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A Study of Fuel Economy Changes Resulting from Tampering with Emission Controls

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Test and Evaluation Branch
Emission Control Technology Division
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Fuel Economy Changes Resulting from Tampering with Emission Controls

INTRODUCTION

As a result of recent concern over vehicle fuel economy, EPA has received numerous inquiries relating to the influence of emission controls on vehicle fuel consumption. Statements have appeared in the press and elsewhere indicating that motorists might improve their fuel economy as much as 25% by merely having a service station adjust the emission control systems. Because to EPA technical staff such claims appeared to be exaggerations, a test program was undertaken to quantify the fuel economy and emission change which would result from disconnecting emission controls and to determine whether private service garages could effectively improve fuel economy.

A group of ten late model (1973 and 1974) cars were obtained representing the full range of typical vehicle weights encountered in the existing vehicle population. The 1973 and 1974 automobiles selected for this program incorporate more alterations for low emissions than earlier models. (See Appendix A for a technical discussion of such alterations.) These vehicles have shown the greatest change in fuel economy from uncontrolled cars. On a sales weighted average 1973/74 cars are 10 to 11% lower in economy than the uncontrolled cars of equivalent weight. Successful re-optimization of these vehicles for best fuel economy would result in greater improvements than should be possible for 1972 and earlier models.

A number of garages were contacted with the request that "they do whatever they could" to improve gasoline mileage. In most of the cases the garages were not informed that the work was part of a test program for EPA so that results of any work done would be comparable to that performed for any private individual.

The majority of garages contacted declined to do the work either for the reason that they thought such work was illegal or because they did not want to contribute to deterioration of air quality, but 25% of the garages agreed to do the work. Some of these garages claimed that they could improve both performance and fuel economy with little impact on emissions; others were uncertain and asked for customer assessment of the results.

The basic test approach utilized in the program consisted of the following sequence of events:

(1) EPA inspection of vehicle and engine tune-up to manufacturers' specifications.

(2) Recording of carburetor and distributor specifications.

(3) Replicate EPA dynamometer test of vehicle to measure emissions and fuel economy utilizing the Federal Test Procedure.

(4) Tampering of the emission control system by either EPA mechanics or private garages.

(5) EPA dynamometer test of vehicle to measure emissions and fuel economy as in (3) above.

(6) EPA mechanics restore vehicle to manufacturers' specifications.

(7) EPA dynamometer test for emissions and fuel economy as in steps (3) and (5).

(8) Repeat test sequence above to insure that each vehicle was tested at least once to EPA and garage tamper.

Seven out of the ten vehicles were subjected to this basic approach. (Some vehicles were used more than once, for a total of 13 garage tampering episodes.) The dynamometer tests [steps (3), (5), and (7)] provided the comparative basis for determining the changes in fuel economy and exhaust emissions resulting from the tampering effort. This permitted conclusions to be drawn as to what fuel economy gains are achievable and what gains typical mechanics would make. Data on the emission and economy changes are shown in the attached tables and discussed in the Test Results section.

Three of the ten vehicles also followed the basic test approach above except the vehicles were not tuned by EPA prior to EPA dynamometer test and delivery to garages for tampering. The purpose of this deviation from the basic test approach was twofold: to ascertain whether the EPA tune-up was inadvertently assisting or biasing the garage tampering attempts and to obtain data on a real-world basis, i.e., tampering with an "as-received" vehicle would represent the normal challenge to the garage.

TEST PROGRAM

The attached Table 1 lists the ten test vehicles. Also shown is whether EPA tampered with the vehicle, and the garages that did tamper with the vehicle. All vehicles were rented from rental agencies or new car dealers. During the test program the 1972 Federal Test Procedure (FTP), as described in the November 15, 1972, Federal Register was used to determine emissions. Fuel economy for the '72 FTP driving cycle, which represents the typical urban commuter trip, was determined using the carbon mass balance technique. For a detailed discussion of this fuel economy test, see A Report on Automobile Fuel Economy, October 1973, by the United States Environmental Protection Agency, Office of Air and Water Programs, Office of Mobile Source Air Pollution Control.

