77-18 FPH

An Evaluation of the Fuel Economy Performance of Thirty-One 1977 Production Vehicles Relative to Their Certification Vehicle Counterparts

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Introduction

The Environmental Protection Agency is conducting a number of studies to identify the magnitude and causes of reported differences between the fuel economies of in-use production vehicles and certification vehicles as reported in the Mileage Guide.

The purpose of the study reported herein was to investigate through a modest test program the magnitude of the differences (if any) in fuel economy between production and certification vehicles when both types of vehicles are tested at equivalent mileage (4000 miles) and state of tune on the dynamometer using the standard Federal Test Procedure.

Eleven car models representing the fuel economy leaders of the 1977 subcompact class were selected for this study. Also, the fuel economy leader within the individual manufacturer's specific car model was generally selected. Thus, the program was experimentally directed toward the highest fuel economy vehicles represented in the Mileage Guide and was not designed to be representative of the wide range of model offerings (and fuel economy) in the Guide.

Subcompact cars were selected because, with their greater fuel economies, there was greater potential for detecting any differences in production versus certification fuel economies. Three production cars from each model were scheduled to be tested at EPA's Motor Vehicle Emission Laboratory (MVEL) according to the 1977 certification testing procedure.

Recognizing the experimental focus on higher fuel economy models and the limited number of models selected, this program was intended to be only a first step toward identifying differences (if any) between production and certification vehicles and toward defining the need and basis for similar programs in the future.

Summary of Findings

1) Despite low mileages, significant adjustments were required to bring many of the vehicles to the proper state of tune as specified in manufacturer's recommendations.

2) Since the idle quality of 26% of the vehicles (eight vehicles) either remained poor or deteriorated after adjustment to manufacturer's specifications, adjustments to improve idle quality may be made in the field which could adversely affect both emission and fuel economy levels.

3) After adjustment to manufacturers' specifications, most vehicles met the 1977 emission standards by a wide margin although the emission standards were exceeded by five vehicles for one pollutant (Dodge Colt for HC, two Fiat 128's for CO, one VW and one Gremlin for NOx), one vehicle for two pollutants (Pontiac Sunbird for HC and CO), and one vehicle for three pollutants (Dodge Colt).

4) Production vehicle fuel economies of the sub-compact class were generally below certification levels with somewhat less than half of the production vehicles being more than 10% lower than the certification values.

5) The percent shortfall of production vehicles from certification vehicle fuel economy was generally greater as the certification fuel economy increased; conversely, the production vehicles in this group that had the lower certification fuel economy values tended to equal or exceed those values when tested in this program.

6) Test-to-test and vehicle-to-vehicle variability for each vehicle and model were low and, therefore, do not explain the production to certification fuel economy disparities.

7) The production vehicles with the largest shortfall, both as a percentage and by absolute mpg, are the "fuel economy leaders" in the Mileage Guide. This pattern is attributable only to the existence of a real difference between certification vehicles and production vehicles.

8) Looking at country of origin, all of the vehicles (four out of 11 vehicle types tested) which exhibited the greatest shortfalls on both the FTP and the HFET were imports from Japan (Honda, Datsun, Toyota and Colt). However, these vehicle manufacturers are the fuel economy leaders irrespective of whether the comparison is based upon the Mileage Guide or the production vehicle results of this program. All of the vehicles (VW, Ford 2.8L Pinto, Gremlin 2.0L) which either exceeded or equalled on average their counterpart certification vehicle fuel economies were either manufactured in Germany or were powered by engines built wholly or in part in Germany. These vehicle types represented three of the 11 types tested. Of the three domestic types tested, the Ford Pinto (2.3L engine) exhibited the smallest shortfall followed by the Pontiac Sunbird and the Chevrolet Chevette for the FTP. The Pontiac Sunbird had the smallest shortfall followed by the Ford Pinto (2.3L engine) and Chevrolet Chevette for the HFET. The Chevette shortfall was almost as large as the worst cases observed.

Conclusions

Analysis of the results from this study suggests that the fuel economy performance of subcompact vehicles supplied to the EPA by the vehicle manufacturers for purposes of emissions certification and fuel economy determination are not in all cases representative of the comparable production vehicles. The small sample size for each vehicle specification precludes an exact statistical quantification of the fuel economy performance difference which exists. No extrapolation to other classes of vehicles can be made from this study, nor would such an extrapolation be appropriate, because in other studies EPA has found that, in general, the prototype to production vehicle fuel economy shortfall is highest for sub-compact vehicles.

The EPA cannot identify technological reasons which would explain the high degree of fuel efficiency observed in the certification vehicles which represent the fuel economy leaders in the Mileage Guide, nor reasons which would explain the apparent lack of consistency of fuel economy performance between the certification vehicles and their production vehicle counterparts.

It is worth noting that no analogous pattern of discrepancies was found for the emission characteristics of the in-use cars, which on the whole handily met the emission standards applicable to them. This may suggest that at least for the fuel economy leaders the basic certification testing program, which is designed for determining the capability of a vehicle complying with emission standards, may be more suitable for that purpose than for precisely quantifying the fuel economy characteristics of a model type. The testing program was not designed to quantify the mean emission level of a model type, but rather to provide a high level of assurance that the emission standard will not be exceeded. More analysis is needed to determine if this program is or can be made to be adequate for concurrently quantifying the mean fuel economy performance of each model type.

The fuel economy values for vehicles listed in the mileage guide usually represent the sales-weighted average fuel economy of several vehicle configurations that were tested in EPA's emission certification and fuel economy programs (e.g., data for four and five speed manual transmission equipped vehicles were averaged in the 1977 Mileage Guide). The test results from this study show that in many cases the production car shortfall for the fuel economy leaders within the subcompact class was even greater when the production car fuel economy was compared against the fuel economy measured for the exactly comparable certification vehicle rather than the sales weighted average fuel economy reported in the Mileage Guide. Conversely the shortfall was usually less or non-existent when the production cars representing lower fuel economies (i.e. lower ranking) in the subcompact class were compared to their exact certification configurations.

This suggests that the degree of precision provided by the average fuel economy reported for each model in the Mileage Guide is being adversely affected by the prototype vehicle configurations producing the highest absolute fuel economies. Since only the high fuel economy configurations were generally tested in this study it is unknown what shortfall (if any) would exist if the fuel economies of the production car configurations were averaged and compared in the same manner as the certification configurations. However, since this study found a sharply decreasing shortfall trend with decreasing absolute fuel economy, it may be concluded that the shortfall (if any) would be lower for the comparison made on an average fuel economy basis. This latter conclusion is important since the primary purpose of the EPA fuel economy program is to determine the sale-weighted corporate average fuel economy (CAFE) for purposes of determining a manufacturer's compliance with fuel economy standards under the Energy Policy and Conservation Act.

In view of the findings of this and other studies, EPA is continuing to study ways of improving the representativeness of the mileage guide fuel economy values. This will include continued study of all possible causes of the discrepancies identified in this test program to help EPA assure that prototype vehicles are fully representative of production cars and to study different methodologies for collection and dissemination of fuel economy information for consumer purposes.

Test Procedure

The eleven 1977 vehicle models selected for testing are briefly described in Table 1. Appendix I contains detailed vehicle descriptions. Two vehicles representing each model were obtained by a contractor from private owners in the Southeastern Michigan area and delivered to MVEL for testing. The vehicles so obtained were required to have between 3,500 and 8,000 miles of owner-accumulated mileage. The owner was requested to sign a statement which established that the vehicle emission controls had not been tampered with and that the correct fuel had been used.

In addition to the two privately-owned vehicles supplied for each model, the manufacturers of each respective model were invited to supply a third representative vehicle. The manufacturers were also invited to participate in the check-in inspection of all of their products and generally did so.

Table 1
General Vehicle Descriptions

Model Year	Model	Engine	Transmission	Final Drive Ratio
1977	AMC Gremlin	2.0L	Manual-4 or Automatic-3	3.31:1
1977	Chevrolet Chevette	1.6L	Manual-4	3.70:1
1977	Datsun B210	1.6L	Manual-5	3.70:1
1977	Dodge Colt	1.6L	Manual-4	3.31:1, 3.54:1, 3.89:1
1977	Fiat 128	1.3L	Manual-4	3.76:1
1977	Ford Pinto	2.3L	Manual-4	2.73:1
1977	Ford Pinto Wagon	2.8L	Automatic-3	3.00:1
1977	Honda Civic CVCC	1.5L	Manual-5	3.88:1
1977	Pontiac Sunbird	2.5L	Manual-4	2.74:1, 2.93:1
1977	Toyota Corolla	1.2L	Manual-4/5	3.91:1, 4.10:1
1977	VW Rabbit	1.6L	Manual-4	3.90:1

The check-in inspection was conducted to ensure that the vehicles were as similar as possible to their certification vehicle counterparts, i.e., that each vehicle had: 1) a leak-free exhaust system, 2) was manufactured with the proper components, 3) had all emission control equipment properly installed and functioning, and 4) was tuned to specification. The items checked varied from vehicle to vehicle but in general included those listed in Table 2. Adjustable items were set to nominal values as recommended by the manufacturers in their service literature or instructions. The fuel tank was emptied and filled with the type of gasoline used in the 1977 certification testing.

Table 2
Typical Parameters Checked During Vehicle Inspection

Exhaust system integrity
Driven wheel brake drag
Axle ratio
Vehicle curb weight
Ignition timing
Ignition dwell
Full spark advance
Spark trace pattern
Fast idle rpm
Curb idle rpm
Idle CO percent and/or other idle mixture measurements
Idle quality
Spark plug condition and gap
Cranking compression
Battery fluid level
Engine oil level
Transmission fluid level
Differential fluid level
Coolant level
Air filter condition
Valve adjustment

Following the check-in procedure, the vehicles were given an initial preconditioning consisting of three EPA urban dynamometer driving schedules (UDDS) prior to the normal UDDS prep cycle. The initial preconditioning was implemented to assure that the evaporative canisters were adequately purged. The testing of each vehicle consisted of three '77 Federal Test Procedures (FTP) and three Highway Fuel Economy Tests (HFET). Two FTPs and two HFETs were conducted on one dynamometer by the same driver for all vehicles. The third FTP and HFET were conducted on another dynamometer by other drivers. This was intended to give some indication of the repeatability of the vehicle and variations induced by alternate driver/dynamometer combinations. At the completion of testing the vehicles were again checked to verify that they were still properly tuned, etc.

Discussion and Results

The check-in procedure for all of the vehicles was detailed and required an average of three hours per vehicle. Nearly all vehicles required some adjustments. Nine vehicles had exhaust systems with leaks severe enough to require correction. Several manufacturers requested to have the valve lash checked and adjusted. The individual vehicle adjustments are summarized in Table 3.

Despite the fact that these were new, low mileage vehicles which supposedly had not been maladjusted or tampered with, many required considerable adjustment to bring them to manufacturers' specification. Five vehicles exhibited poor idle quality as received. The idle quality of eight vehicles either deteriorated as a consequence of adjustment to specifications or remained poor despite adjustment. Poor idle conditions resulting from adjustment to specifications may lead to subsequent adjustments to other than specified settings which could increase emissions and decrease fuel economy. If the vehicles had been tested before tuning, many would undoubtedly have shown higher emissions and poorer fuel economy. Such testing was not a part of this program, because the testing of as-received vehicles has been adequately covered in other EPA surveillance programs.

