Technical Report

A Summary and Analysis of Comments Received in Response to the EPA/NHTSA Information Request Regarding the Effects of Test Procedure Changes on Fuel Economy

by

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NOTICE

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Standards Development and Support Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air, Noise and Radiation
U.S. Environmental Protection Agency

CHAPTER 1

INTRODUCTION

This document presents, summarizes and analyzes vehicle manufacturers' responses to the joint EPA/NHTSA request for information on the effects on fuel economy of changes made in the EPA test procedures since 1975. The responses were solicited by mailing the EPA/NHTSA questionaires dated on March 12, 1979 to the vehicle manufacturers. Comments were received from Toyota, Volkswagen, General Motors, Ford, Chrysler, and American Motors. We would like to express our appreciation for the efforts required of the manufacturers in the preparation of their very informative comments. We hope that this analysis will be of corresponding value to its readers.

This document is divided into eight chapters. Each of chapters 2 through 8 discusses one of the seven subject categories of the original questionnaire, namely: the fuel economy effects of shift schedules, alternate dynamometer adjustments, accessories, inertia weight changes, emission standards, a general category, and light-duty truck road load.

Each chapter consists of a presentation of the EPA/NHTSA introductory statement and questions posed to the manufacturers. Each question is followed by a summary of the comments received from the automobile manufacturers. In those areas where sufficient information was made available to the EPA an analysis and a summary of the issue are presented.

Summaries of the responses to each question by the individual manufacturers are provided as appendices to this report.

CHAPTER 2

SHIFT SCHEDULE MODIFICATIONS

I. Introductory

In 1975, EPA regulations provided that test vehicles with manual transmissions would normally be shifted at 15, 25 and 40 mph. In order to provide more appropriate (representative) shift schedules for unusual vehicles, the regulations also provided the option of shifting at shift points recommended by the manufacturer.

On July 16, 1976 the 15, 25 and 40 mph default shift points were deleted from the regulations and all vehicles shifted according to their manufacturer's recommendation to the ultimate purchaser. EPA soon began to receive shift point requests which appeared to be selected primarily to minimize emissions or to maximize fuel economy, and did not seem to reflect consumer use of the vehicle. EPA investigated this problem and concluded that many of the shift schedules requested by vehicle manufacturers were unrepresentative of typical vehicle use.1/,2/

In order to ensure more representative shift schedules in the future, EPA defined acceptable shift schedules in Advisory Circular No. 72 which provides that the allowable shift schedules are either the 15-25-40 mph schedule originally presented in the regulations, a shift schedule developed by EPA which is based on a percentage of the maximum recommended engine rpm, or any other recommended shift schedule which is based on typical vehicle use data.

II. Summary of Comments

Question 1: "In 1974, and separately in 1975, what percentage of your product line was represented by test vehicles shifted at speeds other than the 15-25-40 mph schedule?"

Answers: Five respondents stated that 100 percent of their 1974 product line was represented by test vehicles shifted at 15-25-40 mph. One respondent stated their test vehicles were not shifted according to the 15-25-40 mph schedule.

Four of the respondents stated that 100 percent of their 1975 product line was represented by test vehicles shifted at 15-25-40 mph; the fifth respondent stated that all of their carlines and 93 percent of their trucklines were shifted using the 15-25-40 mph schedule; the sixth stated that most of their vehicles were shifted at speeds other than 15-25-40 mph.

Question 2: "For those vehicles shifted at other than the 15-25-40 mph schedule, what shift speed schedules were used?"

Answers: For 1974 only one respondent stated that shift schedules other than the 15-25-40 mph schedule had been used. Their shift schedules were:

18-40 mph (LDV),
18-30 mph (LDT),
and 18-30-40 mph (LDT)

For 1975, two respondents stated that alternate shift schedules had been used. These schedules were as follows:

Vehicle Speed at Shift Points (mph)

1st/2nd	2nd/3rd	3rd/4th
10	20	40
20	30	
20	35	
20	20	
20	30	40
10	15	30
20	25	30
25	25-40*	
15	18-25*	40

* Shift whenever a cruise within the specified range has been reached.

Question 3: "What data are available to indicate that those 1974 and 1975 alternate shift schedules were more representative of consumer use than the 15-25-40 mph schedule?"

Answers: No respondents provided data to indicate that the alternate shift schedules were more representative of consumer use. Two of the respondents stated that in their owner's manuals, they have advised their customers to use the alternative shift schedules because: (1) they, "recognized the in-use fuel economy improvement possible" or (2) "it is our obligation to recommend customer operation of the vehicle that is both practical and efficient." A third respondent stated that they recommended the alternate shift points through the owner's manual because, "it was appropriate for off-road" manual transmission type vehicles.

Question 4: "What shift schedule changes have been typically used after 1975?"

Answers: One of the respondents indicated that they had used alternate shift schedules but did not describe them numerically. Another respondent stated that they did not deviate from the 15-25-40 mph shift schedule totally. A third noted that they had deviated once and used a 15-25-30 mph shift schedule on two of their models. The last three respondents used one or more of the following shift schedules:

a) 20-25 mph
b) 20-35 mph
c) 20-25-40 mph (shift whenever cruise speed has been reached)
d) 5-15-25 mph
e) 10-15-30 mph
f) 10-20-30 mph (shift directly to 4th gear once stabilized at 25 mph)
g) 10-20-35 mph (shift directly to 4th gear once stabilized at 25 mph)
h) 10-25-25-mph (shift directly to 4th gear once stabilized at 25 mph)
i) 15-25-40 mph (shift directly to 4th gear once stabilized at 25 mph)
j) 20-25-30 mph
k) 20-30-40 mph
l) 16-17-38 mph (based on RPM)
m) 13-24-31 mph (based on a consumer survey)
n) 10-20-35-45 mph
o) 10-20-35-45* mph (*cruise = 25 mph)
p) 15-26-37-57 mph
q) 15-26-38-58 mph
r) 10-20-40 mph
s) 15/18-25/30 mph
t) 10/15-20/25-30 mph

Question 5: "What effect has the use of these post-1975 shift changes had on specific fuel economies?"

Answers: One respondent stated that they had not determined the effects of these changes on fuel economy. Another respondent using a 1977 model year vehicle, compared the fuel economies obtained with the 15-25-40 mph and an alternate shift schedule and observed that their alternate shift schedule realized a city fuel economy increase of 13 percent (3.0 mpg). A third stated that one of their vehicles showed an 8 percent reduction in fuel economy caused by the 1979 shift schedule restrictions. The fourth respondent stated that tests performed with several vehicles using their recommended and the EPA's (RPM method) shift schedules resulted in city fuel economy losses of from 6.4 to 17.8 percent (1.4 to 2.6 mpg). The last respondent stated that their 1979 certification program caused a reduction in measured fuel economy of about 1.0 mpg (composite).

Question 6: "What effect has the use of these post-1975 shift changes had on your corporate average fuel economy?"

Answers: The responses of those commenters claiming an effect on their CAFE are summarized in the following table.

Estimated CAFE Effect

Respondent	LDV	LDT
A	2% (0.40 mpg)	5%
B	0.06 mpg	0.13 mpg
C	0.08 mpg	-
D	0.30 mpg	0.60 mpg

Question 7: "What data can you present to indicate that these post-1975 shift schedules are more representative of consumer vehicle use than the 15-25-40 mph schedule?"

Answers: Two respondents stated that they had demonstrated the representativeness of alternate shift schedules on several of their models and supplied such findings to EPA. One of these stated that they were conducting similar research on other engine families.

Question 8: "What data can you present to demonstrate that the fuel economy improvements obtained with the post-1975 shift schedules were obtained in consumer use of the vehicles."

Answers: No data were presented in response to this question. One respondent suggested that, "if the shift schedules were optimized with respect to the EPA cycle, the fuel economy for these vehicles would be from 2 to 4.5 percent better than that obtained with 'default' shift schedule" and "since any survey of consumer driving patterns is not likely to show shifting at the true optimum the potential gain . . . would be some fraction of the 2 to 4.5 percent obtainable."

Another respondent stated, "we believe intuitively that our consumers are witnessing the same comparative gain seen during testing . . . cycles."