The first seven vehicles listed in Table I were tuned to manufacturers' specifications by EPA before initial baseline testing. Except in the case of the '74 Pinto, for which replacement parts could not be obtained in time, the tune-up included installation of new plugs, points, condenser, rotor, and air cleaner. These vehicles were then modified by EPA and by at least one of eight garages in the Detroit metropolitan area. Except for garages B & D, there was no knowledge by the garages that their work was part of an EPA tampering test program. Emission and fuel economy testing was conducted by EPA after each modification. The last three vehicles listed in Table I were tested by EPA as received and then taken to garages for modifications without initial tune-ups in order to see what gross effect could be associated with a vehicle in a "typical" state of tune.

In all cases the EPA modification consisted of adjustment of ignition and fuel system parameters without modification or replacement of parts, and the disconnection of specific emission control devices that are external to the basic engine system.

The EPA modifications were made by engineers and technicians who have detailed knowledge of automotive emission control systems, as well as access to sophisticated test equipment. This level of skill and facilities is not ordinarily found in the average repair garage, as the test results will indicate.

TEST RESULTS

Table II summarizes the results of this test program. It can be seen from the EPA modification results that an average improvement of fuel economy of 7.0% was achieved. On the other hand, modifications by eight different garages in 13 different cases showed an average decrease in economy of 3.5%. The increases in emissions associated with the tampering are included in the tables, and must be compared to applicable standards of HC = 3.4 grams per mile (gpm), CO = 39 gpm, NO_x = 3.1 gpm, and to average emissions from pre-controlled cars of HC = 9.6 gpm, CO = 95 gpm, and NO_x = 3.5 gpm.

Tables III and IV give a breakdown by vehicle of the percentage change from the baseline tuned-up condition results.

Table V illustrates what can be achieved by tuning a vehicle to manufacturers' specifications. That is, an average of 9.0% improvement was achieved by tuning up the "as received" rental vehicles to manufacturers' specifications. Of these vehicles two cases out of three showed improvement in fuel economy. Table V also shows the change in fuel economy resulting from independent garage tampering on as-received vehicles. The data illustrate that the improvement was greatest by tuning the vehicle to manufacturers' specification. It should be noted that in the case of the Fury II station wagon one plug was fouled as received and was replaced by the garage. In the case of the '73 Vega a new air cleaner and spark plugs were installed as part of the garage modification.

Costs of the garage tampering averaged $22.86 with a range of $12.50 to $37.50. The tampering modifications made by private garages and their associated costs are listed in Appendix B.

CONCLUSION/SUMMARY

In no case were franchised new car dealers requested to perform the tampering. The Clean Air Act forbids dealers from tampering. The purpose of this program was to acquire technical information; the program was not oriented toward determining the compliance of dealers with Federal law. Therefore the garages that did tamper with the vehicles were all independent organizations. They represent a cross-section of the automobile service industry, and include corner gas stations, commercial tune-up centers, as well as a garage that is widely advertised in the Detroit metropolitan area as a specialist in the removal of emission control devices.

Of significant note, the garage that advertised its expertise in emission control removal modified two cars for EPA and in both cases was unsuccessful in improving fuel economy. Of even greater interest may be the fact that this organization knew that it was participating in the EPA program. It was necessary to inform them of the EPA program because their workload schedule was such that to get an anonymous test would have required a 45-day delay. The failure of this organization to achieve improved fuel economy may be attributable to the fact that it is oriented toward improved performance (for example, acceleration and top speed). This would indicate that application of a hot rodder's knowledge does not insure achievement of improved fuel economy.

This study indicates that at the hands of highly skilled emission control experts who have access to first-class tools and equipment, average passenger vehicle fuel economy improvements of approximately 7.0% can be obtained by tampering on '73-'74 cars equipped with the most stringent emission controls. However, emissions of air pollutants (HC, CO, and NO_x) increased an average of approximately 65.9%, 20.9%, and 125.7% resspectively, through such readjustment. Lesser gains in fuel economy would be expected from tampering with earlier model year controlled vehicles (i.e., 1972 or earlier) which have less stringent emission controls.