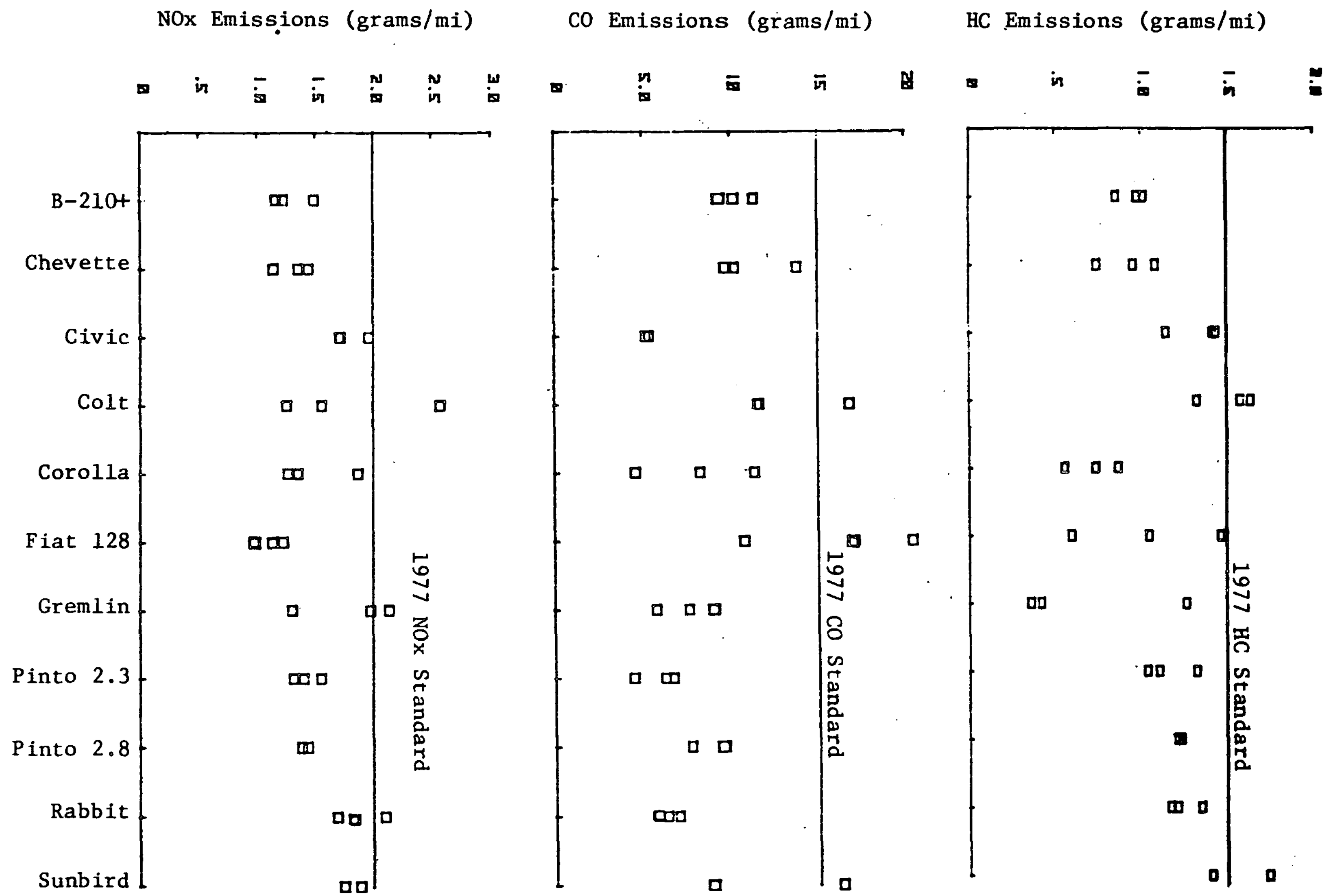
The measured emission levels of the vehicles over the FTP are given (the mean of the results of 3 tests of each vehicle) in Appendix II as average values. To compare these emission levels to the 1977 Federal emission standards of 1.5, 15, and 2.0 grams per mile of HC, CO, and NOx, the measured values are multiplied by the applicable deterioration factors determined from certification for each engine family. For the vehicles tested at more than 4,000 miles, the certification deterioration factors used to project 50,000 miles values were adjusted accordingly. This yields the projected 50,000 mile emission levels for each vehicle. Appendix II also presents these projected emission levels. Figure 1 contains plots of these projected emission values. As can be seen the vehicles were, for the most part, meeting the emission standards, many by a wide margin. Those exceeding the standard in one or more of the three pollutants tended to fail by a small margin. Only one vehicle failed all three pollutant levels.

Table 3
Summary of Pre-Test Adjustments

Vehicle (I.D.)	Timing	Idle Speed	Idle Mixture	Exhaust Leak Fixed	Oil Added	Valve Lash	Spark Plug Gap	Brake Drag	Other	Idle Quality Initial	Idle Quality Adjusted
Chevette (038)			X	X	X					fair	poor
Chevette (084)		X								fair	poor
Chevette (065)		X					X			poor	poor
Colt (382)	X	X	X	X	X	X	X			good	good
Colt (452)			X	X	X		X			--	--
Colt (943)			X	X			X			fair	good
Datsun (746)		X	X			X	X		a, b	good	fair
Datsun (360)						X		X	a, b	--	--
Datsun (411)	X	X	X			X				good	fair
Fiat (199)	X	X								good	good
Fiat (322)	X	X					X			good	good
Fiat (659)	X	X	X				X			--	good
Gremlin (317)		X		X				X		poor	poor
Gremlin (693)		X		X		X			c, d	good	good
Gremlin (587)	X	X	X	X				X		poor	poor
Honda (166)	X	X				X				--	--
Honda (GM) (087)					X					good	good
Honda (Honda) (458)										good	good
Pinto 2.3L (495)	X									fair	--
Pinto 2.3L (742)	X	X	X		X				e	poor	fair
Pinto 2.3L (930)	X	X			X					fair	fair
Pinto 2.8L (330)		X								poor	good
Pinto 2.8L (162)		X			X		X			fair	fair
Sunbird (762)	X		1	X				X		good	good[3]
Sunbird (720)	X	X		X						fair	good
Corolla (075)		X								--	fair
Corolla (331)		X							f	--	--
Corolla (096)	X		X							good	good
Rabbit (310)	X						2			good	good
Rabbit (162)										good	good
Rabbit (532)		X								good	--

a - Throttle dash pot
b - Fuel shut-off system
c - Belt tension
d - Throttle linkage
e - Coolant
f - Clutch
x - Adjustment performed

1 - Was determined to be overly rich after testing GM initially declined adjustment prior to test.
2 - Spark plug broken at inspection & replaced.
3 - Sunbird (762) idle condition deteriorated to poor after idle mixture adjustment. It resulted in a very rough idle condition with severe engine rock.



Average Projected 50,000 Mile Emission Values for Each Vehicle

Figure 1

The fuel economy results are plotted in Figures 2 and 3. It can be seen that the production vehicles generally fell well below their certification vehicle counterparts. Also, nearly 40% of the vehicles achieved less than 90% of the certification value. These results are given in detail as tables in Appendix III. For each vehicle the measured fuel economies over the FTP and HFET are shown for each test as well as the mean and the standard deviation as a percent of the mean. The certification vehicle fuel economies obtained by EPA and by the manufacturer, as well as the fuel economy reported in the Mileage Guide are listed in the left columns of the appendix tables. In the right columns, the production vehicle fuel economies are shown as a percent of both the EPA Certification value and the mileage guide value.[1]

Another method of analyzing the fuel economy results is to look at the relative fuel economy ranking of the vehicles (see Table 4). Comparison of the FTP certification and production vehicle fuel economies shows that VW Rabbit moved from a ranking of twelfth in certification to eighth in production, thereby moving ahead of the two calibrations of 2.3L Pintos, one of the Pontiac Sunbirds, and the Colt station wagon. Similarly, comparing the HFET certification and production vehicle fuel economies shows that the Rabbit moved from tenth to seventh by moving ahead of the 2.3L Pintos and one of the Pontiac Sunbirds. The Gremlin with the manual transmission advanced from thirteenth to eleventh passing one 2.3L Pinto and Fiat.

The 2.8L Pinto station wagons are not really in the mileage leader class as are the remainder of the vehicles tested. The 2.8L Pintos did achieve the largest percentage improvement in fuel economy when comparing production and certification vehicles for the FTP (8.7 and 8.4%) and for the HFET the 2.8L Pintos (7.0 and 4.8%) were second only to the Gremlin manual (8.5%). It is possible that these increases would have advanced the 2.8L Pinto in a ranking of vehicles of comparable fuel economies. Comparable fuel economy vehicles were not tested in this program.