Question 9: "As more efficient automatic transmissions are phased in, what will the relationship between manual- and automatic-equipped vehicles be with respect to EPA measured fuel economy using 1975 and using post-1975 shift schedules?

Answers: Four respondents indicated that as automatic transmissions become more efficient the fuel economy differential obtained with automatic and manual transmissions will be reduced. One of these specifically referred to small vehicles only. Another indicated that post-1975 manual transmission equipped vehicles were expected to achieve an average of 8 to 12 percent higher fuel economies than their automatic transmission equipped vehicles and that in 1975 their manual transmission equipped vehicles had achieved approximately 10 to 15 percent better fuel economies than those with automatic transmissions.

The fifth respondent did not anticipate that the 10 percent fuel economy advantage (combined city/highway) that manual shift transmissions currently have over automatic transmissions would be overcome in the foreseeable future.

Question 10: "What data can you present to indicate manual transmissions will be more or less efficient in actual vehicles use compared with more efficient automatic transmission?"

Answers: One respondent stated that, based on their 1974 study of executive lease vehicles (sub-compact imports and light-duty trucks), manual transmission vehicles showed an average fuel economy advantage of 11.5 percent over those with automatic transmissions. This respondent also stated that utilization of the lockup torque converter is expected to improve the automatic transmission's fuel economy by about 2 percent. "This improvement, which occurs principally during highway operation, is expected to reduce the 'in-use' benefits of manual transmissions to the general driving public from about 10 to about 8 percent." The other five respondents did not provide any actual vehicle use data.

Question 11: "Do you have any programs underway to optimize automatic transmission shift schedules to the EPA test cycles? If so, please describe."

Answers: One respondent stated that they had, "no program underway to change schedules." Another stated that they, "have developed a simulation model to obtain automatic transmission optimized curves for better fuel economy for various driving modes." A third respondent stated that they had no programs to optimize automatic transmission shift schedules with respect to the EPA test cycles, but instead that, "shift schedules are dictated by customers acceptance of acceleration performance." The fourth respondent stated that they, "are continuously working to improve and optimize these transmissions and their shift schedules."

Question 12: The existing shift schedule restrictions allow you to use any manual transmission shift schedule that you can demonstrate is or will be in typical use. Do you intend to encourage your vehicle purchasers to use alternate shift schedules so that those schedules can be used during fuel economy testing? Will this action be accompanied by transmission changes, such as the use of additional or wide ratio gears? What fuel economy benefits do you expect?"

Answers: Three respondents noted that the use of alternate shift schedules will not be encouraged to purchasers. One of the above respondents stated that they "are studying and planning to use wide ratio gear sets in our future manual . . . transmissions." The other three respondents stated that they intended to encourage purchasers to use alternate shift schedules provided that it improves fuel economy as well as performance. Two of these did not indicate whether this action would be accompanied by transmission changes. The third intends to pursue product design improvements, such as wide ratio transmission gears and added that "the potential fuel economy gains from manual transmission improvements cannot be recognized with the current EPA certification procedures."

III. Analysis

In response to the question about the shift schedules used in the 1974 and 1975 exhaust emission and fuel economy tests, all but one commenter stated that virtually all of their manual transmission equipped vehicles were shifted according to the standard EPA 15-25-40 mph shift schedule.

In 1975, the majority of a large and a small manufacturer's vehicles were tested with shift schedules which deviated from the 15-25-40 mph shift schedule. Generally, the alternate schedules requested shifts at higher speeds than the default shift schedules. These higher speeds tended to occur on the 1st to 2nd and the 2nd to 3rd gear changes. The prevailing requested shift point speeds were 20 mph and 30 mph, respectively. No data were presented to indicate that these shift speeds were more representative of typical vehicle use than the 15-25-40 mph default schedule.

From 1976 through 1978 the number of alternate shift schedules requested and used increased. These alternate schedules tended to call for earlier (lower speed) shifting than the standard schedule. The predominant speeds used for the 1st to 2nd, the 2nd to 3rd, and the 3rd to 4th gear changes were 10, 20, and 30 mph, respectively.

The respondents stated that these alternate shift schedules improved the measured fuel economies of specific light-duty vehicles by amounts ranging from 0.2 to 2.6 mpg (6 to 18 percent). The average effect was approximately 1.2 mpg. This effect, expressed in terms of a change in mpg, is relatively large, primarily, because manual transmissions are most frequently used in smaller, more efficient, vehicles.

Although the effects of the shift schedule changes on specific vehicles are significant, their effect on the corporate average fuel economy is much smaller for most manufacturers because of the small percentage of vehicles sold with manual transmissions. Estimates of the effect on the CAFE of the alternate shift schedules ranged from 0.06 to 0.13 mpg or approximately 0.3 to 0.6

percent for light-duty vehicles. For light-duty trucks, the range of the reported effect was 0.1 to 0.6 mpg. A computed arithmetic average of the effect on the CAFE is about 0.2 mpg for both LDV and LDT. This average is not sales weighted and is therefore significantly affected by the small sales volume manufacturer whose product line includes a large fraction of small manual transmission vehicles.

Advisory Circular No. 72, introduced by EPA for the 1979 model year, required that if an alternate shift schedule is to be used by EPA the request for that schedule must be supported by data indicating that the requested schedule is representative of typical vehicle use. Two manufacturers responded that they had met this criterion and have used alternate shift schedules for their 1979 and/or 1980 vehicles. (One of these requested an alternate shift schedule for a turbo-charged vehicle. The requested speeds for the 1st to 2nd and the 2nd to 3rd gear changes were 13 and 24 mph, respectively. These were quite near the default, 15 and 25 mph, speed points. The 3rd to 4th gear change occurs at a point when the turbo-charger has a significant effect the shift speed and was substantially reduced from 40 mph to 35 mph.)

No data were presented to indicate that the lower shift speeds used between 1976 and 1978 were more representative of typical in-use vehicles than either the higher shift speeds used in 1974 and 1975 or the default shift schedule.

Several manufacturers correctly stated that the fuel economy improvements obtained from 1976 through 1978 model years could also be obtained by in-use vehicles. However, no data was presented to substantiate that such shift related fuel economy benefits were actually being obtained by vehicle consumers. One manufacturer correctly stated that if the "shift schedules were optimized with the EPA cycle, the fuel economy for these vehicles would be 2 to 4.5 percent better than the 'default' shift schedule" and "since any survey on consumer driving patterns is not likely to show their shifting at true optimum, the potential gain . . . would be some fraction of 2 to 4.5 percent obtainable."

In regard to questions concerning the efficiency of automatic versus manual transmissions, manufacturers stated that automatic transmissions will continue to improve and that the fuel economy disparity between vehicles with automatic and those with manual transmissions will decrease from the 10 to 15 percent range to the 8 to 12 percent range. No manufacturer indicated that the fuel efficiencies of improved automatic transmission equipped vehicles would equal or exceed those of vehicles having manual transmissions.

IV. Summary and Conclusions

In the 1974 model year few vehicles were tested using shift schedule alternates to the standard 15-25-40 mph schedule. In 1975 their number and proportion increased. During the 1974 and 1975 model years the alternate shift points selected tended to be at speeds higher than the 15-25-40 mph default schedule.

From 1976 through 1978 there was a dramatic increase in the use of alternate shift schedules, but the speeds used during these years tended to be lower than the standard shift schedule. Shifting at lower speeds reduces the engine speed and requires that the engine produce a greater torque. Under conditions of light engine loading, such as many portions of the EPA test cycle, these changes in the engine operational state result in increased engine efficiency.

The use of the requested alternate schedules in typical vehicle operation was generally not substantiated. It appears that many of these alternate shift schedules evolved primarily as a means to improve the EPA measured fuel economy.

Estimates of the effect of alternate shift schedules on the CAFE of various manufacturers ranged from approximately 0.1 mpg to 0.3 mpg. The variation in the magnitude of the effect primarily reflects the proportion of manual transmission vehicles in product lines of the various manufacturers.