This study also suggests that independent garages in most cases (70%) perform modifications in which fuel economy losses result. The average change in fuel economy for thirteen cases of garage tampering was a reduction of (-)3.5%. Only four cases out of thirteen achieved even minor improved fuel economy. Thus, at present it appears that the result of widespread independent garage emission control system tampering would be expected to increase fuel consumption, at significant cost in terms of increased air pollution.

A further caution should be made. These studies did not address the potential damaging effects that tampering may have over long-term mileage accumulation. It is known that engine maladjustments and certain engine modifications can increase engine deterioration rates. Thus fuel economy losses should become even greater with mileage accumulation because of deleterious engine effects such as increased spark plug fouling from enrichment, and from detonation or preignition damage to valves, spark plugs, piston tops, and rings due to improper ignition timing.

TABLE I

Vehicle Selection and Modification Schedule

Vehicle	Year	Engine Disp.	Carb.	Trans.	Test Inertia	Access.	Approx. Mileage	EPA Mod	Number Garage Mods	Garage
VW Type I	'73	96 CID	IV	Std 4	2250 lbs	No	14,800	Yes	1	F
Chevy Impala	'73	350 "	2V	At 3	4500 "	A/C P/S P/B	4,600	Yes	2	A,D
Vega	'74	140 "	1V	At 3	2750 "	No	4,000	Yes	2	A,E
Ford SW	'73	400 "	2V	At 3	5500 "	A/C P/S P/B	12,200	Yes	1	G
Ford Torino	'73	351 "	2V	At 3	4500 "	A/C P/S P/B	9,500	Yes	2	B,E
Pinto	'74	140 "	2V	At 3	2750 "	No	3,700	Yes	1	G
Duster	'73	225 "	1V	At 3	3500 "	P/S P/B	4,200	Yes	1	B
Nova	'74	350 "	2V	At 3	4000 "	P/S P/B	2,000	No	1	C
Vega	'73	140 "	1V	At 3	2750	No	9,100	No	1	D
Fury II, SW	'73	400 "	2V	At 3	5500	A/C P/S P/B	6,700	Yes	1	H

TABLE II

Summary of Tampering Results on Fuel Economy/Emissions

Expressed as % Change from Baseline Tune-Up (Mfg's Spec)

	HC	CO	NO_x	Econ.	Number of Mods Tested	Number of Fuel Econ. Increases
Garage Mod '72 FTP	39.3	89.5	63.0	-3.5	13	4
EPA Mod '72 FTP	64.7	21.0	116.0	7.0	8	7

TABLE III

Fuel Economy/Emissions Effects of Garage Tampering

Expressed as % Change from Basline Tune-up (Mfg's Spec)

Vehicle	Garage	HC	CO	NO_x	Economy
'73 VW	F	35.5	-11.7	104.9	2.1
'73 Impala	A	92.0	116.9	33.9	- 9.1
'73 Impala	D	91.0	317.0	10.9	-15.5
'74 Vega	A	-12.9	- 7.3	-21.3	9.9
'74 Vega	E	14.5	29.9	0.4	- 5.2
'73 Ford SW	G	33.4	191.5	603.4	- 9.3
'73 Torino	B	28.9	69.8	50.6	- 0.9
'73 Torino	E	- 3.3	4.3	5.7	- 7.2
'74 Pinto	G	106.3	66.9	61.7	0.6
'73 Duster	B	0.7	38.8	3.2	0.0
'74 Nova	C	-17.7	-10.3	1.6	- 1.0
'73 Vega	D	10.0	11.2	72.4	- 4.6
'73 Fury SW	H	90.4	208.8	49.0	- 3.2

TABLE IV

Fuel Economy/Emissions Effects of EPA Tampering

Expressed as % Change from Baseline Tune-up (Mfg's Spec)

