formula could be devised which would predict the effects if it included other factors such as engine-out emissions, air injection, type of fuel system, fuel consumption, vehicle weight, etc.

Figures 2-3 show bar charts of the average misfueling emission levels as a percent of baseline levels. Figure 2 is based on all five vehicles for HC and CO, and just the four three-way catalyst vehicles for NOx. Average HC and CO emissions increase most substantially for about the first four tanks of leaded and then increase more slowly; this is only a generalization, however. Average HC emissions are 4.4 times the baseline levels after 10 tanks of leaded gas, average CO emissions are 2.8 times the baseline levels and average NOx emissions are 1.9 times the baseline levels. The baseline amount of emission control (conversion efficiency) is 82% for HC (550-100/550) and after 10 tankfuls of leaded it is 20%; the conversion efficiency for CO is 80% at baseline and 44% after 10 tankfuls of leaded; for NOx it is 76% at baseline and 54% after 10 tankfuls of leaded. This represents a loss in conversion efficiency due to 10 tankfuls of leaded of 76% for HC (82-20/82), 45% for CO and 29% for NOx.

In Figure 3 emission levels are shown for just the three 3-way catalyst vehicles with feedback control. The changes are similar to those in Figure 2, although the percentage increases over baseline levels are slightly greater after 10 tanks of leaded. This may be due to the effect of leaded gas on the oxygen sensors, which causes some loss of feedback control. It is apparent, though, that the main effect was on catalyst poisoning, not oxygen sensor poisoning, since the emission levels returned to near baseline levels when new catalysts were installed. With the new oxygen sensors, HC and CO decreased further on all three vehicles, but NOx increased on two of the vehicles. This indicates that the poisoned oxygen sensors were sending incorrect signals indicating a greater (richer) fuel-air ratio was needed when it really was not. This occurrence is logical, because as a sensor is poisoned it would be expected that its voltage output would become less as it loses its ability to measure oxygen in the exhaust gas, and a lower voltage signal is read by the computer as meaning the fuel-air ratio needs to be richer.

Figure 4 shows the average emission levels of the four three-way catalyst vehicles from this program at a few test conditions, and compares them to the average levels of nine early model year three-way catalyst vehicles which were misfueled in two test programs in 1979 and 1980.(1, 2) As can be seen in Figure 4, emission levels due to misfueling are similar for the two groups. There are several problems in making a direct comparison with these two programs, however, such that we can only say that misfueling had a similar effect on the two groups. The earlier test programs used fuel with a higher average lead content than the present one; six of the nine vehicles used fuel with 2.5 grams of lead per gallon and the other three used fuels with lead averaging about 1.0 grams per gallon. Knowing this, it would be expected that the vehicles in the earlier programs would have higher average emissions after a similar number of tanks of leaded gas than in the present program. Other factors lead to lower emissions, though. Most of the vehicles tested in the earlier program began their test programs at lower mileage than the vehicles in this program and six of the vehicles had new catalysts installed at (or just prior to) the beginning of the misfueling test program, whereas in this program the original catalysts were used. These latter differences are probably the cause of the usually lower baseline and no-catalyst emissions of the earlier models seen in Figure 4, but complicate the misfueling comparisons.

A simpler comparison is shown in Figure 5, which presents just the results from one of the early model year programs (1) with the four three-way catalyst vehicles in this program. Both the three-way catalyst vehicles and the oxidation catalyst vehicles from that early program (all were 1979 MYR) are shown. This single earlier program can be compared more directly to the present one (as opposed to combining both earlier programs), because this one program used gasoline having a nearly identical average lead content as the present one, and the original catalysts. The average emissions of the early three-way catalyst vehicles showed similar trends with misfueling to the current vehicles. The HC and CO emissions of the oxidation catalyst vehicles increased with misfueling more than either of the three-way groups on an absolute basis, but not on a percentage basis. The fact that the percentage increases were greater for the three-way groups is because their baseline emissions were much lower, such that even smaller absolute increases affected the percentage increases more greatly. It is interesting to note that the average emissions of the 1979 MYR three-ways with the catalyst removed were lower for HC and CO, but higher for NOx. Because the earlier vehicles generally were first generation designs, definitive conclusions cannot be made about these differences, however.

Another concern with misfueling is whether it affects cold or warm operation to different degrees. The FTP is divided into three segments of driving and one of these is driving from a "cold" condition (the vehicle not having been operated for at least 12 hours). The emissions from each of the three segments is collected into separate "bags" and analyzed separately. Figures 6-8 show the effects on the three segments (bags) of the FTP from 10 tankfuls of leaded gasoline, for each pollutant. Two graphs are shown for each pollutant on each page. The top graph shows the percentage increase in emissions for the total FTP and also each segment (bag) of it. The bottom graph shows the contribution which each bag of the FTP contributes to the total. Noticeable trends occur for both HC and CO. Bag 1 emissions increase the least amount, and bag 2 the most. Also, whereas before misfueling bag 1 contributed the most to the FTP, after misfueling bag 2 does. The larger increase seen in bag 2 emissions is logical, because normally the catalyst is only operating effectively part of the time in bag 1 (due to the cold initial condition) whereas in bag 2 it is normally operating all of the time. Therefore, a reduction in catalyst effectiveness would be a greater detriment to bag 2. The bag 3 driving cycle is the same as bag 1 except that the vehicle is started warm. As can be seen, bag 3 emissions also increase more than bag 1, but not as greatly as bag 2. The bag 3 percentage contribution to the FTP remains nearly the same. The different driving cycles in bags 2 and 3 are a possible cause for the difference in percentage increases. Bag 3 (and bag 1) has a higher average speed and less stops per mile than bag 2. Apparently, the decrease in catalyst effectiveness from misfueling varies with the driving condition.

Concerning I/M short tests, most of the vehicles continued to have relatively low short test emissions with misfueling, low enough to pass most state I/M standards. This is not surprising, because I/M tests are designed to catch only those vehicles which are emitting at very high emission levels, generally higher than produced by these well tuned vehicles even after misfueling. Also, the I/M tests do not check vehicles under conditions which require much catalyst activity. Short test results are shown in the Appendix for the individual vehicles along with the FTP results. Three of the five vehicles passed all the short tests after 10 tanks of leaded gas, using 207(b) cutpoints. However, two of the five passed all the short tests with the catalyst removed. After 10 tankfuls of leaded, only one vehicle (the Regal) would have failed the simple Idle Test using 207(b) cutpoints of 220 ppm HC and 1.2% CO; the same vehicle was the only one to fail the 207(b) cutpoints for the Loaded Two-mode test; the Reliant was the only vehicle to fail the cutpoints for the Two-Speed Idle test; and no vehicles failed the Idle Test cutpoints after an engine preconditioning of 2500 rpm.