Advisory Circular No. 72 requires that if an alternate shift schedule is used by EPA, the manufacturer must demonstrate in some fashion that this alternate schedule will be used in typical vehicle operation. This Advisory Circular has greatly reduced the use of alternate shift schedules, however, several manufacturers have met this criterion and alternate shift schedules continue to be used.

The option of an alternate shift schedule still exists and this option is currently used to about the same extent that it was during the 1974 and 1975 model years. Therefore, no reduction in fuel economy can be claimed due to alternate shift schedules when comparing "procedures utilized by the Administrator" in 1974 and 1975 versus those utilized at the present time. The recent change in EPA regulations has not eliminated nor restricted the use of a technology which would result in improved consumer fuel economy.

CHAPTER 3

ALTERNATE DYNAMOMETER ADJUSTMENTS

I. Introductory Statement

EPA has always provided the option that a manufacturer may request, for specific vehicles, dynamometer adjustments which are different from the values contained in EPA regulations. A request for such alternate dynamometer power absorptions must be supported by road test data demonstrating the appropriateness of the request. In 1975, the regulations implied that manifold pressure measurements were the required method of generating acceptable road load data. Later the manifold pressure approach was deleted and, subsequently, the coastdown technique has become the prevalent method of generating supporting data for alternate dynamometer power absorption requests. An acceptable coastdown procedure, which has been provided to the industry as an EPA Recommended Practice, has been distributed as an Attachment to Advisory Circular No. 55B.

II. Summary of Comments

Question 1: "To what extent were alternate dynamometer adjustments (DPA) used in 1974, in 1975? To what extent are they currently used?"

Answers: One respondent, a foreign manufacturer, noted that they had used alternate DPAs on two out of nine 1974 models and four out of nine 1975 models. All other respondents stated that they had not used alternate DPAs in 1974 or 1975. In 1979 three respondents noted that between 40 to 87 percent of their light-duty vehicles used alternate DPAs. One of the respondents indicated that all of their light-duty trucks used alternate DPAs, too. Four respondents stated that they intend in 1980 to use the alternate DPAs for between 75 and 100 percent of their light-duty vehicles.

Question 2: " To what extent has the increased use of alternate dynamometer power absorptions improved your corporate average fuel economy (CAFE) compared to the CAFE value that would be obtained if: (1) dynamometer power absorptions from the equation contained in the current regulations were used exclusively, (2) dynamometer power absorptions from the inertial weight based table of the 1975 regulations were used exclusively, or (3) the use of alternate dynamometer power absorptions were restricted to the extent they were used in 1974 or in 1975?"

Answers: Four respondents stated that the use of the alternate DPA improved their light-duty vehicle CAFE compared to either the equation or inertial weight-based table. One respondent commented that their LDT CAFE would improve if the 1975 inertial weight-based table were used for these vehicles. The LDV CAFE improvements claimed as a result of using the alternate DPA were: (1) from 0.8 to 1.5 percent, that is, 0.2 to 0.4 mpg relative to the frontal area equation, and (2) approximately 2.5 percent or about 0.5 mpg relative to the inertial weight-based table.

Question 3: "To what extent does current EPA policy (applicable Advisory Circulars) on alternate dynamometer adjustment restrict your ability to make improvements in vehicle fuel economy which would be observed in consumer use of the vehicles? Please describe."

Answers: One respondent stated that the current EPA policy on alternate dynamometer adjustment does not inhibit their ability to make improvements of fuel economy which may be observed in consumer use. Another stated that they have not determined any such effect. The other four respondents stated that the current EPA policy on alternate dynamometer adjustment has been restrictive in improving their fuel economy in the following ways:

a. Additional and extensive testing requirements.
b. Not being credited for improvements of items, such as optional mirrors, etc.
c. Requiring dynamometer settings to reflect a 33 percent option rate rather than the fifty percent level.
d. Confirmation procedures inhibit the early implementation of improved product actions.
e. Late changes and interpretations of requirements.

Question 4: "Have the administrative procedures implemented since 1975 become burdensome to the point that time and money considerations preclude their use in some instances as compared to using the standard Federal Register procedures? Provide details.

Answers: All of the respondents stated that the administrative procedures implemented since 1975 have become burdensome but did not preclude the use of the alternate dynamometer power adjustments even though they recognized the time and expense penalty. One respondent stated that if the "alternate horsepower values . . . are close to frontal area numbers" the former values "are often not submitted to EPA because of added burden resulting from confirmatory testing."

III. Analysis

Alternate dynamometer adjustments were only used by one small manufacturer in 1974 and 1975. Therefore, strict interpretation of "test procedures utilized by the Administrator in 1975" might preclude the use of alternate dynamometer adjustments by most manufacturers, or restrict their use to a small percentage of the vehicle fleet. However, this option is the method by which a manufacturer obtains credit for aerodynamic and rolling resistance improvements to a vehicle which improve its fuel economy during consumer use.

Presently alternate dynamometer adjustments are widely used by major manufacturers for nearly 100 percent of the test fleet. As a result of this use, LDV CAFE's have improved by about 0.3 mpg compared with the results which would be obtained if current vehicles were tested exclusively according to the 1975 inertia weight-table, or the equation contained in the current regulations.

Some improvement of measured fuel economy might result if the 1975 table were retained for light-duty trucks. The truck question is really not germane since the inappropriateness of the weight-table for trucks was recognized before LDT fuel economy standards were promulgated and these standards were adjusted to account for the more realistic dynamometer adjustments which were anticipated for LDT's. This is basis for Question 1 of Chapter 8, and is discussed further under that question.

Manufacturers did comment that current testing requirements were somewhat burdensome, and therefore, alternate dynamometer adjustments were only requested when significant benefits would be obtained. One manufacturer commented that EPA policy prevents credit for some improvements such as optional mirrors. However, since a manufacturer has the option of testing multiple vehicles, both for alternate dynamometer power absorptions and for fuel economies, this response is really another version of the earlier statement that alternate dynamometer power absorptions are used only when sufficient benefit is obtained.

It should be noted that the use of alternate dynamometer power absorptions is an optional procedure to be used at the discretion of the manufacturer. When its use is elected the manufacturer logically incurs the burden of supplying data to support the requested alternate dynamometer power absorption. One manufacturer specifically stated that confirmatory tests required by EPA to be conducted by independent testing organization cost more than $3,000.

This may well be too great a "burden" when the proposed improvement is an optional mirror. It should be noted, however, that all major manufacturers and many small manufacturers extensively use alternate dynamometer power absorptions.

IV. Summary and Conclusions

The use of alternate dynamometer power absorptions currently yields approximately 0.3 mpg improvements in corporate average fuel economies compared with those which would be obtained using the 1975 inertial weight table. Although this option was not extensively used in 1975, it is the only mechanism by which a manufacturer receives fuel economy credit for improvements in vehicle aerodynamics or tire rolling resistance and should be retained to provide incentive in these areas.

CHAPTER 4

ACCESSORIES

I. Introductory Statement

"EPA now uses a carline/truckline designation rather than an engine family designation for assigning accessory load. Additionally, carline and truckline have been redefined to some degree. Other than this no apparent changes have been made in the EPA test procedure which would affect the simulation of vehicle accessories."

II. Summary of Comments

Question 1: "Has the carline/truckline approach for assigning accessory load had an effect on your corporate average fuel economy? How? To what extent?"

Answers: All of the respondents except two, claimed that switching from the engine family approach to the carline/truckline approach did not affect or had no significant effect on their CAFE. One of the two dissenters stated that the 1980 accessory selection rule, which determines the 33 percent option criterion by carline, caused their effective test weight to increase slightly and coupled with "some resultant additional power absorber penalties" resulted in a 0.1 mpg decline in the 1980 CAFE for their carlines and a 0.3 mpg CAFE decline for their trucklines. The other dissenting respondent claimed that the switch from engine family accessory loading to truckline accessory loading in 1980 had reduced the fuel economy of their 2-wheel drive truck fleet by 0.1 mpg.

Question 2: "Do you believe that there have been other changes made in the EPA test procedure which affect the simulation of the load imposed on the engine by vehicle acessories? What changes? What effect?"

Answers: None of the respondents were aware of any other changes in the EPA test procedure that have affected accessory load simulation.