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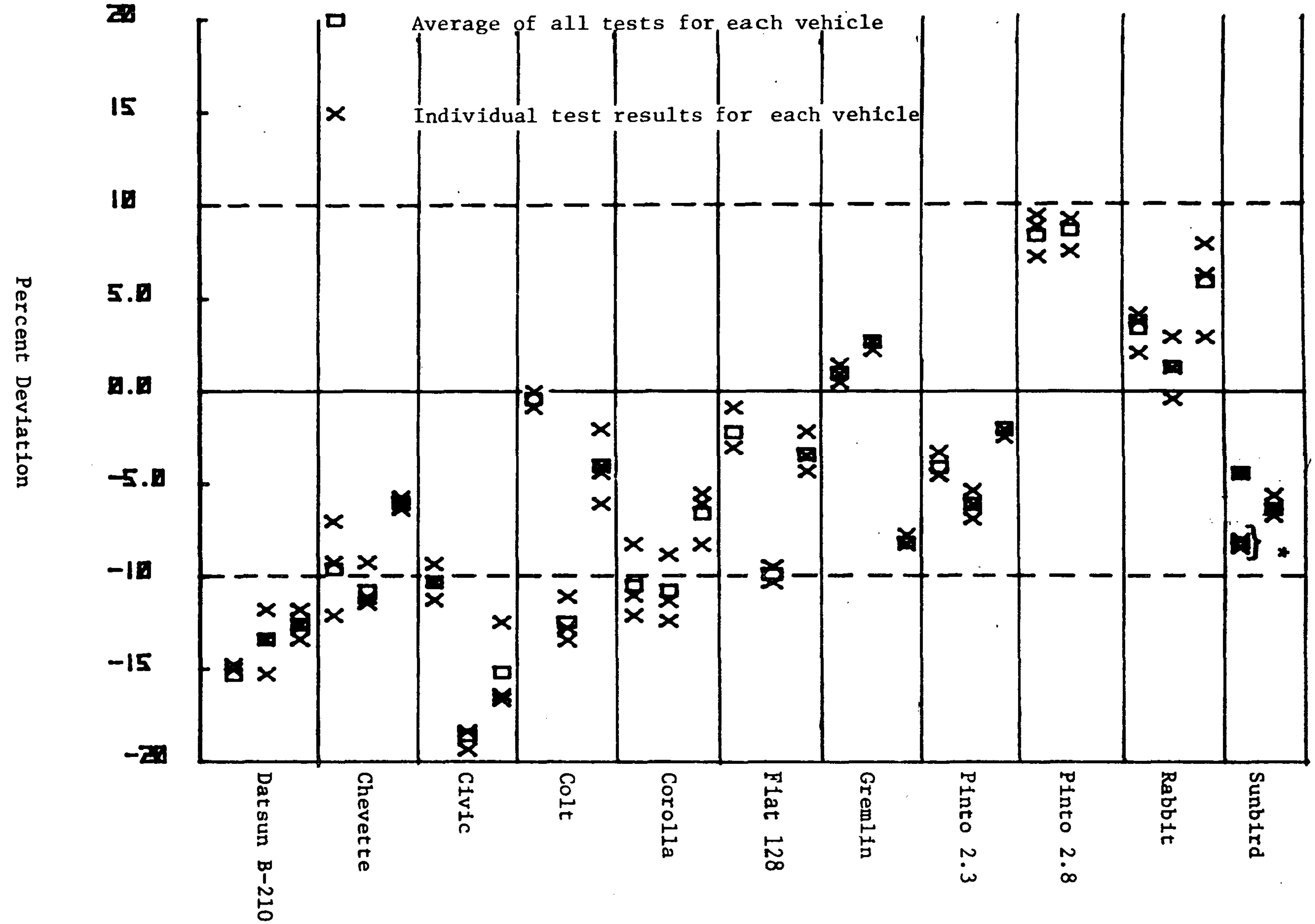
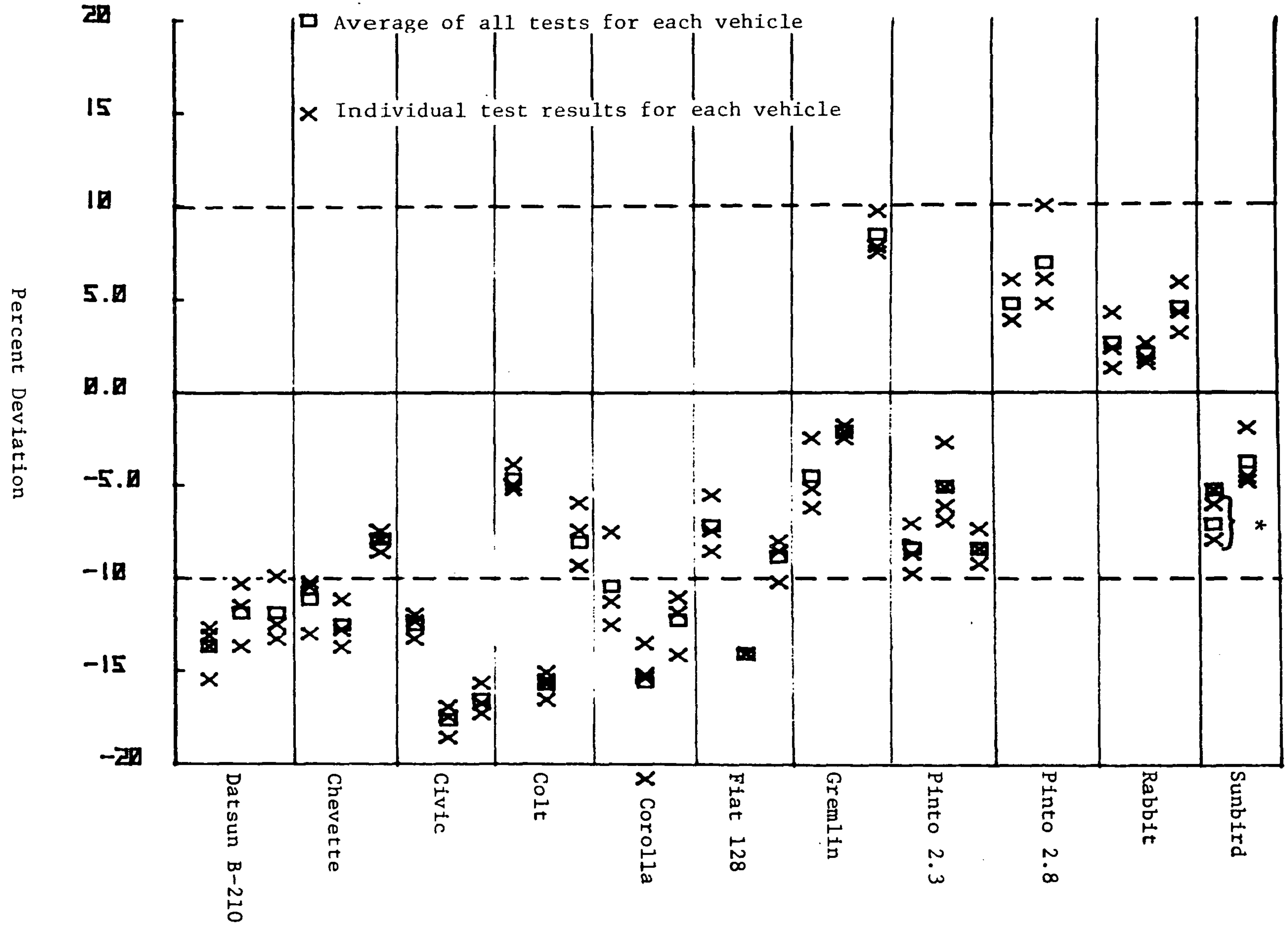
[1] There are several reasons why the Mileage Guide and the EPA Certification values may differ. The more important are: 1) that a number of engine calibrations, each with its own certification value, may be combined to yield the Mileage Guide value, 2) manual 3, 4 and/or 5 speed vehicle fuel economies are combined, and 3) Mileage Guide values are rounded to the nearest whole numbers.



'77 FTP Fuel Economy - Production Vehicle Percent Deviation
from Certification Vehicle by Model

Figure 2

*Prior to idle mixture adjustment.



HFET Fuel Economy - Production Vehicle Percent Deviation
from Certification Vehicle by Model

Figure 3

*Prior to idle mixture adjustment.

Table 4

Ranking of the Vehicles Tested in Order of Decreasing Fuel Economy

FTP			HFET		
Mileage Guide	Certification Vehicle	Production Vehicles	Mileage Guide	Certification Vehicle	Production Vehicles
1-Honda	1-Honda	1-Honda	1-Honda	1-Honda	1-Honda
2-Datsun	2-Datsun	2-Toyota M4	2-Datsun	2-Datsun	2-Datsun
3-Toyota M5	3-Toyota M5	3-Toyota M5	3-Toyota M5	3-Toyota M5	3-Toyota M5
3-Toyota M4	4-Toyota M4	4-Datsun	3-Toyota M4	4-Toyota M4	4-Colt sdn.
5-Chevette	5-Chevette	5-Chevette	5-Colt sdn.	5-Colt sdn.	5-Toyota M4
6-Colt sdn.	6-Colt sdn.	6-Colt sdn.	6-Chevette	6-Chevette	6-Chevette
7-Pinto 2.3 (1)*	7-Sunbird (1)	7-Sunbird (1)**	7-Colt SW	7-Sunbird (1)	7-Rabbit
7-Pinto 2.3 (2)*	8-Pinto 2.3 (1)	8-Rabbit	7-Pinto 2.3 (1)	8-Pinto 2.3 (1)	8-Sunbird (1)
7-Sunbird (1)**	9-Sunbird (2)	9-Pinto 2.3 (1)	7-Pinto 2.3 (2)	9-Pinto 2.3 (2)	9-Pinto 2.3 (1)
7-Sunbird (2)**	10-Pinto 2.3 (2)	10-Colt SW	7-Rabbit	10-Rabbit	10-Colt SW
11-Colt SW	11-Colt SW	11-Sunbird (2)**	7-Sunbird (1)	11-Colt SW	11-Sunbird (2)
11-Rabbit	12-Rabbit	12-Pinto 2.3 (2)	7-Sunbird (2)	11-Sunbird (2)	12-Gremlin M
13-Fiat	13-Fiat	13-Gremline M	13-Fiat	13-Fiat	13-Pinto 2.3 (2)
14-Gremlin M	14-Gremlin M	14-Fiat	14-Gremlin M	14-Gremlin M	14-Fiat
14-Gremlin A	15-Gremlin A	15-Gremlin A	15-Gremlin A	15-Gremlin A	15-Gremlin A
16-Pinto 2.8 SW*	16-Pinto 2.8 SW (1)	16-Pinto 2.8 SW (1)	16-Pinto 2.8 SW (1)	16-Pinto 2.8 SW (1)	16-Pinto 2.8 SW (2)
16-Pinto 2.8 SW*	17-Pinto 2.8 SW (2)	17-Pinto 2.8 SW (2)	16-Pinto 2.8 SW (2)	17-Pinto 2.8 SW (2)	17-Pinto 2.8 SW (1)

* Separated by calibrations.
** Separated by axle ratios.
(1), (2) Represent different calibrations and are included to identify changes in ranking in the calibrations.

Still another way of looking at the fuel economy results is to examine the absolute fuel economy differences between ranked vehicles. Figure 4 clearly shows that the range of fuel economies from the Mileage Guide is significantly larger than that found for the production vehicles (i.e. the difference between the highest and lowest fuel economy models). A buyer weighing the various vehicle choices may use as one factor the expected relative difference between several vehicle fuel economies shown in the Mileage Guide. If this buyer were considering buying either a Honda or a Rabbit, for example, the buyer would find that the Mileage Guide indicates that the Honda would provide a fuel economy advantage over the Rabbit of 67% for the FTP and 40% for the HFET. The production vehicles tested showed these advantages would be only 41% for the FTP and 21% for the HFET. Thus it appears that the Mileage Guide exaggerates fuel economy differences between ranked vehicles in comparison to actual production car fuel economy differences.

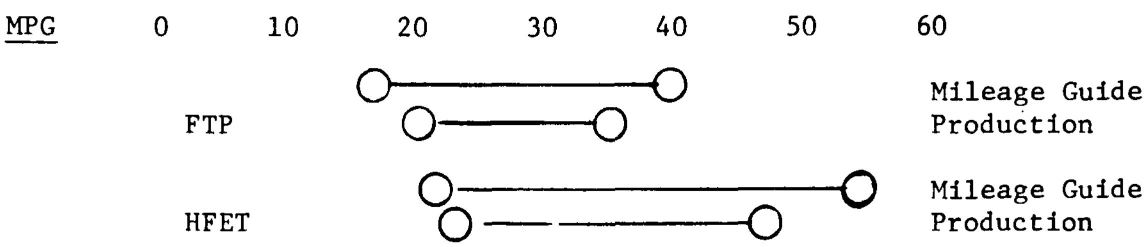


Figure 4
Absolute Range of Fuel Economies
Between Lowest and Highest Fuel Economy Models

Comparison of the harmonic average fuel economies of the test fleet for the FTP and the HFET with the same averages from the comparable certification vehicle fleet showed a 2.7% shortfall on the FTP and a 3.8% shortfall for the HFET. These shortfalls are significantly lower than the worst cases observed and suggests that the existing fuel economy determination procedures are fairly accurate with respect to fleet averages; e.g. Corporate Average Fuel Economy.

Possible Causes for the Observed Disparities

Many factors, either singly or in combination, can be identified as potential causes of the observed disparity between the production vehicle and certification vehicle fuel economy. These factors are: 1) differences in the way mileage is accumulated between production and certification vehicles, 2) differences in tires and their interaction with the dynamometer, 3) systematic lab error/shift, 4) differences in vehicle maintenance procedures, 5) test-to-test variability, 6) vehicle-to-vehicle variability, 7) small test sample size, and 8) significant differences between certification and production vehicles.

Each of these possible causes is discussed below:

1) Mileage accumulation for the certification vehicles is accomplished on a specified durability driving schedule. One cycle consists of 11 laps over a 3.7 mile course. The basic vehicle speeds for each consecutive lap are 40, 30, 40, 40, 35, 30, 35, 45, 35, 55 and 70 mph. Each of the first nine laps contains four stops of 15 seconds each, normal accelerations and decelerations, and five light decelerations from base speed to 20 mph followed by light acceleration back to base speed. The tenth lap is a constant 55 mph. The 11th lap is begun with a wide open throttle acceleration from 0 mph to 70 mph. A normal deceleration to idle is followed by a second wide open throttle acceleration. For the emission and fuel economy data vehicles, this cycle is repeated until a total of approximately 4000 vehicle miles is accumulated with the vehicle at approximately curb weight. This procedure results in nearly continuous operation with few cold starts relative to normal on-the-road driving.

   In contrast, the production vehicle mileage accumulation process can be widely varied. There was no way to accurately ascertain the type of operation that each vehicle was subjected to. It is conceivable that the vehicles could have been primarily used for short trips, mid-range commuting, long trips, or any combination of these. It is expected, however, that the vehicle operation would not be continuous and would involve numerous overnight soaks followed by cold starts. Additionally, the total vehicle weight at which much of the mileage was accumulated could vary from a base weight including only the driver to maximum weight including full passenger, luggage and trailer towing capacities. The total miles accumulated on the test vehicles ranged from 3200 to 8800 miles.

   However, in order for differences in mileage accumulation procedures to be given credence as a significant cause of the observed disparity between production and certification vehicle fuel economy, one would need to conclude that all production vehicles within each model were operated very similarly because of the small differences observed in the production vehicles; e.g. all production Datsun B-210's were operated in such a way as to cause the large observed shortfall in fuel economy while all VW Rabbits were operated in such a way as to cause the observed overage in fuel economy. The observed shortfalls cannot, therefore, be attributable to differences between mileage accumulation procedures.