Vehicles were also tested for lead deposits at the tailpipe using Plumbtesmo lead sensitive paper. Table 5 presents the results. After two tanks of leaded fuel, only two of the vehicles showed a positive lead reading at the tailpipe. After four tanks of leaded fuel, four of the vehicles showed a positive reading and after eight tanks all of the vehicles showed a positive reading.

Conclusions

All catalyst equipped vehicles experience greatly increased emission levels when run on leaded gasoline. Three-way catalyst vehicles experience similar increases in HC and CO emissions as do older oxidation catalyst equipped vehicles, plus they have increased NOx emissions.

For the five vehicles in this study, emission levels were found to steadily increase with misfueling such that after 10 tankfuls of leaded gasoline, HC emissions were over four times the baseline levels and CO emissions nearly three times. For the four vehicles with three-way catalysts, NOx emissions were nearly double the baseline levels.

Most catalyst deactivation occurs within four tankfuls of leaded gasoline. HC and CO emissions continue to increase with further misfueling, but not to the same degree. After 10 tankfuls of leaded gasoline catalysts are not completely deactivated, but only about one-fourth of the original HC control, and one-half of the original CO control remains; nearly three-fourths of the original NOx control remains.

Table 3

Average FTP Emission Levels of
the Five Misfueled Vehicles
(Only the Four 3-Way Catalyst Vehicles for NOx)

	Emissions in grams per mile		
Test Stage	HC	CO	NOx
No catalyst	1.92	25.6	2.87
Baseline	0.35	5.1	0.70
After 2 tanks leaded	0.86	9.5	0.74
After 4 tanks leaded	1.20	11.7	1.07
After 6 tanks leaded	1.22	10.5	1.26
After 8 tanks leaded	1.38	12.0	1.32
After 10 tanks leaded	1.55	14.3	1.32
New catalyst	0.29	3.9	0.30

Table 4

Average FTP Emission Levels of the Three 3-Way Catalyst Vehicles with Oxygen Sensors

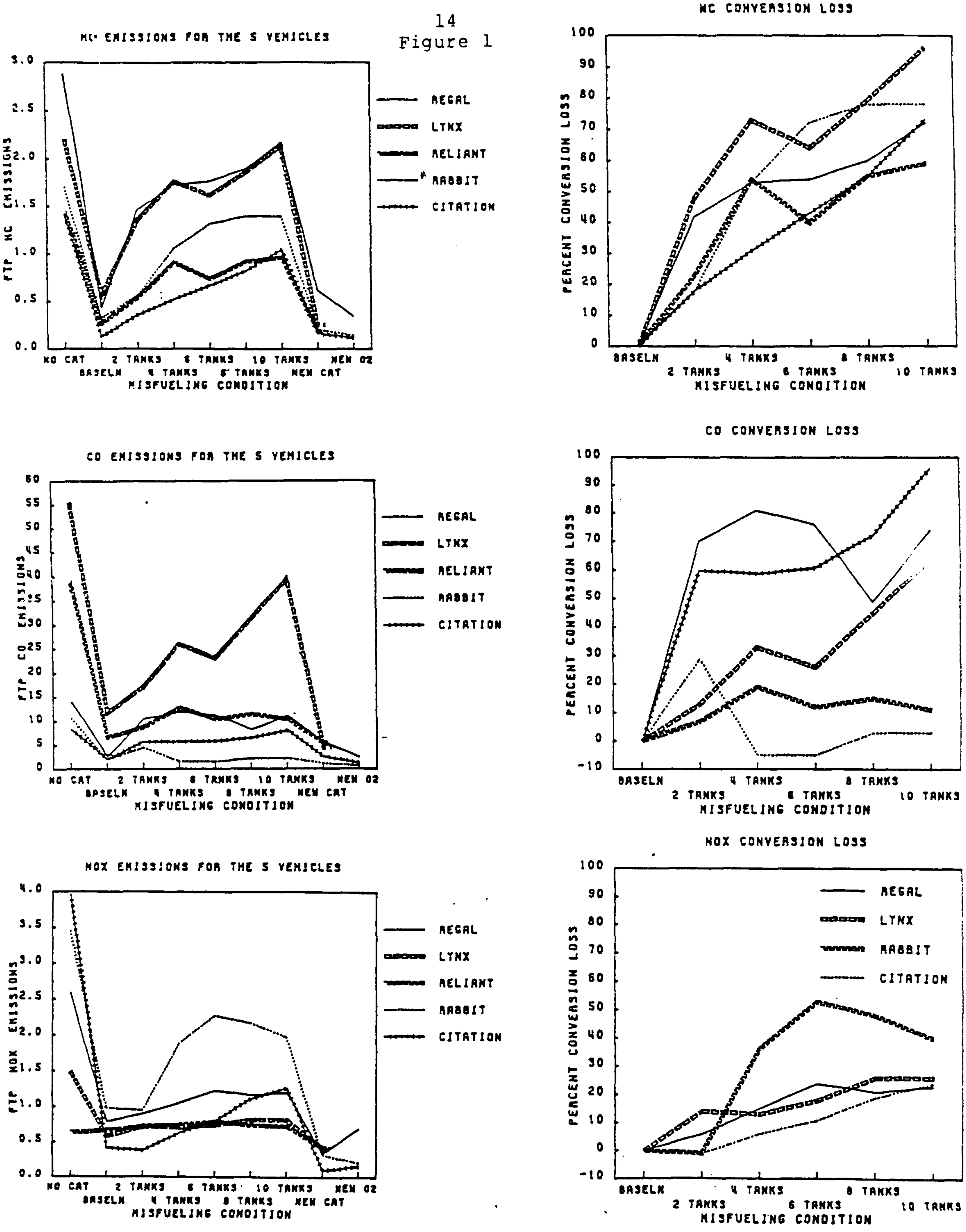
Test Stage	Emissions in grams per mile		
	HC	CO	NOx
No Catalyst	1.99	11.0	3.33
Baseline	0.30	2.30	0.73
After 2 tanks leaded	0.80	7.01	0.75
After 4 tanks leaded	1.10	6.47	1.19
After 6 tanks leaded	1.25	6.29	1.44
After 8 tanks leaded	1.37	5.74	1.48
After 10 tanks leaded	1.54	7.19	1.49
New Catalyst	0.33	3.10	0.26
New Catalyst and New Oxygen Sensor	0.20	1.46	0.36

Table 5
Plumbtesmo Test Results
(x = positive lead detection)

Test	Regal	Lynx	Reliant	Rabbit	Citation
Baseline	-	-	-	-	-
2 Tanks	-	-	-	x	x
4 Tanks	x	-	x	x	x
6 Tanks	x	-	x	x	-
8 Tanks	x	x	x	x	x
10 Tanks	x	x	x	x	x

Note: Some readings which showed positive lead prior to 8 tanks of leaded fuel were marginally detectable.