Question 3: "There appears to be an increasing use of accessories, such as air conditioners, in small vehicles. Is the current EPA simulation of air conditioning (10 percent increase in the dynamometer power absorption) adequate since such smaller vehicles generally have reduced dynamometer power absorptions?"

Answers: Most respondents stated that the current 10 percent increase in the power absorption of the dynamometer to simulate the fuel economy effect of air conditioning was appropriate for both large and small vehicles. One non-concurring respondent commented that the current EPA simulation of air conditioning results in a 1.7 percent fuel economy penalty for large vehicles and a 2.3 percent fuel economy penalty for small vehicles and, therefore, small vehicles are more heavily penalized. Another respondent concurred with this observation but also commented that this was appropriate since the fuel economy effect of air conditioning was greatest on the smaller, typically lower power-to-weight ratio vehicles.

One respondent commented that their subcompacts are penalized relative to the larger vehicles since their average air conditioning installation rate (48.7%) is less than that of larger cars, i.e., compact (75.3%), intermediate (80.2%), and full-size cars (95.6%). Yet EPA treats all of the classes equally since in all instances the installation rate exceeds 33 percent.

<u>Question 4</u>: "What would be the effect on your corporate average fuel economy of a more realistic simulation of the air conditioning load."

<u>Answers</u>: Three of the respondents stated that the current simulation of air conditioning load is probably reasonable and "realistic" as an average annual effect. Four respondents indicated improvement of this procedure would add "to further complication to test procedures" and one stated that the cost impact of the procedures would be prohibitive.

With regard to the fuel economy effect of operating vehicle air conditioners, one respondent stated that their vehicles experienced a 5 to 10 percent fuel economy penalty. Another stated that using vehicle air conditioning under FTP ambient conditions would result in about a 9 percent fuel economy penalty.

In comparison, three respondents stated that the 10 percent increase in the power absorption (PAU) setting used by EPA to simulate vehicle air conditioning resulted in approximately 2 to 4 percent fuel economy loss for their smaller vehicles and only 2 percent or less for their larger ones.

<u>Question 5</u>: "What would be the effect of a more realistic simulation of other engine driven accessories which are not fully utilized in the EPA test procedure (power steering;, engine cooling fan, electrical system load) on your corporate average fuel economy?"

<u>Answers</u>: Two respondents stated that they had neither conducted any studies nor collected any data on the effect of the simulation of other engine-driven accessories on their corporate average fuel economy. One respondent stated that a more realistic simulation of power steering (movement of the steering wheel back

and forth to activate the system) would have a negligible effect on fuel economy. Another suggested that, at straight ahead driving, the EPA measured fuel economy is slightly better than consumer use. One respondent claimed that operation of the electrical systems would reduce fuel economy.

Question 6: "Has the lack of accurate representation of accessory loading precluded or inhibited your development of more efficient accessories or accessory drives?"

Answers: All respondents commented that whether or not accessory loading is realistically represented, this would not preclude or inhibit the development of more efficient accessories in order to improve consumer fuel economy.

III. Analysis

The manufacturers unanimously concurred that the change from engine to carline/truckline classification was the only change in the EPA procedure which has affected the treatment of accessories.

Most manufacturers stated that switching from engine family to the carline approach for assigning accessory load had no significant effect on their LDV CAFE. However, one manufacturer did claim the change reduced their 1980 CAFE 0.1 mpg. In the case of the change from engine family to truckline for assigning accessory loads, two manufacturers commented that this change caused a negative effect of 0.1 mpg to 0.3 mpg on their truckline CAFE. A detailed explanation of how this occurred was not provided, however reference was made to an earlier more detailed submission to DOT.

It is important to understand how fuel economy could be affected by this change in EPA regulations. Consider, for example, light-duty trucks. Previously, vans and pick-up trucks would have been grouped together in a single engine family. If there were equal sales of trucks and vans and, for example, 50 percent of all vans were equipped with air conditioning but only 10 percent of the pick-ups were air conditioned, then air conditioning would be present on only 30 percent of the trucks in the engine family and EPA would have considered a non-air conditioned vehicle as appropriate to represent the sales fleet.

At the present time, EPA separates sales by truckline into pick-up trucks and vans. If a van were selected as the test vehicle, then, since 50 percent of these vehicles were equipped with air conditioning the vehicle would be tested as an air conditioned vehicle. Consequently, the vehicle would be tested with a 10 percent greater dynamometer power absorption and possibly at an increased test weight resulting from the additional weight of the air conditioner.

In all instances it should be noted that, as a result of the change to carline/truckline, the selected vehicle was always tested in a manner more appropriate for the carline/truckline represented. Furthermore, a manufacturer who believes that the selected test vehicle does not adequately represent the product line, has the option of supplying additional test data or additional test vehicles.

In response to the question regarding the appropriateness of the current air conditioner simulation, particularly with respect to smaller vehicles, the general comment was that the current 10 percent increase in dynamometer power absorption was appropriate to simulate the average annual effect of air conditioning for all vehicle sizes. However, no reference to any data or detailed study was provided.

One manufacturer did comment that the selection criteria (air conditioner simulation if more than 33 percent of carline is equipped with air conditioners) tended to penalize subcompacts more heavily than other vehicle categories. This was so because although air conditioners were sold on only slightly more than 40 percent of their subcompact vehicles, they were installed on virtually all full-sized vehicles, and the same percentage dynamometer adjustment penalty applied to the test vehicle representing the subcompact vehicles as was applied to the full-sized test vehicle.

Most manufacturers concurred that the 10 percent increase in dynamometer adjustment used by EPA to simulate the effect of air conditioners caused a 2 to 4 percent decrease in measured vehicle fuel economy. EPA estimates of the effect of air conditioner simulation are generally in the lower portion of this range.3/

In response to a question on the effects of more accurate air conditioner simulation most manufacturers protested that this could be prohibitively complex and expensive. One manufacturer did comment that actual use of air conditioners reduced vehicle fuel economy by 5 to 10 percent, and therefore, more accurate simulation of actual use would have a similar effect.

One approach, generally not considered, would be for EPA to accurately simulate actual air conditioner use. Then consumers could be presented with a much more significant estimate of the cost in fuel economy, of air conditioning and would have greater incentive to choose more fuel efficient vehicles. Also with this approach, the air conditioning penalty could be applied to whatever percentage of vehicles were actually sold with air conditioning, thus eliminating the manufacturers objections that all classes of vehicles, in which more than 33 percent were equipped with air conditioning, are tested equally. This approach would require some additional testing to accurately assess the actual effect of the air conditioner. This testing would not necessarily be prohibitively expensive since air conditioners are probably similar enough over a large segment of any manufacturer's product line that few vehicles would have to be tested.

As for other engine-driven accessories, some manufacturers suggested that although the power steering and electrical systems may cause a reduction in measured fuel economy any effect would be small compared to that of air conditioning.

Finally, manufacturers commented that, even though not credited in the EPA test procedure, the efficiency of engine accessories will continue to be improved to provide improved consumer fuel economy. In this regard however, it should be noted that although DOT has projected significant consumer fuel economy improvements through improved accessory drive mechanisms, such drives, which would show little benefit on the EPA test procedure, do not seem to be actively considered by manufacturers.

IV. Summary

The change in assigning accessory load from engine to carline/truckline families could have had an effect on measured CAFEs. Only one manufacturer claimed such an effect for its LDV CAFE while two manufacturers claimed their LDT CAFEs were affected. This change was made to improve the accuracy of the simulation of the represented vehicles and has resulted in more accurate testing of the represented production vehicles. Additionally, it should be noted that manufacturers have the option of submitting additional test data or additional test vehicles if they wish more accurate representation of their entire product line. The use of this option would tend to eliminate any CAFE effects of the EPA change to carline/truckline.

The air conditioner simulation currently used by EPA understates the fuel consumption effects of actual air conditioner use. This simulation may be appropriate to predict the national aggregate effect of annual air conditioner use, however, no detailed study has been made to confirm this.

In general, the manufacturers have commented that more fuel efficient accessories and accessory drives are being developed to improve consumer fuel economy even though little benefit is obtained from the effort in the EPA tests. However, little evidence of significant improvement in these areas has been seen.