2) Variations in production tires and the associated changes in the tire/dynamometer interface can cause significant differences in fuel economy results. Previous testing has shown that rolling

resistance can vary significantly both on the road and on the dynamometer and depends upon tire rubber composition, size, manufacturer, type of construction and/or model of tire. The production vehicles tested in this project were equipped with a wide range of tires which differed by manufacturer, size and type of construction. Inspection of the data failed to identify any trends which could be attributable to the production tires. If the observed differences between certification and production vehicle fuel economy is attributable to tires, one would need to conclude that the tires used on the certification vehicles were not representative of normal production tires. Data does not exist which would allow comparison of the performance of tires used on certification vehicles with comparable production tires. One cannot conclude at this time, therefore, whether or not the tires used on certification vehicles are the cause of the observed differences between production and certification vehicles.

3) A systematic shift in test results may exist due to some unknown change in the test facility and/or procedure since the 1977 certification vehicles were tested. On-going MVEL quality control programs have shown a systematic downward shift in fuel economy results of about one to two percent. This shift is believed to be due to an increase in the relative humidity during testing. However, this downward shift (1 to 2%) is too small to account for the observed large scale shortfalls (up to 15%). Additionally, if this shift is to be used to explain some of the shortfall then it must also be credited to those vehicles achieving overages. Thus, the difference between maximum percent shortfall and maximum percent overage remains at about 24%.

4) Differences in maintenance history is another possible cause of the fuel economy disparities. While certification vehicle maintenance is well controlled and monitored, production vehicle maintenance varies with each owner. There have been investigations which show that better maintenance generally implies better fuel economy. However, the effect of maintenance does not appear to be a significant factor in this study because some vehicles with meticulous service records exhibited large shortfalls while others which were found to be poorly maintained, e.g., nearly two quarts low on oil when delivered to EPA, exhibited a small shortfall. Additionally, within each make, poorly maintained vehicles did no worse than their better maintained counterparts.

5) Test-to-test variation has been indicated as a possible cause of the fuel economy disparities. This is a combination of laboratory testing variations, variability due to drivers, and variability due

to dynamometers. However, only three drivers and two dynamometers were used in this project and generally each vehicle was tested by two drivers and on two dynamometers so any trend would be applicable to all vehicles. A trend was not noted. The standard deviations (variation in each test point expressed as a percent of the mean) were small for most vehicles with only two vehicles exceeding 2.5% for the FTP and three vehicles for the HFET (see Appendix III).

6) Vehicle-to-vehicle variation can be due to differences in tires, maintenance, mileage accumulation, normal production tolerances, and limits in the accuracy of tuning the parameters affecting fuel economy. Within each vehicle group (vehicles with same model, engine calibration, and driveline) variations between vehicles were small (see Appendix IV).

   In Appendix IV, variations between vehicles are expressed as the range of individual vehicle means divided by the mean of all vehicles within the group. In no case did any vehicle group exceed 10% variation for either the FTP or the HFET (single vehicle groupings resulting from calibration and axle ratio differences were excluded so as not to bias the results toward lower variations). The average variation for the eight groups was 5.86% for the FTP and 3.71% for the HFET.

   This observed low variability within vehicle groups persists even when a similar comparison is made between the range of all tests performed on vehicles within a group relative to the mean of the group; i.e. when test-to-test and vehicle-to-vehicle differences are combined (see Appendix V). In this case, it was found that only three groups exceeded 10% variation for the FTP and the HFET. The average variation for all groups was 5.23% for the FTP and 5.29% for the HFET. Excluding single vehicles where there is no vehicle-to-vehicle variation for the group resulted in average variations of 8.02% for the FTP and 7.38% for the HFET.

   Additionally, it must be noted that in no case where there is a significant production vehicle fuel economy shortfall for a vehicle group does any one of the vehicles approach or exceed the certification vehicle fuel economy.

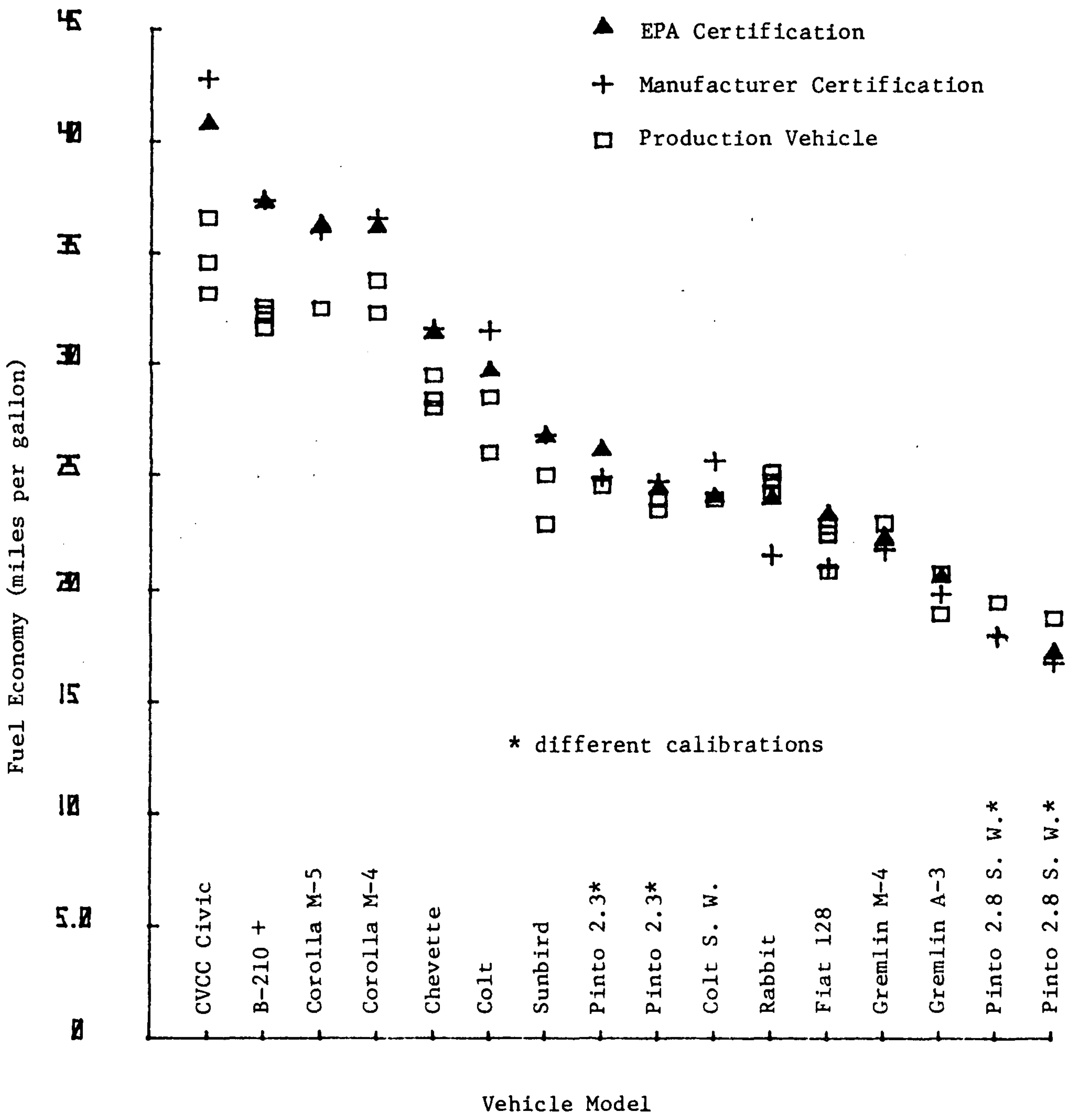
   It should also be noted that the observed high degree of consistancy between vehicles was also exhibited in the emissions results (refer to Figure 1).

7) The small sample size prevents the determination of the <u>statistical</u> significance of the results (i.e., it cannot be determined, statistically, whether there is a real difference between the production

vehicles and the certification vehicles regarding fuel economy or whether the disparity is due to a biased sample). It is worthy of note, however, that the sample size for certification vehicles is usually even smaller (one vehicle) than the sample size used in this production vehicle evaluation project. The small sample size prevents determination of whether some or all of the sample vehicles were or were not representative of the actual production vehicle population for the specific groups. However, the generally small variations among the vehicles within the various groups suggests that the normal production variations tend to be small for these models. This in turn suggests that these sample groups were reasonably good approximations for the purposes of the test program, given the small magnitudes of variations among vehicles relative to the magnitudes of disparities found between certification and production vehicle fuel economies.

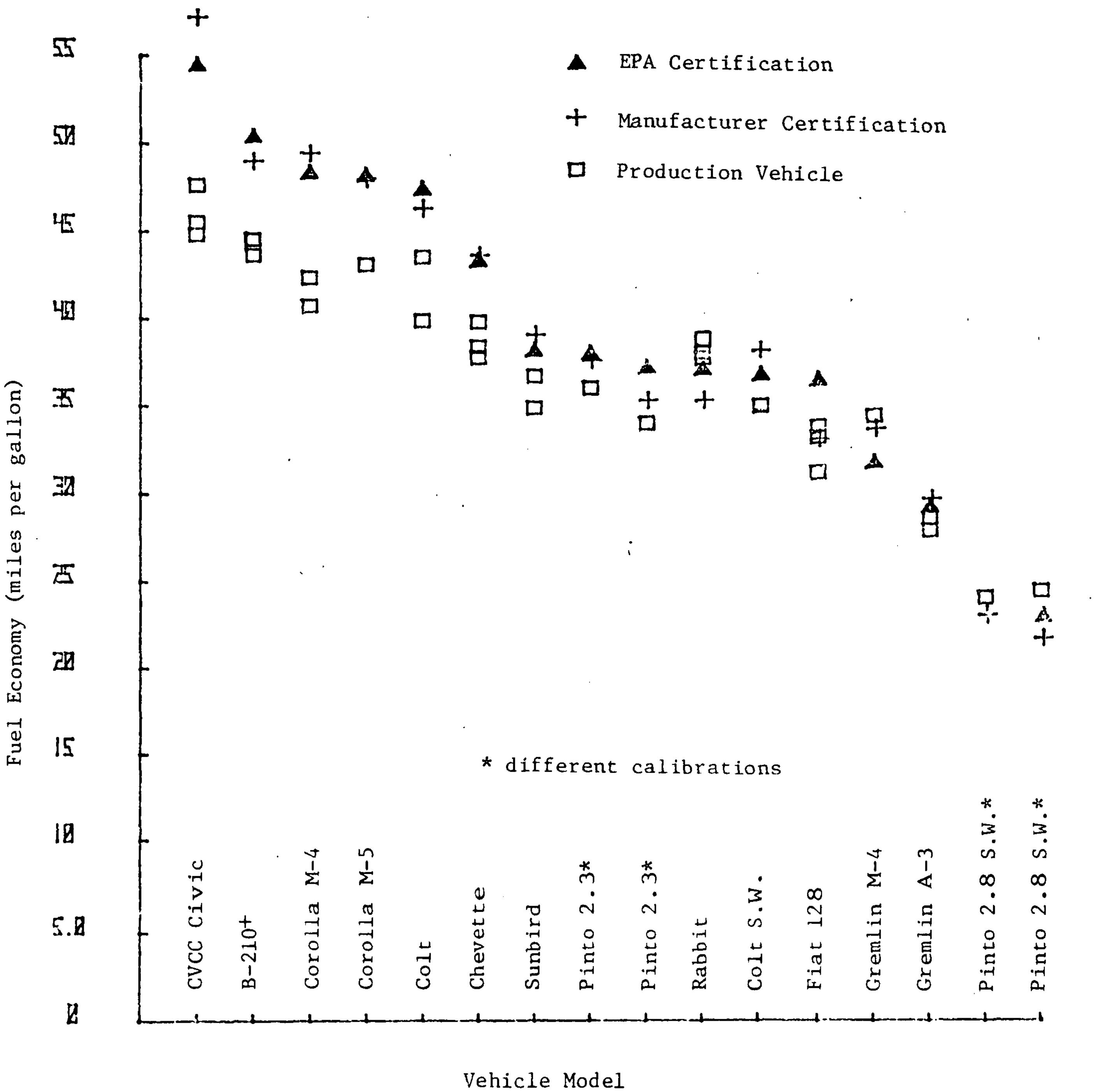
8) The remaining factor which could cause the disparity between certification and production vehicle fuel economies is the existence of a real difference between the production and certification vehicles. The production vehicle check-in was similar to that used with certification vehicles and was limited in scope to "external vehicle checks", i.e. no disassembly for inspection of internal parts. No specific item(s) or parameter(s) capable of causing fuel economy changes were noted, however. Nevertheless, the absence of specific evidence of differences cannot be construed as evidence of the absence of differences.