Figure 1


HC EMISSIONS FOR THE 5 VEHICLES
FTP HC EMISSIONS
3.0
2.5
2.0
1.5
1.0
0.5
0.0
NO CAT
BASELN
2 TANKS
4 TANKS
6 TANKS
8 TANKS
10 TANKS
NEW CAT
NEW O2
MISFUELING CONDITION
REGAL
LYNX
RELIANT
RABBIT
CITATION
HC CONVERSION LOSS
PERCENT CONVERSION LOSS
100
90
80
70
60
50
40
30
20
10
0
BASELN
2 TANKS
4 TANKS
6 TANKS
8 TANKS
10 TANKS
MISFUELING CONDITION
CO EMISSIONS FOR THE 5 VEHICLES
FTP CO EMISSIONS
60
55
50
45
40
35
30
25
20
15
10
5
0
NO CAT
BASELN
2 TANKS
4 TANKS
6 TANKS
8 TANKS
10 TANKS
NEW CAT
NEW O2
MISFUELING CONDITION
REGAL
LYNX
RELIANT
RABBIT
CITATION
CO CONVERSION LOSS
PERCENT CONVERSION LOSS
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80
70
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BASELN
2 TANKS
4 TANKS
6 TANKS
8 TANKS
10 TANKS
MISFUELING CONDITION
NOX EMISSIONS FOR THE 5 VEHICLES
FTP NOX EMISSIONS
4.0
3.5
3.0
2.5
2.0
1.5
1.0
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NO CAT
BASELN
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6 TANKS
8 TANKS
10 TANKS
NEW CAT
NEW O2
MISFUELING CONDITION
REGAL
LYNX
RELIANT
RABBIT
CITATION
NOX CONVERSION LOSS
PERCENT CONVERSION LOSS
100
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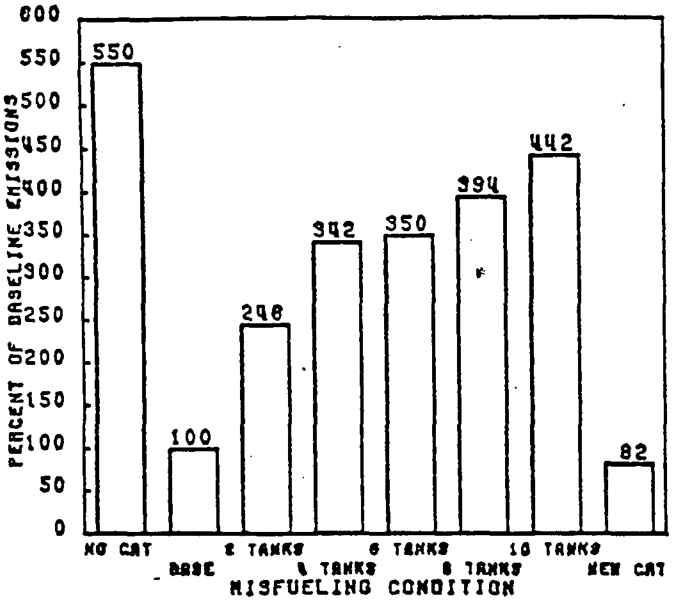
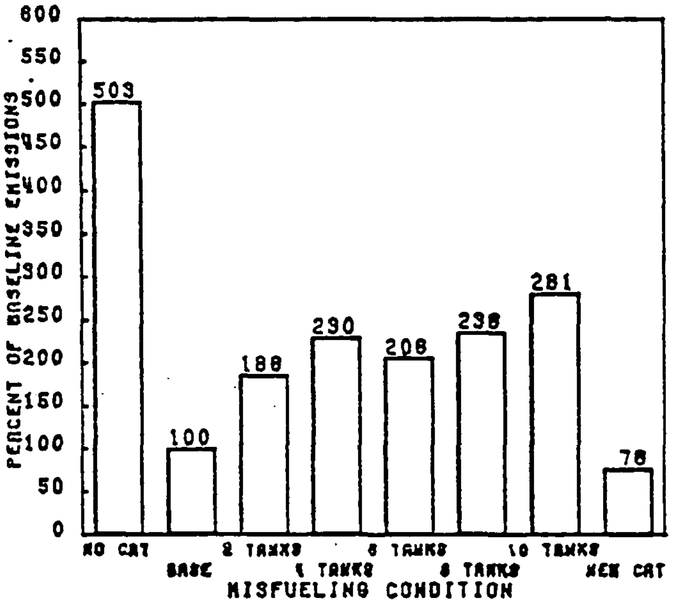
0
-10
REGAL
LYNX
RABBIT
CITATION
BASELN
2 TANKS
4 TANKS
6 TANKS
8 TANKS
10 TANKS
MISFUELING CONDITION