Vehicle	HC	CO	NO_x	Fuel Economy
'73 VW	41.5	-15.8	2.1	10.8
'73 Impala	39.6	59.9	107.5	13.6
'74 Vega	61.6	-17.5	151.3	17.8
'73 Ford SW	169.3	-37.2	442.1	-5.7
'73 Torino	63.6	83.7	38.7	6.3
'74 Pinto	146.9	48.7	87.9	2.2
'73 Duster	-15.3	-30.4	26.2	9.0
'73 Fury SW	31.8	- 4.9	58.0	6.5

TABLE V

Summary of Effects of Tampering
on Three "As Received" Vehicles 1/

Garage Mod & Change from "As Received	HC	CO	NO_x	Economy
* 73 Fury SW	-85.6	0.7	71.4	9.3
** 73 Vega	29.6	25.2	11.2	6.4
74 Nova	0	25.2	-62.6	-2.9
EPA Tune-up to Mfg's spec % Change from "As Received"				
* 73 Fury SW	-92.5	-67.4	14.8	18.2
** 73 Vega	17.6	12.6	-35.5	11.5
74 Nova	21.5	39.6	-63.2	-1.9

1/ Only one emission test on each car, as compared to replicate tests for the other cars in test program.

* Plug fouled in #4 cylinder

** Air cleaner and plugs

Appendix A

Discussion of Emission Control Systems

A very large number of factors influence the fuel economy of passenger cars. These factors fall into the general areas of vehicle operation (e.g., driver habits), ambient and road factors (e.g., temperature, wind, quality of road surface), and vehicle design factors. To determine the difference in the fuel economy of two automobiles, or two configurations of one automobile, it is necessary to hold the vehicle operation, ambient, and road factors constant. This is done during the Federal Emissions Test Procedure, as the test is run using the same conditions in the closely controlled environment of a chassis dynamometer test cell.

There are two key vehicle design factors that have been modified by the vehicle manufacturers to achieve lower exhaust emissions: spark timing, and carburetion (air/fuel ratio). Additionally, there have been compression ratio reductions made to allow for the use of low octane low lead fuel and to reduce NO_x formation. These compression ratio reductions have reduced fuel economy by an average of 3.5%.

Retarding of the spark advance from its optimum setting for best fuel economy can reduce exhaust emissions within the cylinder and outside of the cylinder. With retarded timing the combustion is initiated later and the piston is further down the cylinder during the main portion of the combustion event. This results in reduced exposure to the high temperatures which are conducive to high oxides of nitrogen (NO_x) formation.

Retarded timing also results in increased exhaust temperature because of the reduced expansion of the burned gases which result when the combustion is intiated later in the cycle. The high exhaust temperature promotes the further oxidation (combustion) of hydrocarbon (HC) and carbon monoxide (CO) in the exhaust system.

The carburetion required for minimum emissions depends on the type of control technique being used on the engine. The high oxygen availability of lean mixtures results not only in low HC and CO emissions, but also in optimum fuel economy. Most current vehicles use the lean carburetion approach to meet the emission standards. Alteration of carburetion on such vehicles can result in reduced economy and higher emissions.

Some systems, however, utilize control approaches in which rich carburetion is used to provide high HC and CO emissions to the exhaust manifold. These pollutants are then burned in the exhaust with the help of additional air pumped into the exhaust ports. The high emissions are required to provide sufficient "fuel" to the exhaust manifold so that the temperatures generated are high enough for near-complete combustion. This type of thermal after-treatment approach can be more effective than the lean carburetion approach as far as emissions are concerned, but fuel economy suffers. An additional emissions benefit of the rich carburetion approach is that it results in lower NO_x emissions due to the lower availability of oxygen during the combustion in the cylinder.

Air pumps are sometimes employed to facilitate HC and CO reductions in the exhaust of lean and rich burning engines by increasing the oxygen availability. Air pumps have no significant effect on fuel consumption because the small amount of power required to drive the pump results in only a small (almost immeasurable) loss.

Exhaust gas recirculation (EGR) reduces NO_x emissions by reducing the oxygen concentration and flame temperature during the combustion event. EGR can affect economy in several ways. With well controlled EGR rates economy can be improved slightly because the recirculated exhaust gas reduces the amount of throttling required to run the engine and it also allows more spark advance to be used. Because EGR reduces the octane requirement of an engine, a well-controlled system can allow higher compression ratios. Most EGR systems on current cars, however, do not take advantage of the octane improving properties of recirculated exhaust gas nor are they well controlled.