In plotting the data, a pattern of deviation by production vehicles from certification vehicle fuel economies emerges. Plotting the vehicle fuel economies in order of decreasing certification fuel economy (Figures 5 and 6) points out that the largest discrepancies between production vehicle and certification vehicle fuel economy values occur where the vehicles have certification FTP values above 25 mpg and HFET values above 40 mpg. Conversely, the only instances where the production vehicle fuel economy exceeds the certification vehicle fuel economy are where the FTP and HFET values are below 25 and 40 mpg, respectively. This pattern of disparities is further exemplified by plotting the percent deviation of production vehicle fuel economy from certification vehicle fuel economy in order of decreasing shortfall by models (Figures 7 and 8). The disparities are detailed in Appendix VI. By comparing the figures, it can be seen that the "fuel economy leaders" tend to have the largest absolute and percentage shortfalls of production versus certification vehicle fuel economy.



'77 FTP Fuel Economy by Model in Order
of Decreasing EPA Certification Fuel Economy

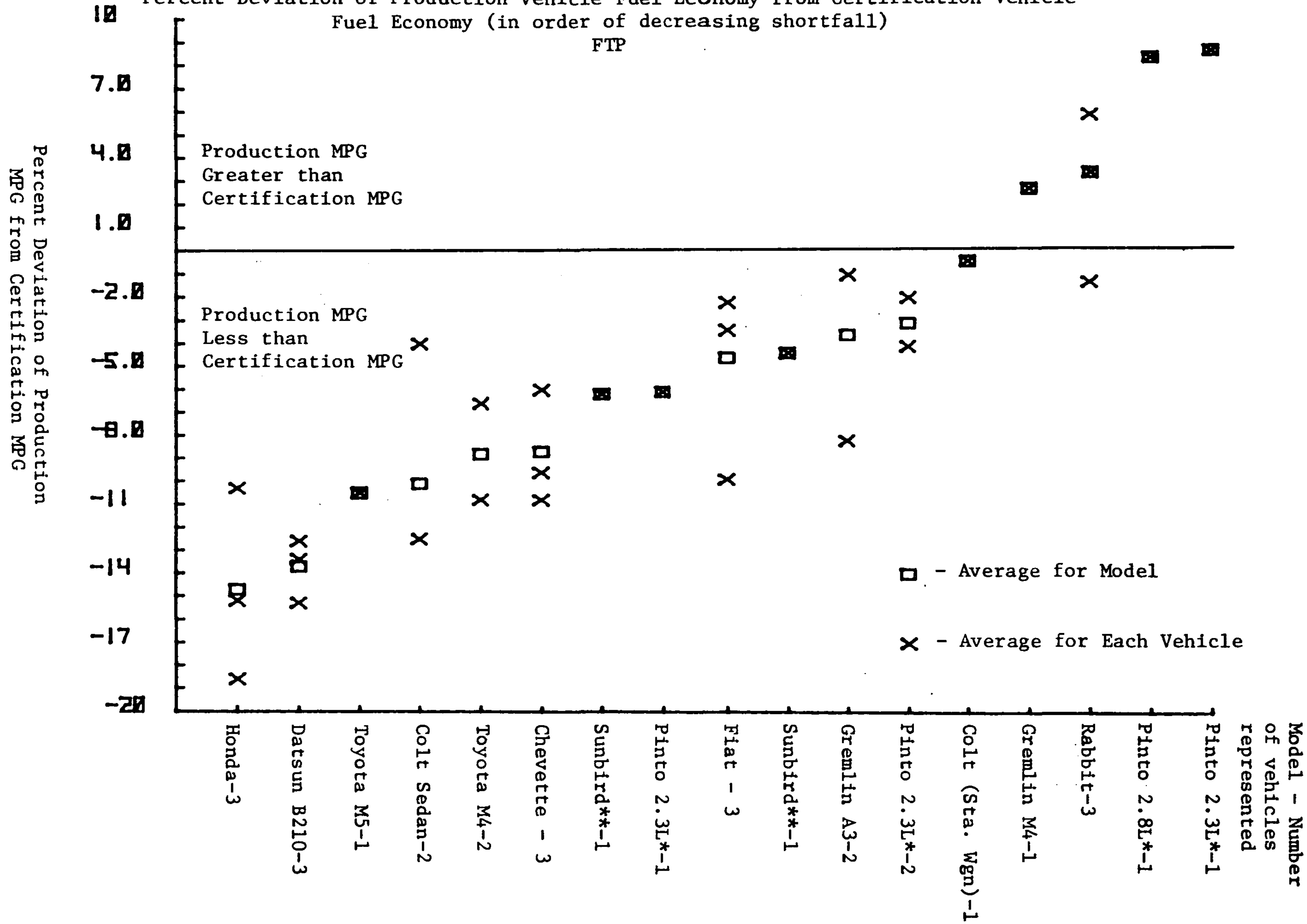
Figure 5



HFET Fuel Economy by Model in Order of
Decreasing EPA Certification Fuel Economy

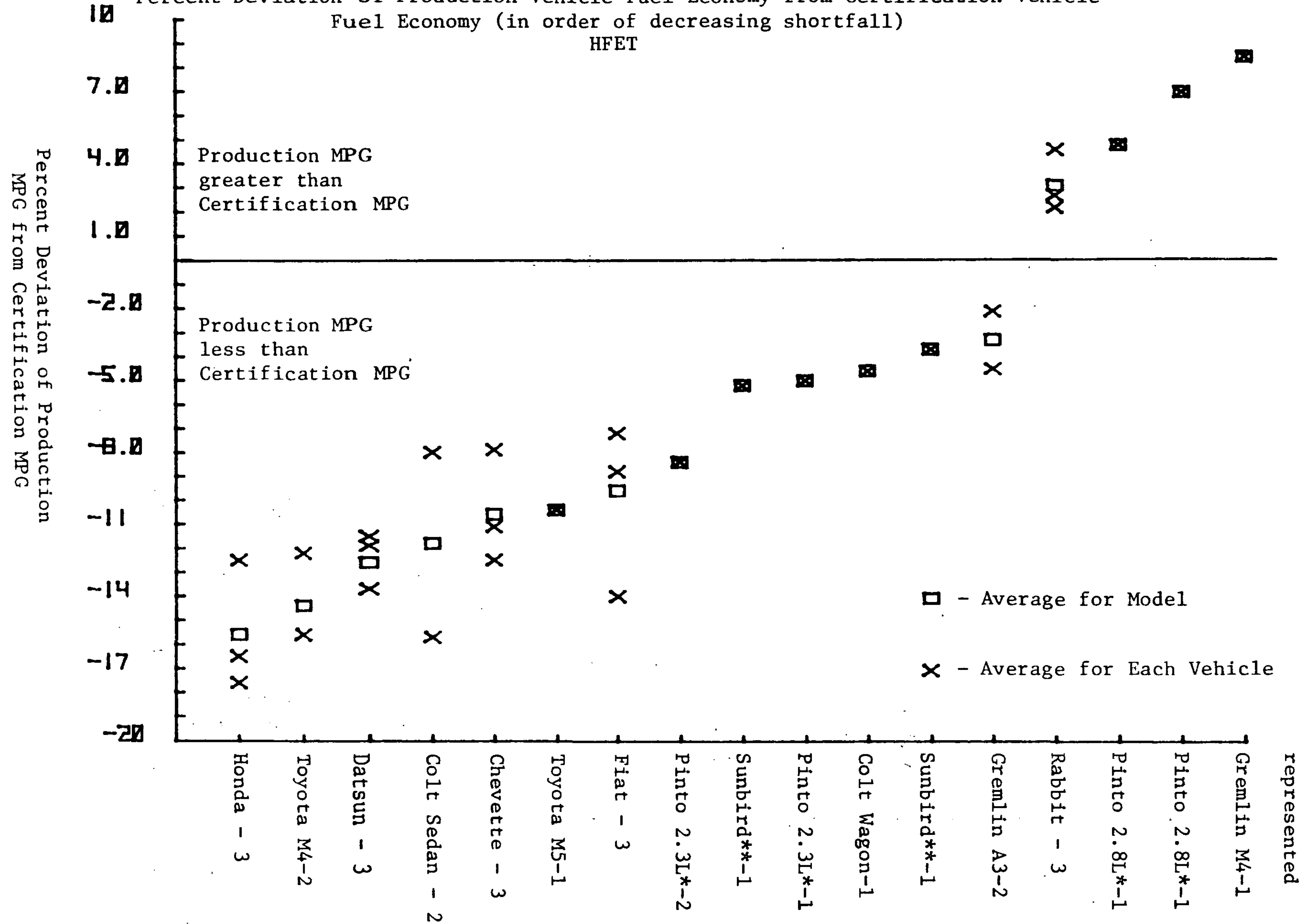
Figure 6

Figure 7
Percent Deviation of Production Vehicle Fuel Economy from Certification Vehicle Fuel Economy (in order of decreasing shortfall)
FTP



* Separated by individual calibration. ** Separated by axle ratio.

Figure 8
Percent Deviation of Production Vehicle Fuel Economy from Certification Vehicle Fuel Economy (in order of decreasing shortfall)
HFET



* Separated by individual calibration. ** Separated by axle ratio.

It is important to note the probable pattern of the occurrence of the various possible causes identified. Mileage accumulation differences, tire-to-dynamometer interface effects (most manufacturers have multiple suppliers for tires and tire types vary extensively, e.g. bias and radial are used interchangeably in production), and maintenance effects would generally occur randomly in the sample of the vehicles. The systematic lab shift, the test-to-test variability, and the small sample problem would generally be applied to all vehicles. Therefore, the only causes which would be expected to be associated to specific model groups would be vehicle-to-vehicle variability and significant differences between certification and production vehicles. However, vehicle-to-vehicle differences were observed to be small. The only plausible explanation is, therefore, that significant differences do exist between production and certification vehicles.

Appendix 1

Chassis Model Year/Make 1977 AMC Gremlin	VIN - A7M4646722317	VIN - A7A464G723693	VIN - A7C465K706587
Engine			
Engine Calibration			
Type	4 stroke Otto cycle, OHC, I-4		
Bore x Stroke	86.5 x 84.4 mm/3.405 x 3.323 in.		
Displacement	2.0L/121 cu. in.		
Compression Ratio	8.1:1		
Maximum Power @ rpm	----		
Fuel Metering	Single 2 venturi carburetor		
Fuel Requirement	Unleaded regular		
Drive Train			
Transmission Type	Manual 4 speed	Automatic	Automatic
Final Drive Ratio	3.31:1		
Chassis			
Type	Front enginer, rear wheel drive		
Tire Size	D78-14, bias, Goodyear	D78-14, bias, Goodyear	CR78-14, radial, Goodyear
Curb Weight	2550 lb. (w/ 1/4 tank)	2606 lb. (w/ 3/16 tank)	----
Inertia Weight	3000 lb.		
Passenger Capacity	four		
Emission Control System			
Basic Type	Evap., air, EGR, catalyst		
Ignition System	Breaker points		
Durability Accumulated on System	6600 mi.	6900 mi.	7300 mi.
(Information is identical to first vehicle listed except as noted.)			