Figure 2

HC EMISSIONS AS PERCENT OF BASELINE
FOR ALL FIVE VEHICLES



CO EMISSIONS AS PERCENT OF BASELINE
FOR ALL FIVE VEHICLES



NOX EMISSIONS AS PERCENT OF BASELINE
FOR THE FOUR 3-WAY CAT VEHICLES

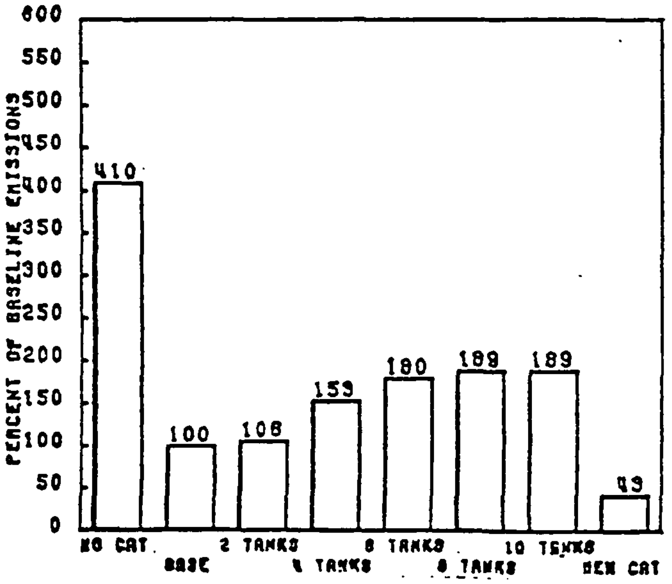
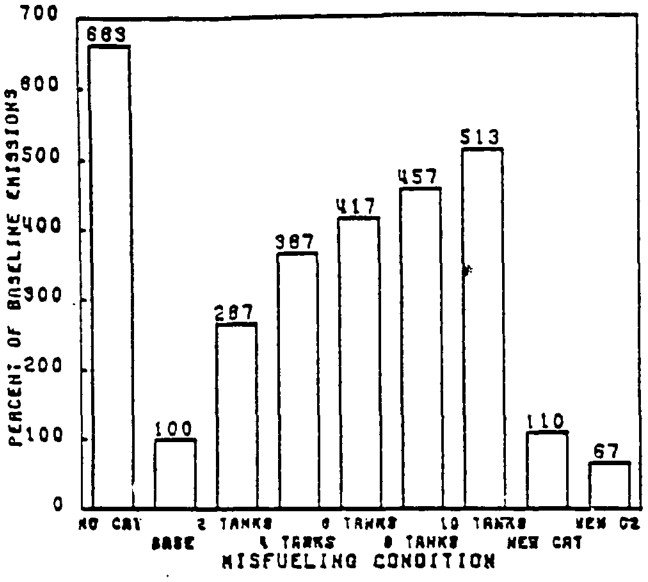
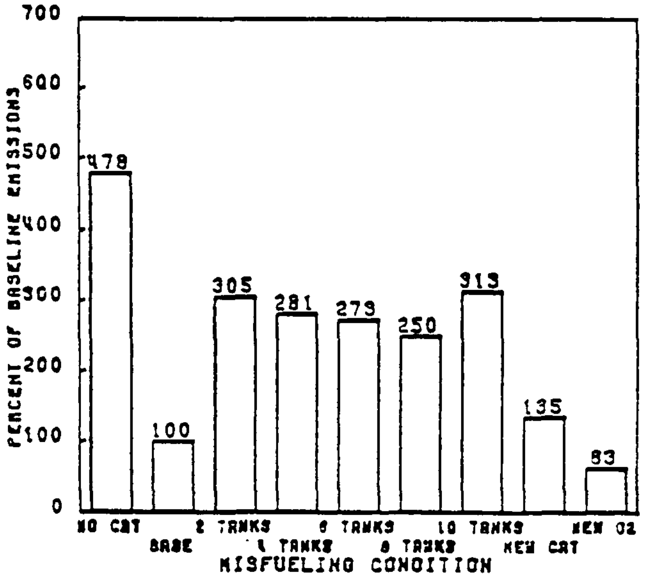


Figure 3

HC EMISSIONS AS PERCENT OF BASELINE
FOR THE THREE 3-WAY FEEDBACK VEHICLES



CO EMISSIONS AS PERCENT OF BASELINE
FOR THE THREE 3-WAY FEEDBACK VEHICLES



NOX EMISSIONS AS PERCENT OF BASELINE
FOR THE THREE 3-WAY FEEDBACK VEHICLES

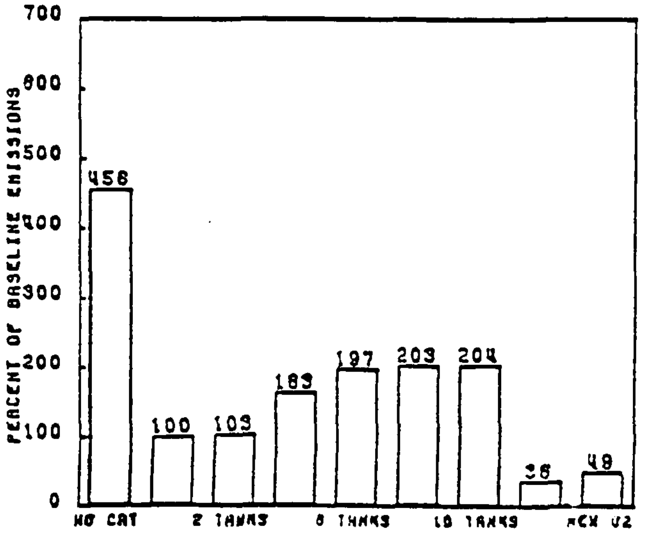
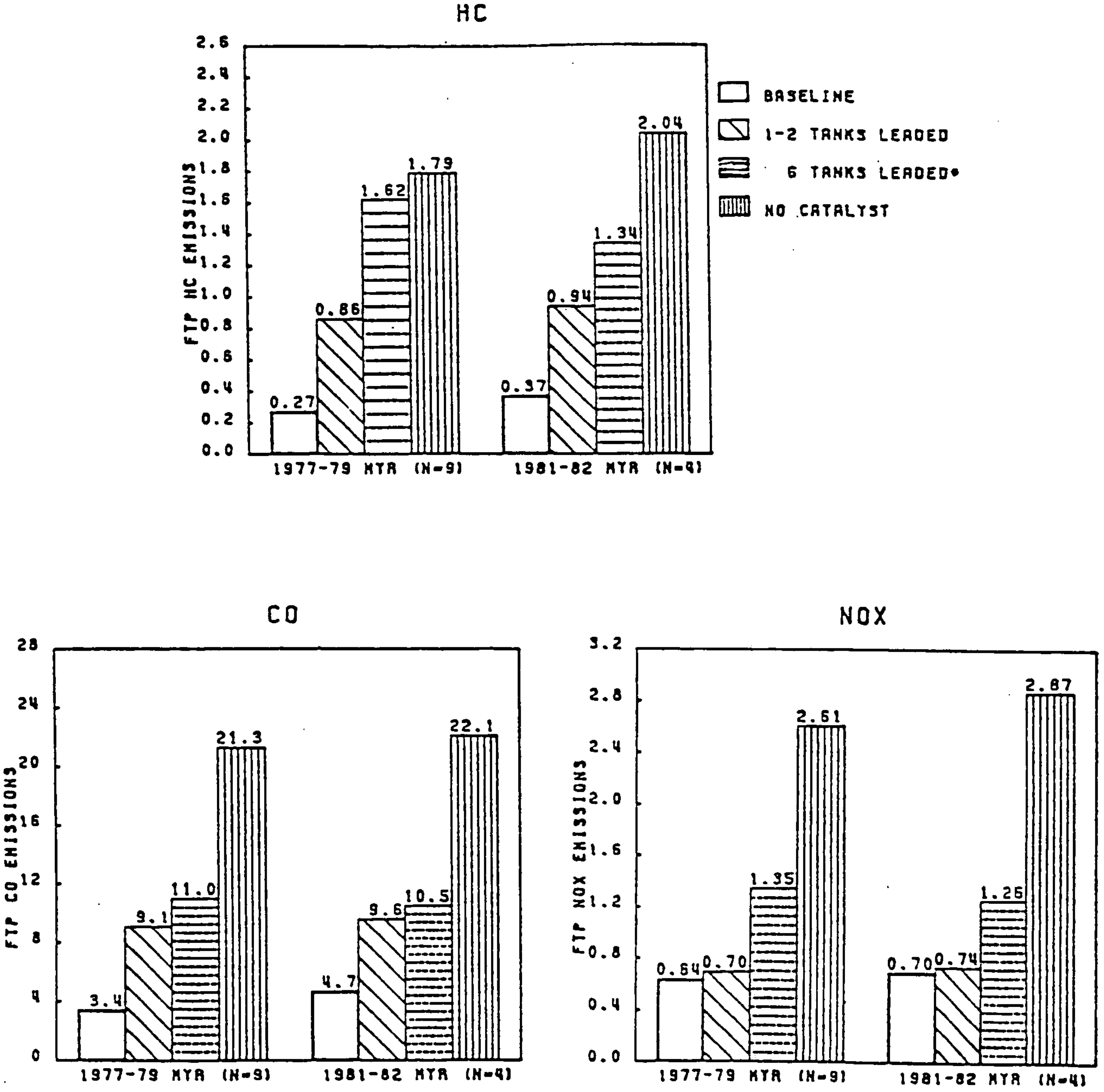