If EGR rates are not properly controlled, or if they are excessive, then fuel economy can suffer. High EGR rates slow down combustion and occasionally cause misfire. These phenomena in themselves reduce efficiency but even more loss can be incurred if richer carburetion is used to help clear up the poor combustion quality.

Current (1973-74) automobiles incorporate the above mentioned emission control techniques in a variety of ways. Most models incorporate some spark retard, EGR, carburetion enleanment, and low compression ratio in order to meet the emission standards.

Appendix B

Garage	A	Neighborhood garage
"	B	Speed Shop (knew cars were from EPA)
"	C	Neighborhood garage
"	D	Service station (knew cars were from EPA)
"	E	Service station
"	F	Neighborhood garage - specializing in VW
"	G	Neighborhood garage
"	H	Franchised tune-up center

Garage Modification Description and Cost

I. 73 VW Type I

a) Garage F - $26.00

1) Adjust valves

2) Advance timing

3) Adjust carburetor to lean idle

4) Change oil

II. 73 Chevrolet Impala

a) Garage A - $24.00

1) Change centrifugal advance springs

2) Adjust carburetor to rich idle

3) Advance timing

4) Readjusted carburetor floats

b) Garage D - $16.00

1) Changed centrifugal advance springs

2) Advanced timing

3) Disconnect EGR

4) Disconnect air pump

5) Adjust carburetor to rich idle

III. 74 Vega

a) Garage A - $25.00

1) Installed lean main jet

2) Advance timing

3) Set lean idle

b) Garage E - $37.00

1) Disconnect EGR

2) Adjust idle to rich idle

IV. 73 Ford station wagon

a) Garage B - $12.50

1) Disconnect EGR

2) Full vacuum advance

3) Adjust carburetor to rich idle

4) Advance timing

V. 73 Torino

a) Garage B - $20.00

1) Remove spark delay valve

2) Change centrifugal advance springs

3) Advance timing

4) Set carburetor to rich idle

b) Garage E - $37.50

1) Disconnect EGR

2) Set carb to rich idle

VI. 74 Pinto

a) Garage G - $17.75

1) Disconnect air pump

2) Disconnect EGR

3) Advance timing

4) Full vacuum advance

5) Adjust carburetor to rich idle

VII. 73 Duster

a) Garage B - $20.00

1) Advance timing

2) Went to full manifold vacuum advance

3) Adjust carburetor to rich idle

VIII. 74 Nova

a) Garage C - $15.00

1) Full vacuum advance

2) Advance timing

3) Adjust carburetor to lean idle

IX. 73 Vega

a) Garage D - $32.57

1) Replace spark plugs

2) Replace air cleaner

3) Retarded timing

4) Disconnect EGR

5) Adjust idle to lean idle

X. 73 Fury Station Wagon

a) Garage H - $13.90

1) Replace fouled plug

2) Tighten fuel line

3) Retune to specifications tuning (was performed in error)

4) Disconnect EGR

5) Disconnect vacuum spark advance thermal override and connected directly to ported carburetor vacuum

6) Tune carburetor to richer idle and lower idle speed

7) Inverted air cleaner thereby disconnecting evaporative and carburetor preheat systems.

Average Cost: $22.86

Appendix C

1972 FTP Results Fuel Economy Tampering

1973 VW Type I (96 CID)

	HC g/mi	CO g/mi	CO_2 g/mi	NO_x g/mi	Eco MPG
			Baseline		
	2.35	22.99	421.5	1.54	19.1
	2.84	21.81	401.8	1.34	19.9
Average	2.60	22.40	411.7	1.44	19.5
			EPA Mod		
	4.91	16.40	358.6	1.51	22.2
	2.44	21.29	384.5	1.43	20.9
Average	3.68	18.85	371.6	1.47	21.6
% Chg. from Baseline	41.5	-15.8	-9.7	2.1	10.8
			Garage F Mod		
	3.47	20.68	417.3	2.98	19.3
	3.56	18.87	393.8	2.92	20.4
Average	3.52	19.78	405.6	2.95	19.9
% Chg. from Baseline	35.5	-11.7	-1.5	104.9	2.1