Appendix I

Chassis Model Year/Make **1977 Chevrolet Chevette**	VIN - 1B08E7Y188038	VIN - 1B08E7Y155084	VIN - 1B08E7Y109065
Engine			
Engine Calibration	710W1 AB		
Type	4 stroke Otto cycle, OHC, I-4		
Bore x Stroke	82.0 x 75.7 mm/3.228 x 2.900 in.		
Displacement	1.6L/97.6 cu. in.		
Compression Ratio	8.5:1		
Maximum Power @ rpm	----		
Fuel Metering	Single 1 venturi carburetor		
Fuel Requirement	Unleaded regular		
Drive Train			
Transmission Type	Manual 4 speed		
Final Drive Ratio	3.70:1		
Chassis			
Type	Front engine, rear wheel drive		
Tire Size	P155/80D-13, 4 ply bias, Uniroyal	P155/80R-13, radial, B. F. Goodrich	P155/80D-13, bias, Goodyear
Curb Weight	2070 lb. (w/ 5/8 tank)	2020 lb. (w/ 1/2 tank)	----
Inertia Weight	2250 lb.		
Passenger Capacity	four		
Emission Control System			
Basic Type	EM, EGR, Catalyst, PCV, thermostatically controlled air cleaner, evap.		
Ignition System	Electronic		
Durability Accumulated on System	4800 mi.	4900 mi.	7800 mi.

(Information is identical to first vehicle listed except as noted.)

Chassis Model Year/Make 1977 Datsun B210 +	VIN - HLB210-222360	VIN - DHLB210202411	VIN - HLB210208746
Engine			
Engine Calibration	A141F		
Type	4 stroke Otto cycle, OHV, I-4		
Bore x Stroke	76.0 x 77.0 mm/2.992 x 3.031 in.		
Displacement	1.4L/85.24 cu. in.		
Compression Ratio	8.5:1		
Maximum Power @ rpm	----		
Fuel Metering	Single 2 venturi carburetor		
Fuel Requirement	Unleaded regular		
Drive Train			
Transmission Type	Manual 5 speed		
Final Drive Ratio	3.70:1		
Chassis			
Type	Front engine, rear wheel drive		
Tire Size	155SR-13, radial, Yokohama	155SR-13, radial, Dunlop	155SR-13, radial, Dunlop
Curb Weight	2060 lb. (w/ full tank)	2035 lb. (w/ no fuel)	2060 lb. (w/ 7/8 tank)
Inertia Weight	2250 lb.		
Passenger Capacity	four		
Emission Control System			
Basic Type	Catalyst, evap., EGR, EFE, Air.		
Ignition System	Breaker points		
Durability Accumulated on System	4700 mi.	4200 mi.	4700 mi.
(Information is identical to first vehicle listed except as noted.)			

Appendix I

Chassis Model Year/Make 1977 Dodge Colt	VIN - 6H45K75115452 (SW)	VIN - 6H41K74201943 (Sedan)	VIN - 6M21K71102382 (Sedan)
Engine			
Engine Calibration	4G32		
Type	4 stroke Otto cycle, OHC, I-4		
Bore x Stroke	77.0 x 86.1 mm/3.03 x 3.39 in.		
Displacement	1.6L/97.5 cu. in.		
Compression Ratio	8.5		
Maximum Power @ rpm	----		
Fuel Metering	Single 2 venturi carburetor		
Fuel Requirement	Regular		
Drive Train			
Transmission Type	Manual 4 speed		
Final Drive Ratio	3.89:1	3.54:1	3.31:1
Chassis			
Type	Front engine, rear wheel drive		
Tire Size	165SR-13, radial, Firestone	155 SR-13, radial, B. F. Goodrich	6.00-13, bias, B. F. Goodrich
Curb Weight	2392 lb. (w/ 1/8 tank)	2120 lb. (w/ 3/4 tank)	----
Inertia Weight	2750 lb.	2250 lb.	2250 lb.
Passenger Capacity	four		
Emission Control System			
Basic Type	Evap., EGR, AIR, PCV		
Ignition System	Breaker points		
Durability Accumulated on System	4800 mi.	3800 mi.	8800 mi.
(Information is identical to first vehicle listed except as noted.)			

Chassis Model Year/Make
1977 Fiat 128 Sedan

	VIN - 128A12314199	VIN - 128A12395322	VIN - 128A12B70659
Engine			
Engine Calibration	EF128		
Type	4 stroke Otto cycle, OHC, I-4		
Bore x Stroke	86 x 55.5 mm/3.39 x 2.19 in.		
Displacement	1290 cc/78.70 cu. in.		
Compression Ratio	8.5:1		
Maximum Power @ rpm	62 HP		
Fuel Metering	Single 2 venturi carburetor		
Fuel Requirement	Unleaded regular		
Drive Train			
Transmission Type	Manual 4 speed		
Final Drive Ratio	3.76:1		
Chassis			
Type	Front engine, front wheel drive		
Tire Size	145SR13, radial, Michelin	145SR13, radial, Michelin	145SR13, radial, Pirelli Cinturato
Curb Weight	1980 lb. (w/ 3/4 tank)	----	1900 lb. (w/ 3/4 tank)
Inertia Weight	2250 lb.		
Passenger Capacity	four		
Emission Control System			
Basic Type	EM, evap., catalyst, air, EFE		
Ignition System	Breaker points		
Durability Accumulated on System	3200 mi.	3400 mi.	4100 mi.

(Information is identical to first vehicle listed except as noted.)

Appendix I

Chassis Model Year/Make **1977 Pinto 2.3L**	VIN - F7X11Y187495	VIN - F7771Y115742	VIN - F7X11Y185930
<u>Engine</u>			
Engine Calibration	7-2B-RO	7-2B-RO	7-2A-R13
Type	4 stroke Otto cycle, OHC, I-4		
Bore x Stroke	96.0 x 79.4 mm/3.78 x 3.126 in.		
Displacement	2.3L/140 cu. in.		
Compression Ratio	----		
Maximum Power @ rpm	----		
Fuel Metering	Single 2 venturi carburetor		
Fuel Requirement	Unleaded regular		
<u>Drive Train</u>			
Transmission Type	Manual 4 speed		
Final Drive Ratio	2.73:1		
<u>Chassis</u>			
Type	Front engine, rear wheel drive		
Tire Size	A78 x 13, bias, Goodyear	A78 x 13, bias-belted, Firestone	BR78 x 13, radial, Goodyear
Curb Weight	2500 lb. (w/ no fuel)	2580 lb. (w/ 3/8 tank)	2480 lb. (w/ 1/3 tank)
Inertia Weight	2750 lb.		
Passenger Capacity	four		
<u>Emission Control System</u>			
Basic Type	EM, EGR, catalyst, PCV, air		
Ignition System	Electronic		
Durability Accumulated on System	5500 mi.	7600 mi.	6800 mi.
(Information is identical to first vehicle listed except as noted.)			

Appendix I

Chassis Model Year/Make **1977 Pinto 2.8L Station Wagon**	VIN - 7T12Z139162	VIN - 7T12Z127330	VIN -
Engine			
Engine Calibration	74AR2		
Type	4 stroke Otto cycle, OHV, V-6		
Bore x Stroke	93.0 x 68.6 mm/3.66 x 2.70 in.		
Displacement	2.8L/171 cu. in.		
Compression Ratio	8.7:1		
Maximum Power @ rpm	93 HP @ 4600 rpm		
Fuel Metering	Single 2 venturi carburetor		
Fuel Requirement	Unleaded regular		
Drive Train			
Transmission Type	Automatic		
Final Drive Ratio	3.00:1		
Chassis			
Type	Front engine , rear wheel drive		
Tire Size	BR78-13, radial, General	B78-13, bias, Uniroyal	
Curb Weight	2783 lb. (w/ 5/16 tank)	2920 lb. (w/ 1/2 tank)	
Inertia Weight	3000 lb.		
Passenger Capacity	four		
Emission Control System			
Basic Type	Catalyst, EGR, PCV, air		
Ignition System	Electronic		
Durability Accumulated on System	4200 mi.	6000 mi.	
(Information is identical to first vehicle listed except as noted.)			

Appendix I

Chassis Model Year/Make Honda	VIN - SGE3508458 (Honda)	VIN - SGE-3001087 (GM)	VIN - SGE-3511166 (Canadian)
Engine			
Engine Calibration	----		
Type	4 stroke Otto cycle, OHV, I-4		
Bore x Stroke	74.0 x 86.5 mm/2.91 x 3.41 in.		
Displacement	1.5L/90.8 cu. in.		
Compression Ratio	7.9:1		
Maximum Power @ rpm	60 HP		
Fuel Metering	Single 3 venturi carburetor		
Fuel Requirement	Unleaded regular		
Drive Train			
Transmission Type	Manual 5 speed		
Final Drive Ratio	3.88:1		
Chassis			
Type	Front engine, front wheel drive		
Tire Size	600-S12, bias, Bridgestone	600-S12, bias, Bridgestone	155-SR12, radial, B. F. Goodrich
Curb Weight	1880 lb.	1790 lb.	1765 lb. (w/ full tank)
Inertia Weight	2000 lb.		
Passenger Capacity	four		
Emission Control System			
Basic Type	Stratified charge.		
Ignition System	Breaker points		
Durability Accumulated on System	3300 mi.	5500 mi.	7300 mi.
(Information is identical to first vehicle listed except as noted.)			

Chassis Model Year/Make **1977 Pontiac Sunbird Sedan**	VIN - 2M27V72332762	VIN - 2M27V72340720	VIN -
Engine			
Engine Calibration	710C2-F		
Type	4 stroke Otto cycle, OHV, I-4		
Bore x Stroke	101.6 x 76.2 mm/4.00 x 3.00 in.		
Displacement	2.5L/151 cu. in.		
Compression Ratio	8.25:1		
Maximum Power @ rpm	----		
Fuel Metering	Single 2 venturi carburetor		
Fuel Requirement	Unleaded regular		
Drive Train			
Transmission Type	Manual 4 speed		
Final Drive Ratio	2.93:1	2.74:1	
Chassis			
Type	Front engine, rear wheel drive		
Tire Size	BR78 x 13, radial, Uniroyal	BR78 x 13, radial, Uniroyal	
Curb Weight	2810 lb. (w/ 1/2 tank)	2800 lb. (w/ 1/4 tank)	
Inertia Weight	3000 lb.		
Passenger Capacity	four		
Emission Control System			
Basic Type	EM, EGR, catalyst, PCV, evap., EFE		
Ignition System	Electronic		
Durability Accumulated on System	3600 mi.	7600 mi.	

(Information is identical to first vehicle listed except as noted.)

Appendix I

Chassis Model Year/Make
1977 Toyota Corolla

	VIN - KE30178075	VIN - KE30169331	VIN - KE30224096
Engine			
Engine Calibration	3K-C		
Type	4 stroke Otto cycle, OHV, I-4		
Bore x Stroke	75.0 x 66.0 mm/2.95 x 2.60 in.		
Displacement	1.2L/71.15 cu. in.		
Compression Ratio	9.0:1		
Maximum Power @ rpm	58 HP @ 5800 rpm		
Fuel Metering	Single 2 venturi carburetor		
Fuel Requirement	Unleaded regular		
Drive Train			
Transmission Type	Manual 4 speed		Manual 5 speed
Final Drive Ratio	3.91:1		
Chassis			
Type	Front engine, rear wheel drive		
Tire Size	155S-13, bias, Dunlop	155S-13, bias, Dunlop	155SR-13, radial, Dunlop
Curb Weight	1930 lb. (w/ 1/8 tank)	1975 lb. (w/ 3/4 tank)	2020 lb. (w/ full tank)
Inertia Weight	2250 lb.		
Passenger Capacity	four		
Emission Control System			
Basic Type	Catalyst, Air PCV, evap., fuel shut-off, mixture control valve		
Ignition System	Breaker points		
Durability Accumulated on System	5800 mi.	7400 mi.	4300 mi.