Figure 4

Comparison of Current 3-Way Catalyst Vehicles With Two Earlier Programs



Data for the 1981-82 MYR cars were taken after 6 tanks of leaded fuel. For the 1977-79 MYR cars, the tests were not conducted at specific tanks of leaded fuel, but averaged 6 tankfuls.

Figure 5

Comparison of Current 3-Way Catalyst Vehicles
With 3-Ways and Oxidation Catalyst Vehicles
From One Earlier Program

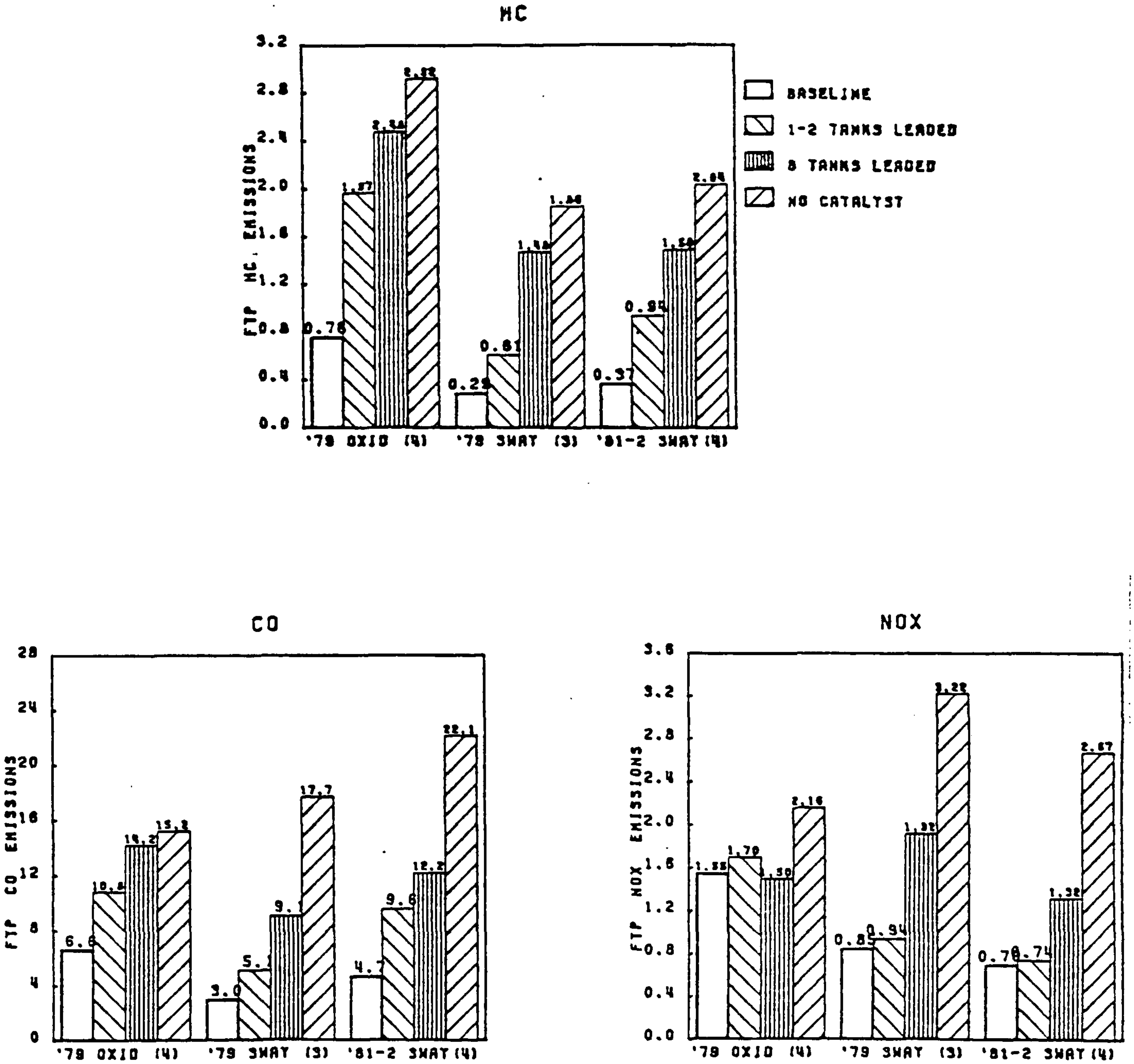
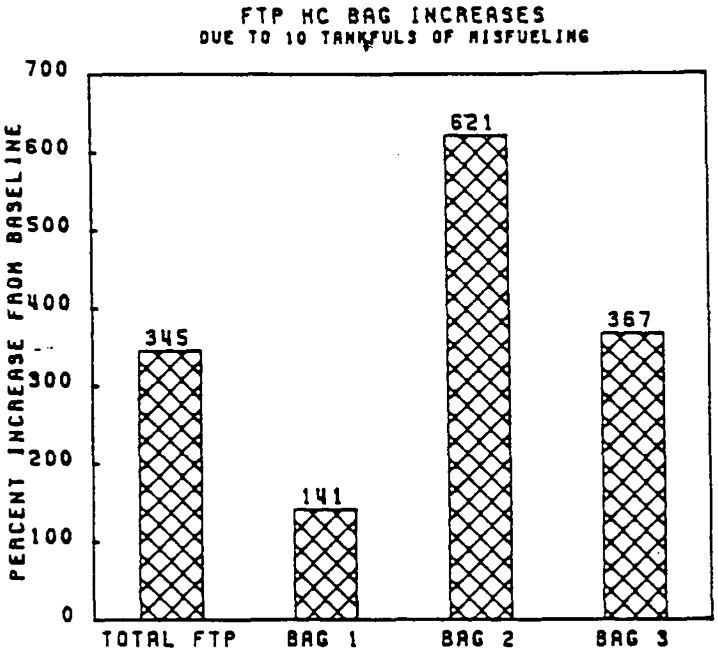