Appendix C

1972 FTP Results Fuel Economy Tampering

1973 Chevrolet Impala (350 CID)

	HC g/mi	CO g/mi	CO_2 g/mi	NO_x g/mi	Eco MPG
			Baseline		
	3.29	45.64	723.2	1.66	11.0
	2.56	24.22	702.2	1.81	11.9
	2.80	47.9	783.3	.92	10.2
Average	2.88	39.25	736.2	1.46	11.0
			EPA Mod		
	4.38	64.45	603.7	3.16	12.3
	3.65	61.10	592.4	2.90	12.7
Average	4.02	62.78	598.1	3.03	12.5
% Chg. from Baseline	39.6	59.9	-19.0	107.5	13.6
			Garage A Mod		
	6.96	81.33	743.9	2.09	9.9
	4.10	88.98	731.9	1.81	10.0
Average	5.53	85.16	739.9	1.95	10.0
% Chg. from Baseline	92.0	116.9	0.5	33.6	-9.1
			Garage D Mod		
	5.77	177.41	683.3	1.41	9.1
	5.23	149.9	693.3	1.83	9.4
Average	5.50	163.66	688.3	1.62	9.3
% Chg. from Baseline	9.10	317.0	-6.5	10.9	-15.5

Appendix C

1972 FTP Results Fuel Economy Tampering

1974 Vega

	HC g/mi	CO g/mi	CO_2 g/mi	NO_x g/mi	Eco MPG
			Baseline		
	1.65	18.68	421.6	2.71	19.6
	1.53	18.58	405.8	2.45	20.2
	1.81	25.87	441.0	2.67	18.2
	1.91	23.03	439.2	1.40	18.4
Average	1.72	21.50	426.9	2.30	19.1
			EPA Mod		
	2.44	18.89	349.73	5.80	22.9
	3.11	16.59	365.45	5.76	22.1
Average	2.78	17.74	357.6	5.78	22.5
% Chg. from Baseline	61.6	-17.48	-16.2	151.3	17.8
			Garage A Mod		
	1.45	19.50	385.9	1.50	21.1
	1.63	22.05	403.5	2.13	20.0
	1.41	18.28	371.1	1.80	21.9
Average	1.50	19.94	386.8	1.81	21.0
% Chg. from Baseline	-12.9	-7.25	-9.4	-21.3	9.9
			Garage E Mod		
	1.99	30.23	431.6	2.08	18.3
	1.95	25.60	447.9	2.55	17.9
Average	1.97	27.92	439.7	2.31	18.1
% Chg. from Baseline	14.5	29.86	2.9	0.4	-5.2

Appendix C

1972 FTP Results Fuel Economy Tampering

1973 Ford SW (400 CID)

	HC g/mi	CO g/mi	CO_2 g/mi	NO_x g/mi	Eco MPG
Baseline					
	3.01	25.06	807.1	1.83	10.4
	2.85	16.87	754.5	1.07	11.2
Average	2.93	20.96	780.8	1.45	10.8
EPA Mod					
	8.18	14.8	823.1	6.95	10.17
	7.6	11.7	828.0	8.76	10.19
Average	7.89	13.2	825.6	7.86	10.18
% Chg. from Baseline	169.3	-37.2	5.7	442.1	-5.74
Garage G Mod					
Average	3.91	61.10	792.5	10.2	9.8
% Chg. from Baseline	33.4	191.5	1.5	603.4	-9.25