CHAPTER 5

INERTIA WEIGHT CHANGES

I. Introductory Statement

"Beginning with the 1980 model year, EPA reduced the increments of simulated inertia by approximately a factor of two (from 500 pounds to 250 pounds for vehicles over 4,000 pounds). This change was made to provide more accurate simulation of the test vehicle weight."

II. Summary of Comments

Question 1: "If the current test weight increments were applied first to the 1974 test vehicle fleet, then to the 1975 test vehicle fleet, what percentage of those vehicles would have been tested at higher simulated inertia? At lower simulated inertia?"

Answers: If the current inertia weight increments had been applied to the 1974 and 1975 fleets, the percentage of the vehicles that would have been tested at the lower and at the higher simulated inertias are as follows:

In the case of the 1974 test fleet (no responses from the major manufacturers):

Respondent	Vehicles (%) Tested at the Higher Inertia	Vehicles (%) Tested at the Lower Inertia	Remarks
A	27	9	
B	50	0	LDT (Family 1)
	100	0	LDT (Family 2)
C	11	11	

In the case of the 1975 test fleet:

Respondent	Vehicles (%) Tested at the Higher Inertia	Vehicles (%) Tested at the Lower Inertia	Remarks
A	0	0	
B	24	0	
C	75	0	LDT
D	28	31	LDV
	19	18	LDT

Note: Response D represents the greatest number of sales by a major manufacturer.

Question 2: "If the current test vehicle fleet were tested using the pre-1979 inertia increments, what percentage of vehicles would be tested at the higher simulated inertia? At the lower simulated inertia?"

Answers: With regard to the current test vehicle fleet, the percentage of vehicles that would have been tested at the higher and the lower simulated inertia categories are as follows:

Respondent	Vehicles (%) Tested at the Higher Inertia	Vehicles (%) Tested at the Lower Inertia	Remarks
A	0	100	
B	9	31	
C	10	40	LDT
	0	60	LDV
D	3	75	LDT
	21	17	LDV

One respondent stated that if their 1979 model year fleet were tested according to the 1980 test procedure, their fleet average test weight would increase 112 pounds.

Question 3: "What additional improvements in the EPA measured fuel economies would have been obtained if this change in EPA inertia categories had not been made? What data exists to indicate that these EPA measured fuel economy improvements would have been realized by the consumer use?"

Answers: Five of the six respondents stated that the change in inertial weight increments resulted in a reductions in measured fuel economies of from 0.1 to 0.3 mpg. The sixth stated that their answers to the question were "undertermined."

Only two respondents directly addressed the second part of the question, both stated that the change would not be detectable to the consumer.

Question 4: "What was the average difference between production vehicle weights and the EPA simulated vehicle weights determined under the 1980 procedures? Under the pre-1980 procedures?"

Answers: Only one respondent provided data. Under the pre-1980 model year regulation, the production vehicle weight was greater than the EPA simulated vehicle weight by 27.9 pounds. Under the 1980 regulation the production vehicle weight is 4.2 pounds less than the EPA simulated vehicle weight.

Question 5: "Are the above claimed effects permanent or transitory? If transitory, what percentage of your fleet is affected and for how long? Please explain your answer."

Answers: Four respondents stated that the effects were permanent. One stated that the fuel economy loss would eventually level off and the sixth stated that the effects were transitory because the sensitivity of fuel economy is anticipated to be changeable depending on future design modifications.

III. Analysis

If the 1979 inertia simulation weights were applied to the 1974 and 1975 test vehicles, there would have been little net effect. As one commenter observed, "As of 1975, the actual weights of . . . passenger cars and light trucks were more or less randomly distributed within each inertia weight category."

As vehicle downsizing occurred manufacturers directed their goals toward the EPA inertia categories, and consequently in 1979 vehicles tended to be grouped near the upper regions of the categories. This motivated EPA to decrease the test weight category increments and, thereby, to improve the accuracy of the simulation of the vehicle road experience during the EPA tests. As expected, this frequently reduced the measured vehicle fuel economy for current vehicles. Most commenters expressed the opinion that the resulting decrease in 1980 corporate average fuel economy was approximately 0.2 mpg.

This decrease in corporate average fuel economy was a result of improved test accuracy and did not affect in-use vehicle fuel consumption. This position is supported by comments indicating that the average difference between the vehicle design and the EPA tests weights significantly decreased in 1980 and also by comments stating that the in-use vehicle fuel consumption would be unchanged.

Most commenters objected to the change to smaller inertial weight increments on the basis that this change eliminated some of the gains in measured fuel economy which were made in the 1977 and 1978 model years. While these gains may not have represented real progress in reduction of in-use fuel consumption, they were, nevertheless, used in the progress of establishing fuel economy standards for future model year vehicles.

Several manufacturers commented that the changes in inertial weight increments had a permanent effect on measured fuel economies, but others stated that the effect was transistory. It is more logical to consider the effect transistory since any losses can be recovered in future weight reduction programs, since a manufacturer would receive credit for smaller increments of weight reduction. Therefore, benefits may be obtained from design refinements rather than major redesign efforts.

IV. Summary and Conclusions

In 1979 EPA reduced the increments of simulated vehicle weight used during the EPA fuel economy test for the purpose of improving the accuracy of the simulation of the vehicle road experience during the EPA tests.

This change reduced the measured fuel economy of many 1980 model year test vehicles because these vehicles tended to fall near the upper bounds of the previous test weight categories. The reduction in the test weight increments would have had little effect if applied to the 1975 test fleet. Therefore, this change in test procedure yields results which are equivalent to those obtained from the test procedure used in 1975.

CHAPTER 6

EMISSION STANDARD MODIFICATIONS

I. Introductory Statement

In other areas of this questionnaire it is important that the issue of test procedure changes is not confused with comments related to emission standards. However, since some manufacturers may wish to comment in issues related to emission standards the following questions are presented.

II. Summary of Comments

Question 1: "Has the imposition of the 1981 emission standards (0.41 g/mi HC, 3.4 g/mi CO, and 1.0 g/mi NOx) inhibited the development of alternate engines and control strategies relative to conventional spark ignition (SI) engines?"

Answers: The respondents stated that the imposition of the 1981 emission standards has inhibited the development of alternate engines and control strategies in two ways. Three respondents stated that the development efforts to meet the 1981 emission standards, as well as the current fuel economy standards, have diverted their capital and manpower resources from the alternate engine programs. Four respondents stated that they have been devoting resources in the development or improvement of alternate engines but were having difficulty meeting the 1981 emission standards with them.

The diesel engine was frequently mentioned as an example of an attractive alternate engine, at least from the fuel economy standpoint, however, several manufacturers commented that current technology on diesel engines could not simultaneously meet the 1.0 g/mi NOx standard and the proposed particulate standard.

Question 2: "On September 19, 1978, EPA distributed a draft Advisory Circular with regard to emissions at temperatures and operating conditions typical of the urban environment, such as vehicle operation at 50°F, but not specifically evaluated by the FTP. What effect would this draft Advisory Circular have on your present corporate average fuel economy? What effect would it have on your future ability to improve fuel economy as measured on the EPA tests and in consumer use? In particular, what would be the effect of this draft Advisory Circular on the use of electronics and on the use of other new types of fuel economy improvement technology such as turbocharging, and variable displacement engines? What data are available to support your response?

Answers: The majority of respondents stated that they did not have sufficient data available to assess the potential effect this Advisory Circular might have, or that the application of the Advisory Circular was not sufficiently clear to allow an assessment of the effect.

Three respondents did state that fuel economy would decrease with decreased ambient temperature. One of these cited a study conducted by the Canadian government.

Question 3: "What effect did the change by Congress of the 1978 light-duty Vehicle Emission Standards (0.41 g/mi HC, 3.4 g/mi CO, and 0.4 g/mi NOx) to 0.41 g/mi HC for 1980, 3.4 g/mi CO for 1981 (with possible waiver to 7.0 g/mi), and 1.0 NOx for 1981 have on your 1978 through 1985 corporate average fuel economies? Please answer separately for conventional SI engines, stratified charge SI engines and diesel engines."