Figure 6

FTP HC Bag Emissions (N=5)



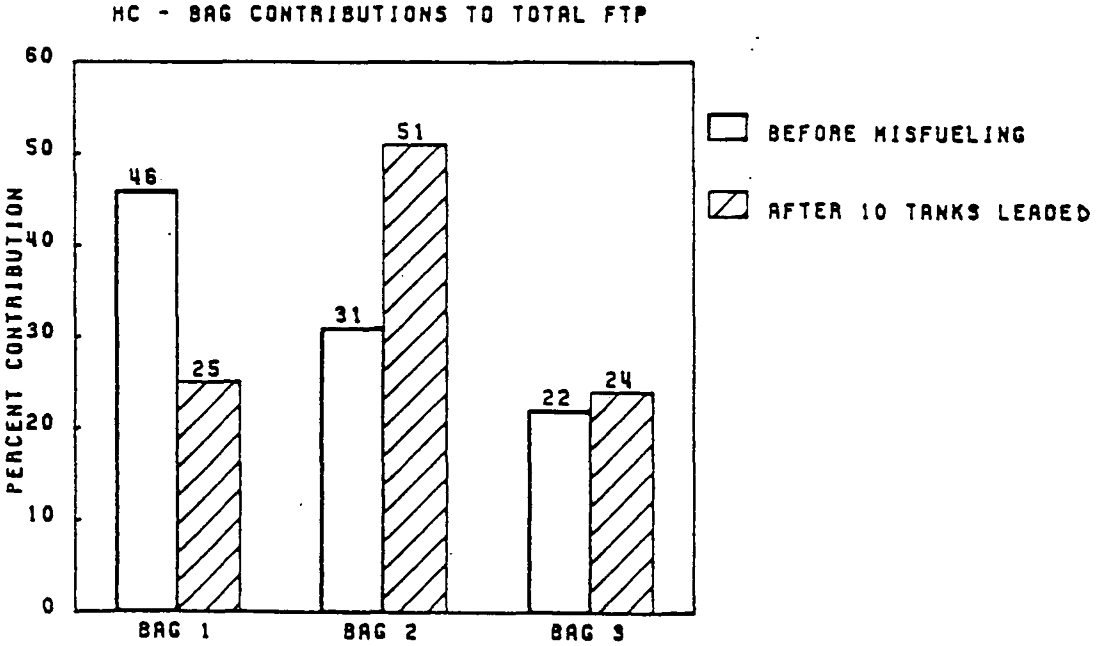
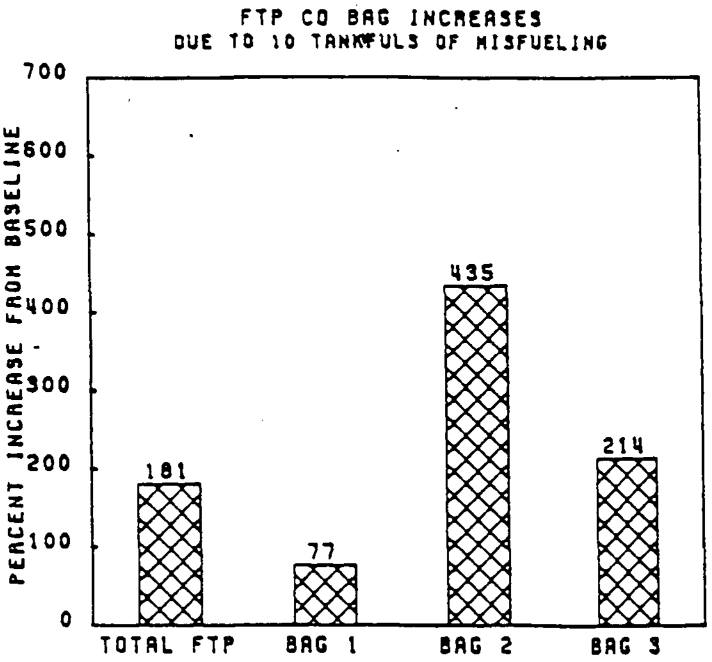


Figure 7

FTP CO Bag Emissions (N=5)