(Information is identical to first vehicle listed except as noted.)

Appendix I

Chassis Model Year/Make **1977 Volkswagen Rabbit**	VIN - 1773271310	VIN - 1773373162	VIN - 1773396532
Engine			
Engine Calibration	EE		
Type	4 stroke cycle, OHC, I-4		
Bore x Stroke	79.5 x 80.0 mm/3.13 x 3.15 in.		
Displacement	1.6L/97 cu. in.		
Compression Ratio	8.0:1		
Maximum Power @ rpm	78 HP @ 5500 rpm		
Fuel Metering	Mechanical fuel injection		
Fuel Requirement	Regular		
Drive Train			
Transmission Type	Manual 4 speed		
Final Drive Ratio	3.90:1		
Chassis			
Type	Front engine, rear wheel drive		
Tire Size	155SR-13, radial, Continental	155SR-13, radial, Michelin	155SR-13, radial, Continental
Curb Weight	----	1885 lb. (w/ full tank)	1955 lb. (w/ 3/8 tank)
Inertia Weight	2250 lb.		
Passenger Capacity	four		
Emission Control System			
Basic Type	Evap., PCV		
Ignition System	Breaker points		
Durability Accumulated on System	5000 mi.	3900 mi.	5100 mi.

(Information is identical to first vehicle listed except as noted.)

Appendix II

Vehicle	Odo.	Test Emissions HC	CO	NOx	Expected 50,000 Mile Emission Levels Corrected for Mileage HC	CO	NOx
Chevette (private) 1B08E7Y155084	4900	0.79	10.2	1.43	0.96	10.2	1.44
Chevette (private) 1B08E7Y188038	4800	0.62	9.8	1.14	0.75	9.8	1.14
Chevette (GM) 1B08E7Y109065	7800	0.89	13.8	1.35	1.09	13.8	1.35
Colt (Mitsubishi) 6H41K72401943	3800	1.33	11.6	1.25	1.33	11.6	1.25
Colt (private) 6M21K71102382	8800	1.64	16.8	2.58	1.64	16.8	2.58
Colt (private) 6H45K75115452	4800	1.58	11.5	1.56	1.58	11.5	1.56
Datsun B210+ (private) HLB210208746	4700	0.67	6.8	1.16	1.02	10.2	1.16
Datsun B210+ (Datsun) HLB210222360	4700	0.64	6.3	1.49	0.98	9.5	1.49
Datsun B210+ (private) HLB210202411	4200	0.56	7.5	1.22	0.86	11.3	1.22
Fiat 128 (private) 128A12370659	4100	1.35	19.2	1.13	1.47	20.4	1.13
Fiat 128 (private) 128A12395322	3400	0.96	16.0	0.95	1.05	16.9	0.95
Fiat 128 (Fiat) 128A12314199	3200	0.60	10.7	1.22	0.60	10.7	1.22
Gremlin A-3 (AMC) A7C465K706587	7300	0.29	7.4	1.98	0.36	7.8	1.98
Gremlin M-4 (private) A7M464G722317	6600	1.03	8.7	1.30	1.27	9.2	1.30
Gremlin A-3 (private) A7A464G723693	6900	0.34	5.5	2.14	0.42	5.8	2.14

Appendix II (cont.)

Vehicle	Odo.	Test Emissions HC	CO	NOx	Expected 50,000 Mile Emission Levels Corrected for Mileage HC	CO	NOx
Pinto 2.3L (Ford) 7X11Y187495	5500	0.72	5.0	1.55	1.04	6.3	1.55
Pinto 2.3L (private) 7X11Y185930	6800	0.78	3.6	1.31	1.11	4.5	1.31
Pinto 2.3L (private) 7T11Y115742	7600	0.94	5.4	1.40	1.33	6.8	1.40
Pinto 2.8L (Ford) 7T12Z127330	6000	0.73	6.2	1.28	1.22	7.9	1.43
Pinto 2.8L (private) 7T12Z139162	4200	0.73	7.5	1.23	1.24	9.6	1.38
Sunbird (private) 2M27V72340720	7600	1.25	8.6	1.82	1.42	9.1	1.89
Sunbird (private) 2M27V2332762	3600	1.53	15.4	1.68	1.75	16.3	1.75
Toyota Corolla (Toyota) KE30224096	4300	0.56	8.5	1.26	0.56	8.5	1.26
Toyota Corolla (private) KE30167331	7400	0.87	11.3	1.35	0.87	11.3	1.35
Toyota Corolla (private) KE30178075	5800	0.74	4.6	1.87	0.74	4.6	1.87
VW Rabbit (private) 1773271310	5000	1.22	6.4	1.86	1.22	6.4	2.10
VW Rabbit (VW) 1773373162	3900	1.18	7.1	1.49	1.18	7.1	1.69
VW Rabbit (private) 1773396532	5100	1.36	5.7	1.60	1.36	5.7	1.81
Honda (Canadian) SGE3511166	7300	1.42	5.4	1.96	1.42	5.4	1.96
Honda (Honda) SGE3508458	3300	1.44	5.4	1.71	1.44	5.4	1.71
Honda (GM) SGE3001087	5600	1.15	5.2	1.72	1.15	5.2	1.72

Appendix III
Fuel Economy Results

	Certification Vehicle MPG						Production Vehicle MPG							
	Manufacturer		EPA		Mileage Guide		EPA		Mean		Std. Dev. as % of Mean		[Production Mean/ Mileage Guide] x 100%	
Vehicle	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET
Chevette, 1.6L	31.6	43.4	31.4	43.1	31	43	29.2	38.6						
Manual 4, 1V,							27.6	38.7						
Cat.							28.5	37.5						
1B08E7Y155084									28.4	38.3	2.8%	1.7%	92%,	89%,
													90%*	89%*
Chevette 1.6L	31.6	43.4	31.4	43.1	31	43	27.8	37.2						
Manual 4, 1V,							27.9	37.6						
Cat.							28.5	38.3						
1B08E7Y188038									28.0	37.7	1.4%	1.5%	90%,	88%,
													89%*	87%*
Chevette 1.6L	31.6	43.4	31.4	43.1	31	43	29.5	39.9						
Manual 4, 1V,							29.4	39.7						
Cat.							29.6	39.4						
1B08E7Y109065									29.5	39.7	0.3%	0.6%	95%,	92%,
													94%*	92%*
Colt, 1.6L	25.6	38.1	24.0	36.6	24	37	23.8	34.8						
M-4, AIR							24.0	34.7						
Station Wagon							24.0	35.2						
6H45K75115452									23.9	34.9	0.5%	0.8%	100%	94%
													100%*	95%*
Colt, 1.6L	31.5	46.1	29.7	47.2	29	45								
M-4								40.1						
6H41K72401943							25.9	39.9						
Bronze & White							25.7	39.4						
							26.4	39.8						
									26.0	39.8	1.4%	0.7%	90%	88%
													87%*	84%*
Colt 1.6L	31.5	46.1	29.7	47.2	29	45	29.1	44.4						
M-4, AIR							28.4	42.8						
6MZ1K71102382							27.9	42.8						
							28.5	43.7						
									28.5	43.4	1.7%	1.8%	98%	96%
													96%*	92%*

*Production Mean/EPA results from cert. vehicle of same calibration.

Appendix III (cont.)

Vehicle	Certification Vehicle MPG: Manufacturer FTP	Manufacturer HFET	EPA FTP	EPA HFET	Mileage Guide FTP	Mileage Guide HFET	Production Vehicle MPG: EPA FTP	EPA HFET	Mean FTP	Mean HFET	Std. Dev. as % of Mean FTP	Std. Dev. as % of Mean HFET	[Production Mean/ Mileage Guide] x 100% FTP	[Production Mean/ Mileage Guide] x 100% HFET
Datsun B210+	37.4	48.9	37.3	50.5	37	50	31.8	43.9						
1.4L, Manual 5							31.7	42.7						
2V, Cat., AIR							31.7	44.1						
DHLB210202411								43.6						
									31.6	43.6	1.0%	1.4%	85%	87%
													85%*	86%*
Datsun B210+	37.4	48.9	37.3	50.5	37	50	32.3	44.7						
1.4L, M5, 2V,							31.6	43.6						
Cat., AIR							32.9	45.3						
DHLB210222360									32.3	44.5	2.0%	1.9%	87%	89%
													87%*	88%*
Datsun 1.4L,	37.4	48.9	37.3	50.5	37	50	32.3	43.8						
M5 (Datsun)							32.6	44.2						
DHLB21208746							32.9	45.5						
									32.6	44.5	0.9%	2.0%	88%	89%
													87%*	88%*
Fiat 128	21.1	32.9	23.2	36.3	23	35	22.5	33.2						
1.3L, M-4							22.5	33.6						
AIR							23.0	34.3						
128A12314199									22.7	33.7	1.3%	1.6%	99%	96%
													98%*	93%*
Fiat 128, M-4	21.1	32.9	23.2	36.3	23	35	20.8	31.2						
White							21.0	31.1						
128A12595322									20.9	31.2	0.7%	0.2%	91%	89%
													90%*	86%*
Fiat 128, M-4	21.1	32.9	23.2	36.3	23	35	22.4	32.6						
Blue							22.7	33.4						
128A12570659							22.2	33.2						
									22.4	33.1	1.1%	1.3%	97%	95%
													97%*	91%*

*Production Mean/EPA results from cert. vehicle of same calibration.

	Certification Vehicle MPG						Production Vehicle MPG							
	Manufacturer		EPA		Mileage Guide		EPA		Mean		Std. Dev. as % of Mean		[Production Mean/ Mileage Guide] x 100%	
Vehicle	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET
Gremlin	19.8	29.5	20.6	29.1	21	29	20.8	28.4						
2.0L, A-3,							20.9	28.6						
Cat., AIR, EGR							20.7	28.5	20.8	28.5	0.5%	0.4%	99%	98%
A7A464G723693													101%*	98%*
Gremlin	21.2	33.3	22.2	31.6	21	33	22.8	34.1						
2.0L, M-4	22.5	33.5					22.7	34.0						
Cat., AIR, EGR		33.6					22.8	34.7					108%	105%
A7M464G722317									22.8	34.3	0.2%	1.1%	103%*	110%*
Gremlin	19.8	29.5	20.6	29.1	21	29	18.9	27.3						
2.0L, A-3							19.0	27.6						
Cat., AIR, EGR							18.9	28.4						
A7C4G5K706587									18.9	27.8	0.3%	2.0%	90%	96%
													92%*	96%*
Honda 1.5L	42.8	57.1	40.8	54.4	40	52	37.0	47.2						
Manual 5, 3V							36.6	47.7						
Strat. Charge							36.2	47.9						
(supplied by									36.6	47.6	1.1%	0.8%	92%	92%
Honda)													90%*	88%*
SGE3508458														
Honda 1.5L	42.8	57.1	40.8	54.4	40	52	33.3	44.9						
Manual 5, 3V							33.3	45.2						
Strat. Charge							32.9	44.3						
(supplied by									33.2	44.8	0.7%	1.0%	83%	86%
GM)													81%*	82%*
SGE3001087														
Honda 1.5L	42.8	57.1	40.8	54.4	40	52	34.0	45.0						
Manual 5, 3V							34.1	45.3						
Strat. Charge							35.7	45.9						
(Canadian)									34.6	45.4	2.8%	1.0%	86%	87%
SGE3511166													85%*	83%*

*Production Mean/EPA results from cert. vehicle of same calibration.