Answers: Two respondents indicated that the relaxation of the emission standards by Congress had a positive effect on fuel economy when compared to the effect which would have been obtained if the original more stringent standards had remained. One respondent stated that the relaxation of standards avoided a fuel economy penalty of 5 percent in model year 1980 and 3 percent for subsequent model years. Three other respondents stated that they were unable to assess the magnitude of the effects.

One respondent stated that failure to grant a 1980 model year NOx waiver or the promulgation of stringent particulate standards may preclude the inclusion of the diesel engine in their corporate fleet. The anticipated effect of this loss on CAFE would be 0.4 mpg in the 1982 model year and 0.8 mpg in the 1985 model year.

Question 4: "Are any synergistic effects present when simultaneous changes are made in emissions standards and test procedures, which do not occur when one of those factors is changed alone? Explain."

Answers: One respondent stated that they do not believe that there are inherent synergistic effects, three respondents indicated that this was undetermined, and two indicated that an antagonistic effect was evident, primarily because of leadtime constraints.

III. Analysis

This area of the questionnaire addressed the effects of emission standards on the development of alternate engines. An analysis of this section of the questionnaire responses has not been provided since the main EPA concern herein is with the effects on fuel economy of changes in test procedure and also because very little alternate information in this area is available.

IV. Summary

Since no analysis of this section of the questionnaire was made the following statements, a condensation of the received comments, are not necessarily indicative of EPA conclusions.

Most respondents commented that the current emission standards inhibit the development of alternate engines or control strategies either because of the demands on their resources of meeting the standards with conventional engines or because of the cost or because of the uncertainty of meeting current standards with alternate engines.

With regard to the effects of a proposed Advisory Circular on measuring fuel emissions and fuel economy under conditions not specifically evaluated by the current test procedure: most manufacturers commented that the effects of the application of this Advisory Circular were undetermined.

According to the majority of respondents, the relaxation of the NOx emission standard by Congress from 0.4 g/mi to 1.0 g/mi and the postponement of the HC and CO statutory standards resulted in fuel economy gains compared to fuel economies obtainable under the original more stringent standards. One respondent stated that this relaxation of the standards avoided a fuel economy penalty of 3 to 5 percent. Most of the respondents did not quantify the effect.

Several manufacturers commented that there is an antagonistic effect when both emission standards and test procedures are changed simultaneously because of generally inadquate leadtimes. Other commenters indicated that no synergistic effects were experienced.

CHAPTER 7

GENERAL QUESTIONS

I. Introductory Statement

"The following questions are not within the previous [or subsequent] question groups. However, since they address areas where some changes may have occurred, your comments are requested."

II. Summary of Comments and Analysis

In this chapter the summary of the comments, the analysis, and any conclusions are presented after each individual question since the questions are not grouped by subject.

Question 1: "Emissions and fuel economy tests are performed on vehicles which are specially prepared by the manufacturer for these tests. Would there be an effect on your corporate average fuel economy if production vehicles were randomly selected for fuel economy testing? What effect do you estimate?"

Answers: Two respondents stated that there would be little or no effect on their CAFE. Two respondents believed that the production vehicle would have a higher fuel economy than its prototype. Others responded that the difference would be unpredictable and the procedure impractical.

Analysis: EPA tests have indicated that in some instances production vehicles appear to obtain lower fuel economies than their prototypes tested during the certification process.4/,5/

Question 2: "What data can you present to indicate that the fuel economy improvements measured on the EPA tests have also occurred in consumer vehicle use?"

Answers: Some respondents stated that consumer in-use fuel economy is lower than the fuel economy measured by the EPA test procedure. One respondent stated, that this discrepancy is decreasing. Two others stated that the EPA's fuel economy data is closely representative of the actual fuel consumption of in-use vehicles. Two manufacturers did not provide data.

Analysis: Investigations by EPA concur that, in general, fuel economy improvements measured according to the EPA test procedure also occur in consumer vehicle use. However, EPA and DOE observations indicate that the difference between in-use fuel economy and that measured by EPA is increasing. One manufacturer concurred with this EPA observation and commented that while their fuel economy shortfall has increased over the years, their fuel consumption shortfall has remained constant at 0.01 gal/mi.

Question 3: "Prior to the 1975 model year, all EPA fuel economy measurements were conducted on vehicles selected by EPA. Many of these selected vehicles were 'worst case' offenders from an exhaust emission standpoint. Did these vehicles also tend to be the 'worst case' vehicles from a fuel economy standpoint? Since 1975, EPA has allowed testing of vehicles selected by the manufacturer in the fuel economy program. To what extent has your corporate average fuel economy been improved since 1975 by the addition of these potentially favorable test vehicles?"

Answers: The general consensus among the commenters was that "worst case" emissions vehicles tended to be "worst case" fuel economy vehicles.

Most respondents stated that the inclusion of the fuel economy data vehicles had improved their CAFE between 0.06 to 0.17 mpg in 1979.

Analysis: No detailed data were presented to confirm the stated CAFE benefits of using voluntary data vehicles. It is noted that this option has been used primarily on an "as needed" basis. That is, if a manufacturer was able to meet the CAFE standards without using voluntary data vehicles there was little incentive to submit such data. Consequently this option will probably be used more extensively used as the CAFE standards become more stringent.

Question 4: "How does EPA selection process for fuel economy testing influence a manufacturer's capability to improve its corporate average fuel economy? How does it influence your potential to make future improvements in fuel economy?"

Answers: Three of the respondents had no direct comment and a fourth did not know. The fifth respondent had no major objection to the EPA selection criteria. One respondent stated that the running change fuel economy data requirements limited their ability to incorporate fuel economy improvements. Another stated that the EPA selection process influenced future improvements based on volume considerations.

Analysis: No data or information requiring analysis was presented.

Question 5: "It has been an EPA practice that if laboratory test results for a particular vehicle were within 10 percent of the manufacturer's data for the same vehicle, EPA would use the EPA data. Recently, however, EPA has used discretionary administrative actions to select 'official' test results upon which the corporate average fuel economy is calculated. Has this improved or diminished your corporate average fuel economy? To what extent?"

Answers: The majority commented that the selection of "official" test results by EPA had decreased their CAFEs between 0.03 to 0.07 mpg. One respondent stated that this change had not had a significant impact on their fleet average fuel economy.

Analysis: It should be noted that the vehicles which are selected for confirmatory testing are those for which the most questionable data have been submitted. Consequently, it is not surprising that the discretionary administrative selection of the "official" result leads to a slight reduction in measured CAFE.

Question 6: "The EPA test is conducted with Indolene Clear test fuel having an octane rating of nearly 98 RON. Typical unleaded fuel in the marketplace has an octane rating of 93 RON. To what extent is your corporate average fuel economy improved by the use of higher octane fuel during fuel economy testing. What effect does this difference have on consumer use fuel economy, wherein spark timing retardation may be necessary to avoid objectionable or harmful detonation? How has the Octane Requirement Increase (ORI) rating of your engines changed with the switch to unleaded fuel?"

Answers: Most respondents indicated that the use of 98 RON Indolene Clear test fuel had little or no effect on fuel economy compared to the use of 93 RON fuel. One respondent indicated that there would be an improvement in fuel economy with 98 RON fuel for vehicles which were equipped with knock sensors. They, however, did not have any of these vehicles and could present no data. One respondent submitted data which showed no significant difference between the fuel economies of knock sensor equipped vehicles using Indolene Clear or 91 RON test fuels. Addressing the question of spark retardation, most respondents claimed little effect on in-use fuel economy. All respondents indicated that their ORI is slightly higher for unleaded fuels compared to leaded fuels.

Analysis: Based on the comments received in response to this question there should be little or no objection to a proposed change in the test fuel specifications to require a more representative RON fuel.

Question 7: "Certification tests are performed on vehicles with a nominal accumulated distance of 4,000 miles. What was the actual average accumulated distance of the vehicles used in your 1975 test program and in your 1979 test program? Would you favor some other distance for certification testing?"

Answers: Three respondents stated that their average certification test vehicle mileage was 4,000 ± 250 miles for both the 1975 and 1979 test programs. Another claimed that their average accumulated mileages were 4,300 miles in 1975 and 4,800 miles in 1979. A fifth responded that the accumulated mileages of their certification vehicles were 4,160 ± 150 miles in 1975 and 4,020 ± 175 miles in 1979.