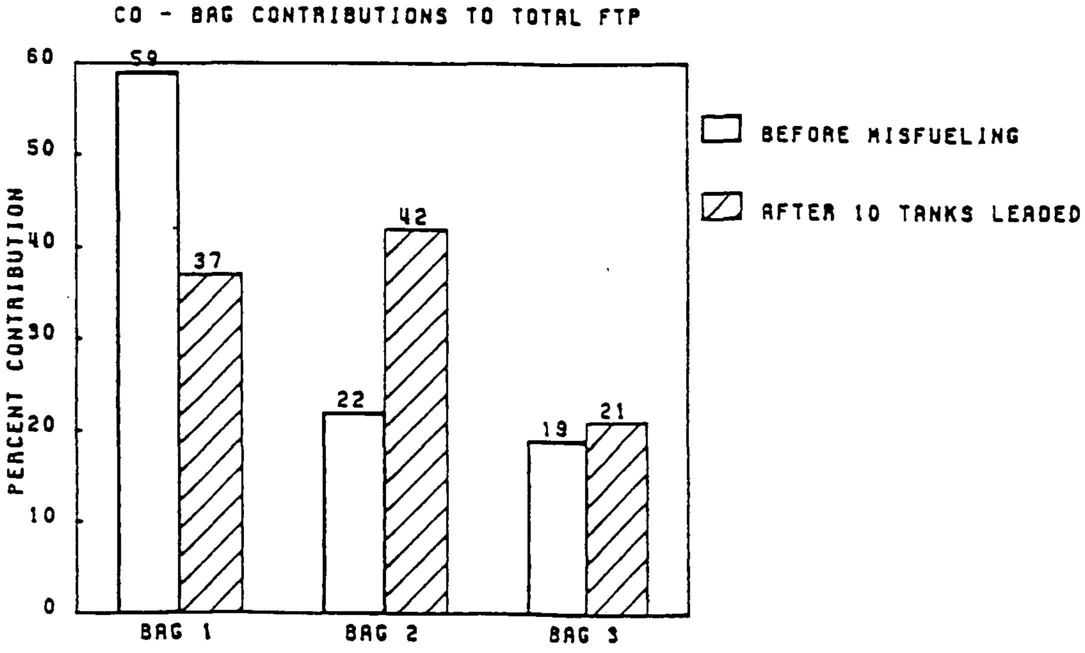
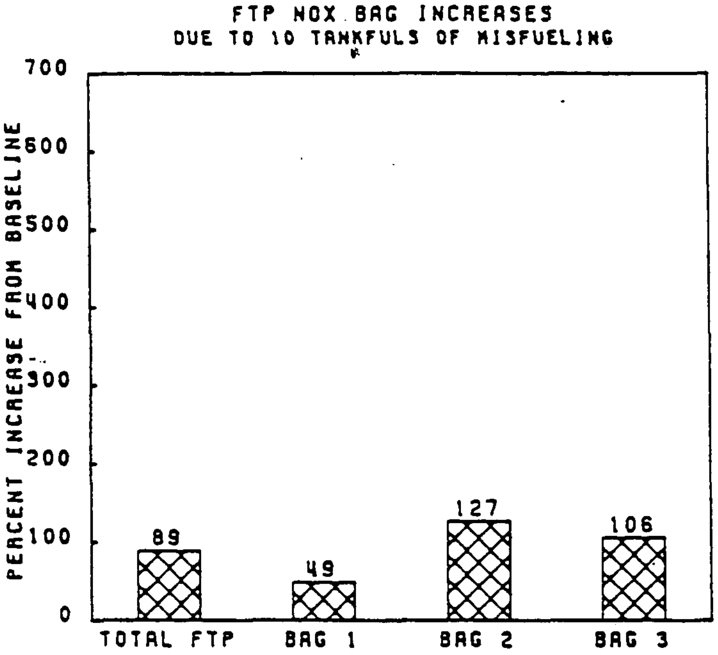
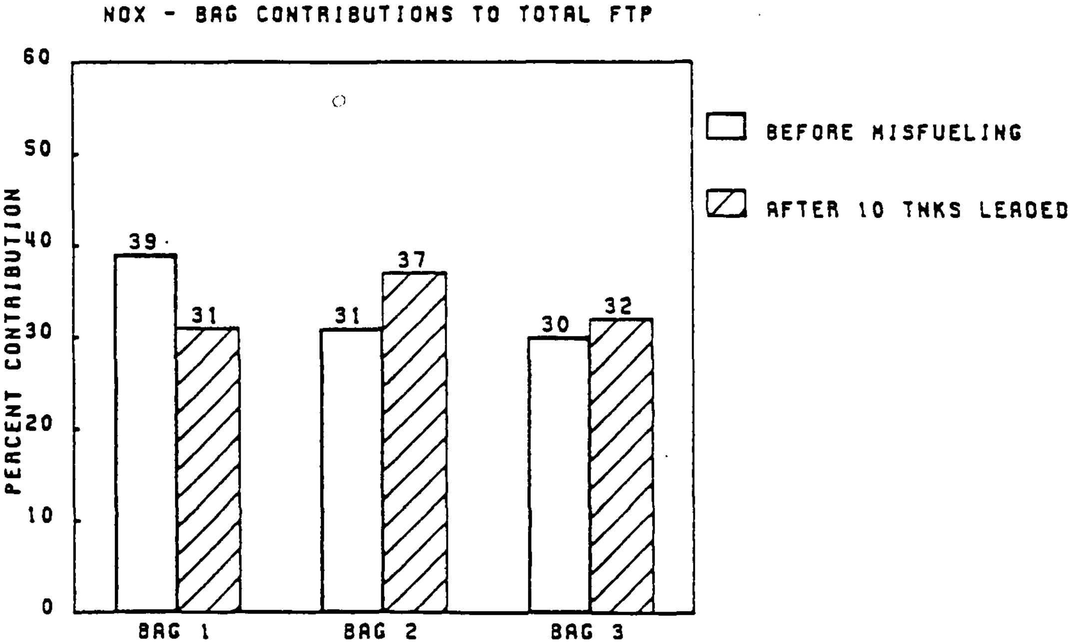


Figure 8

FTP NOx Bag Emissions (4 3-Way Catalyst Vehicles)





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APPENDIX

Test Vehicle Information

Item	Vehicle 1	Vehicle 2	Vehicle 3	Vehicle 4	Vehicle 5
Manufacturer	GM	Ford	Chrysler	Volkswagen	GM
Make	Buick	Mercury	Plymouth	VW	Chevrolet
Model	Regal	Lynx	Reliant	Rabbit	Citation
Model Year	1981	1981	1981	1981	1982
Eng. Displacement (CID)	231	98	156	105	151
Fuel System	Carb(2V)	Carb(2V)	Carb(2V)	Port F.I.	TBI
No. of Cylinders	6	4	4	4	4
Transmission Type	Auto (Lockup)	Auto	Auto	4-speed	Auto (Lockup)
Catayst Type	CL-Loop 3-Way	Open-Loop 3-Way	Oxidation	CL-Loop 3-Way	CL-Loop 3-Way
Supplementary Air	Pump	Pump	Pulse	None	None
V.I.N.	1G4AJ47A6BG1-18373	1MEBP6527-BW606833	1P313K46D5-BF129193	1VWBB0179-BV010897	1GIAX68R3C-6106894
Engine Family	14E2TM	1.6AP	BCR2.6V2BJ2	BVW1.7V6-FF537F	C2G25V5 -TPG5
Test Inertia Weight	3750	2625	2750	2375	3000
Test Hp	11.2	6.5	7.5	7.7	7.3
Initial Odometer	25,902	24,850	42,620	21,657	16,934
Tire Size	P195/75R14	P165/80R13	P175/80R13	155SR13	P185/80R13
EPA Fuel Economy					
City	21	26	23	28	25
Highway	30	36	31	42	40