Appendix C

1972 FTP Results Fuel Economy Tampering

1973 Ford Torino (351 W CID)

	HC g/mi	CO g/mi	CO_2 g/mi	NO_x g/mi	Eco MPG
			Baseline		
	4.76	63.0	665.01	1.66	11.4
	2.99	40.9	717.60	2.15	11.2
	3.21	39.95	767.3	1.39	10.6
Average	3.65	47.95	716.64	1.73	11.1
			EPA Mod		
	6.13	91.0	597.56	2.55	11.7
	5.80	85.2	594.26	2.24	11.9
Average	5.97	88.1	595.91	2.40	11.8
% Chg. from Baseline	63.6	83.7	-16.8	38.7	6.3
			Garage B Mod		
	4.57	75.0	672.81	3.41	11.0
	4.94	78.5	671.52	3.43	10.9
Average	4.76	76.8	672.17	3.42	11.0
% Chg. from Baseline	30.4	60.2	-6.2	97.7	-00.9
			Garage E Mod		
Average	3.53	50.0	757.28	2.33	10.3
% Chg. from Baseline	-3.3	4.3	5.7	34.7	-7.2

Appendix C

1972 FTP Results Fuel Economy Tampering

1974 Ford Pinto (2.3 l)

	HC g/mi	CO g/mi	CO_2 g/mi	NO_x g/mi	Eco MPG
			Baseline		
	1.32	32.0	509.3	1.42	15.7
	1.53	34.0	495.9	1.01	16.0
Average	1.43	33.0	502.6	1.22	15.9
			EPA Mod		
	3.37	51.6	464.8	2.36	15.9
	3.15	46.4	452.4	2.22	16.6
Average	3.26	49.1	458.6	2.29	16.3
% Chg. from Baseline	146.9	48.7	-8.8	87.9	2.2
			Garage G Mod		
	2.97	55.3	454.2	2.17	16.1
	2.92	54.8	464.0	1.77	15.9
Average	2.95	55.1	459.1	1.97	16.0
% Chg. from Baseline	106.3	66.9	-8.7%	61.7	0.6

Appendix C

1972 FTP Results Fuel Economy Tampering

1973 Duster (225 CID)

	HC g/mi	CO g/mi	CO_2 g/mi	NO_x g/mi	Eco MPG
Stock Baseline	2.55	25.77	522.2	3.70	15.5
	Garage B Mod				
	2.71	33.4	503.1	3.31	15.7
	2.66	38.2	514.9	3.85	15.2
Average	2.72	35.8	509.0	3.58	15.5
% Chg. from Baseline	0.7	38.8	-2.5	3.2	0.0
	EPA Mod				
	2.15	16.18	502.2	5.22	16.6
	2.16	19.68	480.8	4.13	17.1
Average	2.16	17.93	491.5	4.67	16.9
% Chg. from Baseline	-15.3	-30.4	-5.9	26.2	9.0

Appendix C

1972 FTP Results Fuel Economy Tampering

1973 Fury II SW

	HC g/mi	CO g/mi	CO_2 g/mi	NO_x g/mi	Eco MPG
			Baseline		
	3.11	30.8	920.4	4.41	9.1
			EPA Mod		
	4.10	29.3	838.1	6.97	9.9
% Chg. from Baseline	31.8	-4.9	-8.9	58.0	6.5
			Garage H Mod		
	5.92	95.1	814.5	6.57	9.0
% Chg. from Baseline	90.4	208.8	-11.5	49.0	-3.2

Appendix C

1972 FTP Results--As Received Vehicles

HC g/mi	CO g/mi	NO_x g/mi	Eco MPG
74 Nova			
As Received			
1.77	18.5	1.71	10.5
Garage C Mod			
1.77	23.1	0.64	10.2
EPA-Spec. Tune			
2.15	25.8	0.63	10.3
73 Vega			
As Received			
2.26	34.9	2.59	17.3
Garage D Mod			
2.93	43.7	2.88	18.4
EPA-Spec. Tune			
2.66	39.3	1.67	19.3
73 Fury III SW			
As Received			
41.3	94.4	3.84	7.7
Garage H Mod			
5.92	95.1	6.58	9.0
EPA-Spec. Tune			
3.11	30.8	4.41	9.1

Appendix C

Overall Average 72 FTP Results

HC g/mi	CO g/mi	NO_x g/mi	Eco MPG
Baseline (spec. tune)			
2.57	30.7	2.00	14.2
EPA Mod			
4.23	37.1	4.31	15.2
Garage Mod			
3.58	58.2	3.25	13.7