One respondent suggested that the accumulated distance should be reduced to 2,000 miles or less for certification testing and a correction factor be applied on the CAFE. Another suggested that 3,800 to 4,800 miles would be a practical range. The remaining respondent favored retaining the 4,000 $\pm$ 250 miles accumulated distance specification.

Analysis: The major concern is that higher mileage vehicles, with their attendent better fuel economics, may be used for certification or fuel economy test vehicles and particularly as running change vehicles. Apparently, this is not a problem if one assumes that the responses from the commenters are representative of all manufacturers. This assumption should be verified from the EPA data base.

Question 8: "Front-wheel drive is becoming an increasingly popular engineering option for producing space-efficient vehicles. Front wheel drive vehicles typically have a higher percentage of their curb weight on the driving wheels than do their rear wheel drive counterparts. What effect does this have on the simulated road load curve and hence, fuel economy? To what extent are alternate dynamometer power absorptions requested for your front-wheel drive vehicles? To what extent does this affect their measured fuel economy and benefit your corporate average fuel economy? How is the air conditioning affected by these alternate dynamometer adjustments and how does this effect your corporate average fuel economy?

Answers: Most respondents indicated that front wheel drive vehicles were at a disadvantage when using the frontal area equation for dynamometer power adjustments because the greater curb weight on the drive wheels causes an increase in the tire energy dissipation on the dynamometer. All respondents stated that they use alternate (coastdown) dynamometer power absorptions on their front wheel drive vehicles. Several respondents stated that this significantly improved the measured fuel economy of the vehicle. One manufacturer stated that their CAFE may have increased by up to one percent through the use of this option.

Analysis: As the respondents commented, alternate dynamometer power absorptions are being used extensively for front wheel drive vehicles. This is because of the relatively high tire energy dissipation associated with the weighted drive axles. This resulted in some very low dynamometer power absorption requests. One particular concern which was not directly addressed by the commentors is the meaningfulness of the air conditioner simulation for front wheel drive vehicles. The air conditioner simulation used in the EPA tests is simply an additional dynamometer loading equal to 10 percent of the basic dynamometer adjustment. Therefore, in the case of front wheel drive vehicles the additional incremental loading used to simulate air conditioning is generally less than that which would be applied to similar conventional front engine, rear wheel drive vehicles. Consequently, the effect of air conditioning on the fuel economy would be smaller on front wheel drive vehicles than on conventional drive vehicles. The concern is that this underestimation may be a contributing factor in the increasing sales of air conditioners on small vehicles.

Question 9: "The oil industry has recently developed new engine lubricants which incorporate either lower viscosity or additives to reduce friction. What would be the effect on your average fuel economy if these oils were approved for use? To what extent have they penetrated the replacement oil market? To what extent would the fuel economy of in-use vehicles be improved by the use of these oils.

Answers: Three respondents, through speculation or testing, claimed that certification vehicles would experience 0.5 to 3.0 percent fuel economy improvements. One respondent stated, however, that there would be no advantage in the use of "slippery oils." Two respondents stated that in-use vehicles would experience fuel economy improvements equal to or greater than those determined by the EPA test.

Only one respondent made a statement regarding the market penetration of the improved oils. This manufacturer reported that there are 19 low friction engine oils on the market in the U.S. and Canada.

Analysis: The fuel economy effects of "slippery oils" mentioned by the respondents are in agreement with values generally reported in the literature. In regard to the question of the market penetration of such oils, the desired information was the sales volume penetration of the market. We are concerned that the use of such oils during the EPA tests would be unrepresentative of typical use until the sales of these oils represent a significant percentage of automotive lubricant sales.

Question 10: "What effects have the EPA changes in dynamometer calibration (electronic feedback dynamometer control system and changes made to support automatic control features) had on your corporate average fuel economy?"

Answers: Two respondents claimed that there has been a loss in fuel economy because of changes in dynamometer procedure. One respondent estimated a 0.3 mpg loss in their CAFE. Another respondent stated that there was no significant effect on their CAFE. One respondent specifically claimed that changes in the PAU exponent and in the use of the vehicle factor potentiometer caused a loss of about 0.1 mpg in their 1980 CAFE.

Analysis: A change in the application of the vehicle factor potentiometer was made in 1980 which might have had an effect on measured fuel economy. This practice has since been discontinued.

Question 11: "What effect has the change from 55 to 75 grains in the average humidity level at the EPA test facility had on your corporate average fuel economy?"

Answers: "Three respondents stated or expected that there would be a decrease in fuel economy due to the change in the average humidity level. One respondent claimed that their CAFE loss was 0.14 mpg and two respondents claimed losses between 0.7 and 1.5 percent.

Analysis: In April 1976 EPA changed its average laboratory humidity from approximately 55 grains of water per pound of air to 75 grains. This change was made to reduce the magnitude of the humidity correction factors applied in the calculation of the NOx emissions. This reduction was desirable to improve the accuracy of vehicle NOx emissions estimates.

EPA concurs that this change would, in general, be expected to decrease the measured fuel economy of a vehicle since the combustible portion of the incoming fuel-air mixture would be reduced and the vehicle would, thus, tend toward enriched operation. This is, however, dependent on the "calibration" of the vehicle. For 1975 through 1978 model vehicles, the theoretically anticipated enrichment effect would probably result in some loss of fuel economy. However, for 1979 and later model year vehicles using fuel system feedback technology, this enrichment condition would be sensed and the fuel delivery compensated. Alternately, when vehicles are "calibrated" for the increased humidity test condition the amount of EGR might be reduced resulting in fuel economy improvements under some operating conditions.

Although above analysis is speculative in nature, it indicates that there is reason to believe that little or no fuel economy degradation need be anticipated for current or future vehicles using sensor-feedback technologies. The analysis indicates the inappropriateness of a too general application of fuel economy "correction factors" which are based on previous technology to current or future vehicle technologies.

It should also be noted that the higher test humidity conditions were chosen as standard conditions before 1975. This is evident since the NOx correction factor in the EPA exhaust emissions calculations has used 75 grains of water per pound of air as the standard condition from very early in the regulations. The only change made was to cause the actual test conditions to correspond to the theoretical standard condition of the calculations. This change was made as soon as the Ann Arbor facility could consistently and accurately maintain the higher humidity.

Question 12: "What effect has the change from the use of the 'nominal' vehicle distance traveled per test to the 'actual' measured vehicle distance traveled had on your corporate average fuel economy? What effect will this change have on your ability to improve your corporate average fuel economy as you shift to vehicles of lower power-to-weight ratios?"

Answers: Five respondents indicated that their fuel economy was decreased by using the actual distance traveled instead of the nominal test distance. The estimates of the magnitude of the loss ranged from 0.25 to 0.60 percent of the measured CAFE; that is a loss of about 0.05 to 0.12 mpg.

Four respondents stated that this loss may be even greater in future model years because of an anticipated decrease in the power-to-weight ratios of future vehicles.

Analysis: Although it is apparent that differences between the actual and nominal mileages driven during specific FTP and HFET driving cycles will be reflected, on a percentage difference basis, in emission rate and fuel consumption rate changes these differences are randomly distributed, and this average is quite small. Using 1978 and 1979 certification test data EPA compared the actual and nominal miles driven during each of the three FTP cycle phases and the HFET cycle.6/ The largest average decrements in apparent "fuel economy" were obtained during the second 'stabilized', portion of the FTP. For the 1978 and 1979 model year certification fleets these "second bag" differences were -0.13 and -0.51 percent, respectively. These differences were partially compensated for during the transient portions of the FTP so that differences in the full FTP mean differences were about 0.14 percent in 1978 and -0.21 percent in 1979. If the FTP and HFET distances are combined in a 55:45 ratio, the differences of the average combined distances become 0.28 and -0.04 percent for 1978 and 1979 respectively.

Thus, the use of actual rather than nominal driving distances in 1978 led to approximately 0.28 percent (0.5 mpg) increase in 1978 and an approximately 0.04 percent (0.01 mpg) decrease in the average apparent fuel economy compared to estimates based on the nominal 7.5 mile distance used previous to the 1978 model year.