						Four-Mode Idle Test						Loaded Two-Mode			
		FTP Data				1st Idle		2500 RPM		2nd Idle		30 mph		Idle	
Vehicle	Test	HC	CO	NOx	mpg	HC	CO	HC	CO	HC	CO	HC	CO	HC	CO
Regal	BASELN	.44	2.81	.80	19.07	24.	.09	10.	.00	7.	.04	10.	.02	51.	.09
	NOCAT	2.88	14.08	2.59	19.81	340.	.60	93.	.51	321.	.51	178.	.69	533.	.64
	LEAD_2	1.47	10.66	.91	20.19	150.	.34	56.	.08	47.	.05	93.	.10	112.	.05
	LEAD_4	1.73	12.02	1.06	19.43	236.	.19	89.	.08	99.	.19	148.	.29	217.	.25
	LEAD_6	1.77	11.36	1.23	19.23	217.	1.69	69.	.19	59.	.13	217.	.44	197.	.29
	LEAD_8	1.90	8.37	1.17	19.47	236.	1.29	69.	.12	158.	.12	168.	.19	217.	.07
	LEAD10	2.18	11.20	1.21	19.70	256.	.67	79.	.16	177.	.40	197.	.32	256.	.25
	NEWCAT	.62	5.64	.35	19.91	197.	1.06	20.	.01	20.	.04	30.	.05	10.	.03
	NEW_02	.35	2.50	.70	19.38	10.	.02	20.	.02	10.	.02	20.	.02	10.	.01
Lynx	BASELN	.57	11.82	.59	23.60	22.	.00	27.	.08	21.	.00	54.	.12	16.	.00
	NOCAT	2.20	55.49	1.49	23.72	112.	.19	121.	1.89	112.	.18	187.	2.43	112.	.42
	LEAD_2	1.36	17.35	.72	23.48	49.	.00	79.	.11	30.	.00	128.	1.25	39.	.00
	LEAD_4	1.76	26.12	.71	23.57	59.	.02	79.	.16	39.	.01	138.	1.19	39.	.01
	LEAD_6	1.62	23.15	.75	24.03	59.	.01	118.	.18	39.	.00	138.	.88	39.	.01
	LEAD_8	1.86	31.37	.82	24.02	59.	.01	79.	.16	39.	.01	118.	1.06	39.	.00
	LEAD10	2.14	39.64	.82	24.20	79.	.04	79.	.48	49.	.03	138.	1.06	39.	.03
	NEWCAT	.26	4.52	.42	23.38	20.	.01	10.	.01	10.	.01	59.	.02	10.	.01
Reliant	BASELN	.27	6.72	.67	24.72	10.	.00	22.	.02	9.	.00	27.	.08	9.	.00
	NOCAT	1.45	39.31	.64	23.66	37.	.44	65.	2.63	28.	.42	75.	1.64	37.	.42
	LEAD_2	.54	8.89	.73	23.05	30.	.02	39.	.04	20.	.01	49.	.07	10.	.01
	LEAD_4	.91	12.85	.75	23.32	30.	.04	49.	.11	20.	.02	59.	.32	20.	.01
	LEAD_6	.74	10.47	.79	24.12	30.	.05	39.	.13	20.	.03	59.	.29	20.	.02
	LEAD_8	.92	11.48	.74	26.14	30.	.05	59.	.53	20.	.02	79.	.48	20.	.03
	LEAD10	.97	10.46	.73	26.67	30.	.04	79.	1.00	10.	.02	99.	.88	20.	.03
	NEWCAT	.19	5.51	.43	26.47	10.	.00	10.	.00	10.	.00	10.	.01	10.	.00
Rabbit	BASELN	.33	2.01	.98	27.87	12.	.01	15.	.01	15.	.00	19.	.11	13.	.00
	NOCAT	1.70	10.67	3.45	27.98	65.	.99	56.	.74	75.	1.02	112.	.46	93.	1.08
	LEAD_2	.57	4.56	.95	24.58	18.	.00	9.	.00	18.	.00	30.	.05	15.	.00
	LEAD_4	1.06	1.60	1.88	28.13	39.	.01	30.	.02	39.	.01	118.	.12	49.	.01
	LEAD_6	1.32	1.59	2.28	27.92	49.	.02	49.	.04	59.	.02	128.	.15	59.	.01
	LEAD_8	1.40	2.27	2.17	28.45	49.	.01	59.	.04	59.	.01	118.	.13	59.	.01
	LEAD10	1.40	2.24	1.98	28.63	59.	.02	39.	.04	59.	.02	128.	.13	69.	.00
	NEWCAT	.21	1.14	.32	28.32	3.	.00	3.	.00	2.	.00	5.	.01	3.	.00
	NEW_02	.14	.67	.21	28.83	16.	.00	6.	.00	2.	.00	2.	.03	3.	.00
Citation	BASELN	.13	2.09	.42	22.95	9.	.15	6.	.00	13.	.33	12.	.04	6.	.02
	NOCAT	1.39	8.35	3.96	23.31	93.	.59	19.	.29	84.	.59	112.	.30	93.	.54
	LEAD_2	.36	5.82	.38	23.35	37.	.46	9.	.03	47.	.50	65.	.12	37.	.64
	LEAD_4	.52	5.79	.63	23.66	39.	.72	10.	.22	79.	.77	89.	.13	69.	.67
	LEAD_6	.67	5.93	.80	22.95	39.	.22	-0.	.08	20.	.22	89.	.15	49.	.29
	LEAD_8	.82	6.59	1.11	23.09	69.	.82	10.	.07	69.	.57	118.	.19	79.	.62
	LEAD10	1.05	8.12	1.27	22.76	59.	.36	10.	.16	59.	.36	128.	.24	89.	.94
	NEWCAT	.16	2.53	.10	22.60	13.	.26	2.	.01	6.	.11	67.	.08	12.	.08
	NEW_02	.11	1.20	.16	23.13	2.	.05	3.	.00	2.	.00	3.	.01	2.	.05

Appendix
FTP and Short Test Data for the Individual Cars