Certification Vehicle MPG — Production Vehicle MPG

Vehicle	Manufacturer		EPA		Mileage Guide		EPA		Mean		Std. Dev. as % of Mean		[Production Mean/ Mileage Guide] x 100%	
	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET
Pinto 2.3L,	24.1	35.1	23.5	38.4	26	37	23.3	34.4						
Manual 4, 2V,	26.0	36.6	25.2	35.5			23.6	33.8						
Calib. #72B-RO	24.1						23.3	33.4	23.4	33.9	0.7%	1.5%	90%	92%
Cat., AIR													96%*	92%*
7T11Y115742		Ave.	24.4	37.0										
Pinto 2.3L,	24.9	37.4	27.1	38.6	26	37	24.3	35.9						
Manual 4, 2V,			25.1	36.9			24.5	35.5						
Calib. #72A-R13								36.8						
Cat., AIR							24.7	35.2						
7X11Y185930									24.5	35.9	0.8%	1.9%	94%	97%
		Ave.	26.1	37.8									94%*	95%*
Pinto 2.3L, M-4,	24.1	35.1	23.5	38.4	26	37	23.8	33.6						
Calib. 72B-RO	26.0	36.6	25.2	35.5			23.9	33.9						
Cat., AIR	24.1						23.9	34.3						
(Ford)									23.9	33.9	0.2%	1.0%	92%	92%
F7X11Y187495		Ave.	24.4	37.0									98%*	92%*
Pinto SW 2.8L,	17.9	23.1	NO EPA DATA		18	23	19.5	24.3						
A-3, calib.	17.9	22.0	FOR 3000#				19.6	23.8						
7-4A-R2, Cat.,	17.8	23.5	AVE. IS OF				19.2	23.8						
AIR, 3000#			MFR. DATA						19.4	24.0	1.1%	1.2%	108%	104%
7T12Z139162 Ave.	17.9	22.9											108%**	105%**
Pinto SW 2.8L,	18.2	21.3	17.4	22.7	18	23	18.8	24.2						
A-3, Cat., AIR,	16.4	22.2	17.0	23.0			18.5	23.9						
7T12Z127330	16.1	21.3					18.8	25.1						
	16.4								18.7	24.4	0.9%	2.6%	104%	106%
		Ave.	17.2	22.8									109%*	107%*

*Production Mean/EPA results from cert. vehicle of same calibration.

**Production Mean/Mfr. results from cert. vehicle of same calibration.

Appendix III (cont.)

	Certification Vehicle MPG								Production Vehicle MPG					
	Manufacturer		EPA		Mileage Guide		EPA		Mean		Std. Dev. as % of Mean		[Production Mean/ Mileage Guide] x 100%	
Vehicle	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET	FTP	HFET
Rabbit 1.6L,	21.6	35.1	23.4	36.9	24	37	24.4	37.4						
Manual 4, Fuel			24.4				24.9	38.5						
Injection							24.8	37.8						
1773271310									24.7	37.9	1.1%	1.5%	103%	102%
		Ave.	23.9	36.9									103%*	103%*
Rabbit 1.6L	21.6	35.1	23.4	36.9	24	37	23.8	37.9						
M-4, Fuel			24.4				24.2	37.6						
Injection							24.6	37.5						
1773373162									24.2	37.7	1.6%	0.6%	101%	102%
													101%*	102%*
Rabbit 1.6L,	21.6	35.1	23.4	36.9	24	37	24.6	38.1						
M-4, Fuel			24.4				25.8	39.1						
Injection							25.4	38.5	25.3	38.6	2.4%	1.3%	105%	104%
1773396532		Ave.	23.9	36.9									106%*	105%*
Sunbird, M-4	23.9	35.1	24.9	36.6	26	37	22.8	33.7						
151 CID							22.9	34.4						
Cat., EGR									22.8	34.0	0.3%	1.4%	88%	92%
2M27V72332762													92%*	93%*
							(23.8**)	34.7						
								34.7	23.8	34.7	--	0.0	92%	94%
													96%*	95%*
Sunbird, M-4	26.8	38.9	26.7	38.0	26	37	25.0	36.3						
151 CID, Cat.,							25.2	36.2						
EGR							24.9	37.3						
2M27V72340720									25.0	36.6	0.6%	1.7%	96%	99%
													94%*	96%*

*Production Mean/EPA results from cert. vehicle of same calibration.

**Estimated from Hot LA-4 and previous data.

Appendix III (cont.)

Vehicle	Certification Vehicle MPG: Manufacturer FTP	Manufacturer HFET	EPA FTP	EPA HFET	Mileage Guide FTP	Mileage Guide HFET	Production Vehicle MPG: EPA FTP	EPA HFET	Mean FTP	Mean HFET	Std. Dev. as % of Mean FTP	Std. Dev. as % of Mean HFET	[Production Mean/ Mileage Guide] x 100% FTP	[Production Mean/ Mileage Guide] x 100% HFET
Toyota 1.2L	36.0	49.3	36.3	48.0	36	49	32.3	42.0						
Manual 5, 2V							31.9	42.6						
Cat (white)							33.3	44.4						
Corolla									32.5	43.0	2.2%	2.9%	90%	91%
(Toyota)													90%*	90%*
KE30224096														
Toyota 1.2L	36.6	47.8	36.2	48.2	36	49	32.1	40.9						
Manual 4, 2V							31.7	38.2						
Cat. (yellow)							33.0	41.7						
Corolla								40.8						
KE30169331									32.3	40.7	2.0%	3.5%	90%	83%
													89%*	84%*
Toyota 1.2L,	36.6	47.8	36.2	48.2	36	49	33.2	41.4						
Manual 4, 2V,							34.2	42.5						
Cat. (silver)							34.0	42.9						
Corolla									33.8	42.3	1.6%	1.8%	94%	86%
KE30178075													93%*	88%*

*Production Mean/EPA results from cert. vehicle of same calibration.

Appendix IV
Spread of Vehicle Test Means by Group

	FTP			HFET		
	Mean for each Vehicle	Mean for all Vehicles	Range of means/ mean x 100)	Mean for each Vehicle	Mean for all Vehicles	Range of means/ mean x 100)
Chevette (084)	28.4	28.67	5.23	38.3	38.58	5.18
(038)	28.0			37.7		
(065)	29.5			39.7		
Colt Sed*(943)	26.0	27.41	--	39.8	41.61	--
(382)	28.5			43.4		
Colt Wgn.(452)	23.9	23.90	--	34.9	34.90	--
Datsun (411)	31.6	32.20	3.11	43.6	44.14	2.04
(360)	32.3			44.5		
(746)	32.6			44.5		
Fiat (199)	22.7	22.14	8.13	33.7	32.83	7.61
(322)	20.9			31.2		
(659)	22.4			33.1		
Gremlin (693)	20.8	19.87	9.56	28.5	28.13	2.49
A3 (587)	18.9			27.8		
Gremlin M4 (317)	22.8	22.77	--	34.3	34.3	--
Honda (458)	36.6	34.79	9.77	47.6	45.93	6.10
(087)	33.2			44.8		
(166)	34.6			45.4		
Pinto 2.3(742)	23.4	23.63	2.12	33.9	33.9	0
(495)	23.9			33.9		
Pinto 2.3(930)	24.5	24.5	--	35.9	35.85	--
Pinto 2.8(162)	19.4	19.4	--	24.0	23.97	--
Pinto 2.8(330)	18.7	18.7	--	24.4	24.4	--
Rabbit (310)	24.7	24.72	4.45	37.9	38.04	2.37
(162)	24.2			37.7		
(532)	25.3			38.6		
Sunbird (762)	23.8	23.8	--	34.7	34.7	--
Sunbird (720)	25.0	25.0	--	36.6	36.6	--
Toyota M5(096)	32.5	32.50	--	43.0	43.00	--
Toyota M4(331)	32.3	33.03	4.54	40.7	41.26	3.88
(075)	33.8			42.3		
Average w/o Colt, Gremlin M4, and all Pintos			5.86%			3.71%

*Two different axle ratios.

Appendix V

Vehicle-to-Vehicle Individual Test Variability of Fuel Economy Within Each Model

Model	# of Vehicles In Group	FTP Range	Mean of Individual Tests	(Range/Mean) x 100%	HFET Range	Mean of Individual Tests	(Range/Mean) x 100%
Chevette	3	27.6–29.6	28.67	6.98%	37.2–39.9	38.58	7.01%
Colt Sedan	2	25.7–29.1	27.41	12.40%	39.4–44.4	41.61	12.02%
Colt Sta. Wgn.	1	23.8–24.0	23.9	0.84%	34.7–35.2	34.9	1.43%
Datsun	3	31.7–32.9	32.20	3.73%	42.7–45.5	44.14	6.34%
Fiat	3	21.0–23.0	22.14	9.03%	31.1–34.3	32.83	9.75%
Gremlin A3	2	18.9–20.9	19.87	10.07%	27.3–28.6	28.13	4.62%
Gremlin M4	1	22.7–22.8	22.77	0.44%	34.0–34.7	34.27	2.04%
Honda	3	32.9–37.0	34.79	11.78%	44.3–47.9	45.93	7.84%
Pinto 2.3*	2	23.3–23.9	23.63	2.54%	33.4–34.4	33.9	2.95%
Pinto 2.3*	1	24.3–24.7	24.5	1.63%	35.2–36.8	35.85	4.46%
Pinto 2.8*	1	19.2–19.5	19.43	1.54%	23.8–24.3	23.97	2.09%
Pinto 2.8*	1	18.5–18.8	18.7	1.60%	23.9–25.1	24.4	4.92%
Rabbit	3	23.8–25.8	24.72	8.09%	37.4–39.1	38.04	4.47%
Sunbird	1	23.8	23.8	--	34.7	34.7	0%
Sunbird**	1	24.9–25.2	25.0	1.20%	36.2–37.3	36.6	3.01%
Toyota M5	1	31.9–33.3	32.50	4.31%	42.0–44.4	43.00	5.58%
Toyota M4	2	31.7–34.2	33.03	7.57%	38.2–42.9	41.26	11.39%

* Different calibrations

**Different axle ratios

Appendix VI

Production Vehicle Fuel Economy Percent Shortfall from Certification Vehicle Values in Order of Decreasing Shortfall

( ) - indicates production value greater than certification value

% Shortfall FTP

	Model Mean	Vehicle Mean	Shortfall Rank	Overage Rank
Honda	14.7	10.3/18.6/15.2	1	
Datsun	13.7	15.3/13.4/12.6	2	
Toyota M5	10.5	10.5	3	
Colt Sedan	10.1	12.5/4.0	4	
Toyota M4	8.8	10.8/6.6	5	
Chevette	8.7	9.6/10.8/6.0	6	
Sunbird**	6.2	6.2	7	
Pinto 2.3L*	6.1	6.1	8	
Fiat	4.6	2.2/9.9/3,4	9	
Sunbird**	4.4	4.4	10	
Gremlin A3	3.6	1.0/8.2	11	
Pinto 2.3L*	3.1	4.1/2.0	12	
Colt S.W.	0.4	0.4	13	
Gremlin M4	(2.7)	(2.7)		4
Rabbit	(3.4)	(3.4)/1.3/(5.9)		3
Pinto 2.8L*	(8.4)	(8.4)		2
Pinto 2.8L*	(8.7)	(8.7)		1

% Shortfall HFET

	Model Mean	Vehicle Mean		
Honda	15.6	12.5/17.6/16.5	1	
Toyota M4	14.4	15.6/12.2	2	
Datsun	12.6	13.7/11.5/11.9	3	
Colt (sedan)	11.8	15.7/8.0	4	
Chevette	10.6	11.1/12.5/7.9	5	
Toyota M5	10.4	10.4	6	
Fiat	9.6	7.2/14.0/8.8	7	
Pinto 2.3L*	8.4	8.4/8.4	8	
Sunbird**	5.2	5.2	9	
Pinto 2.3L*	5.0	5.0	10	
Colt S.W.	4.6	4.6	11	
Sunbird**	3.7	3.7	12	
Gremlin A3	3.3	2.1/4.5	13	
Rabbit	(3.1)	(2.7)/(2.2)/(4.6)		4
Pinto 2.8L*	(4.8)	(4.8)		3
Pinto 2.8L*	(7.0)	(7.0)		2
Gremlin M4	(8.5)	(8.5)		1

*Separated by individual calibration.
**Separated by axle ratios.