When vehicles cannot follow the EPA driving cycle a significant decrease in measured fuel economy occurs if the actual rather than the nominal distance traveled is used in the fuel economy calculation. However, very few, if any, vehicles tested today are unable to follow the EPA speed-time cycles. If future vehicles are unable to follow the cycle, it is illogical to credit these vehicles with inappropriate fuel economies based on distances not actually traveled.

Question 13: "What will be the effect of a requirement to couple the front and rear rolls of twin-roll dynamometers on measured fuel economy and on your corporate average fuel economy?

Answers: Two respondents stated that they had not determined this effect. The other respondents indicated that this coupling of the rolls would decrease their CAFE. Only one respondent gave estimated data, reporting an approximately 8 percent decrease in urban fuel economy and a 6 percent decrease in highway fuel economy. This respondent also reported estimated increases in HC, CO, and NOx.

Analysis: A recent EPA investigation has shown that coupling the dynamometer rolls greatly reduces an existing error in the velocity simulation of the vehicle during fuel economy measurements. EPA measurements indicate that the elimination of this velocity error results in a decrease in measured fuel economy of 3 to 5 percent.7/

Question 14: "Do you know of any procedural changes other than those listed in previous questions which have already affected your corporate average fuel economy, or have increased or diminished your potential to make future improvements?"

Answers: Recalibration requirements of Advisory Circular No. 24-2 and lack of sufficient leadtime for instituting procedural changes were cited as factors inhibiting manufacturers from making fuel economy improvements. One manufacturer specifically claimed that the requirements of A/C No. 24-2 had caused them to recalibrate certain electronic control systems and reduced the fuel economy benefit of their lean cruise control system.

Analysis: Advisory Circular No. 24-2 merely provides an optional objective criteria to the manufacturers to assist them and EPA in evaluating any auxilliary emissions control devices which may be questioned as a "defeat device." A/C No. 24-2 does not supercede the original criteria, but merely provides additional optional objective criteria to the to the manufacturer and, therefore, the arguments that it has resulted in reduced fuel economy do not seem valid.

One change which was made and not explicitly mentioned, but was included in tabulations of changes since 1975 was the change in the value of the CO_2 density used in the fuel economy calculations. On November 14, 1978 the EPA changed the value from 51.85 g/cu.ft to 51.81 g/cu.ft. This increases the measured fuel economy by slightly less than 0.08 percent.

CHAPTER 8

LIGHT-DUTY TRUCK ROAD LOAD

I. Introductory Statement

"In establishing the light-duty truck fuel economy standards for model years 1979 through 1981, NHTSA allowed an 8 percent fuel economy penalty for a procedural change in establishing road load horsepower for light-duty trucks."

II. Summary of Comments

Question 1: "Was the adjustment appropriate? If not, what should it be? What data are available to support your position?"

Answers: Most respondents stated that the 8 percent adjustment provided by NHTSA to compensate for the 1979 increase in the dynamometer power absorption used for light-duty trucks was appropriate. One manufacturer stated that the effect on their light-duty CAFE was actually 7 percent while another manufacturer claimed the effect was 10 percent.

Several manufacturers commented that the more stringent light-duty truck exhaust emission standards introduced in 1979 resulted in an additional 5 to 8 percent fuel economy penalty which was not considered by NHTSA.

Question 2: "When computing the above adjustment, alternate dynamometer power absorption requests were not considered. Should such alternate dynamometer power absorptions be allowed?"

Answers: Four respondents stated that the alternate dynamometer power absorption requests should be allowed because this is the only incentive for manufacturers to make improvements in vehicle aerodynamics.

Question 3: "To what extent do you anticipate using alternate dynamometer power absorptions?"

Answers: Five respondents indicated they planned to use the alternate settings. Two indicated they would apply it to all vehicles for which it would be beneficial. Only one respondent did not anticipate using the alternate settings.

Question 4: "Should the 8 percent correction factor be reduced to account for any reduction in the actual anticipated test dynamometer power absorptions?"

Answers: The general response was that the 8 percent value should not be reduced. One manufacturer provided the rationale that since their data were included in developing the revised dynamometer power absorptions, and that no benefit would have been obtained in 1979 for alternate dynamometer power absorptions. Therefore, any use of alternate dynamometer power absorptions represented improvements in the vehicles since the 1979 model year.

III. Analysis

Most manufacturers considered the 8 percent fuel economy adjustment to be appropriate for the change made in the dynamometer power absorption table. Most manufacturers stated, however, that they do not often use this table but rely strongly on alternate dynamometer power absorption requests. Consequently, on the average, light-duty trucks are not being subjected to nearly as great a change in the dynamometer power absorption as was assumed when the 8 percent fuel economy adjustment was provided. Therefore, an adjustment was provided for an effect which did not occur, at least not to the extent presumed.

One manufacturer did comment that the 8 percent was appropriate, since the reductions in dynamometer loadings which have resulted from alternate dynamometer power absorption requests represented recent vehicle improvements for which credit should be provided. No details of the "improvements" were provided and few recent changes have been noted in light-duty trucks.

A number of manufacturers commented that alternate dynamometer power absorption requests should be allowed in order to provide an incentive for manufacturers to improve vehicle aerodynamics and tire rolling resistance. This incentive-benefit is important, however, it is also important that the alternate dynamometer power absorption requests represent real vehicle improvements.

Several manufacturers commented that an additional 5 to 8 percent adjustment should have been provided by NHTSA because of the increased stringency of the 1979 light-duty truck exhaust emission standards. These comments were not related to the question of a change in test procedure.

IV. Summary and Conclusions

The 8 percent fuel economy adjustment provided by NHTSA for changes in the dynamometer power absorption table was probably an excessive compensation for the actual change in the dynamometer power absorption used in testing light-duty trucks. This discrepancy occurred because of the extensive use of alternate dynamometer power absorption requests by manufacturers. Elimination of the option of alternate dynamometer power absorption requests for light-duty trucks would make the 8 percent adjustment more accurate. The option should be retained, however, since it is a mechanism by which manufacturers perceive incentive for and benefits from improvements in vehicle aerodynamics and reductions in tire energy dissipation.

References

1/ EPA-MVEL Technical Report LDTP 17-6, "Shift Schedules for Emissions and Fuel Economy Testing," November 1977.

2/ EPA-MVEL Technical Report TAEB 77-15, "Effects of Shift Points on Emission and Fuel Economy of a 1977 Chevrolet Chevette," December 1977.

3/ EPA-MVEL Technical Report TAEB 77-12, "Dynamometer and Track Measurements of Passenger Car Fuel Economy Influences," September 1977 (DRAFT).

4/ EPA-MVEL Technical Report TAEB 77-18, "Evaluation of Fuel Economy Performance of 31 Production Vehicles (1977) Relative to their Certification Vehicle Counterparts," January 1978.

5/ EPA-MVEL Technical Report, "Evaluation of the Representativeness of EPA Fuel Economy Estimates," January 1978 (DRAFT).

6/ EPA-MVEL Technical Memorandum, "Actual Distances in Certification Testing," (DRAFT)

7/ EPA-MVEL Technical Report SDSB 79-26, "Track to Twin-Roll Dynamometer Comparison . . .," June 1979.

Appendix A

SHIFT SCHEDULE COMMENTS

I. Introductory Statement

In 1975, federal regulations provided that test vehicles with manual transmissions would normally be shifted at 15, 25 and 40 mph. In order to provide for more appropriate (representative) shift schedules for unusual vehicles, the regulations also provided the option of shifting the vehicle at the shift points recommended by the manufacturer.

On July 16 of 1976, the 15, 25 and 40 mph default shift points were deleted from the regulations. Subsequently the vehicles were shifted according to the manufacturer's recommendation to the ultimate purchaser in order to allow more representative shift schedules. EPA soon began to receive shift point requests which appeared to be selected primarily to minimize emissions or to maximize fuel economy, and which did not appear to reflect consumer use of the vehicle. EPA investigated this problem and conluded that many of the shift schedules requested by vehicle manufacturers were unrepresentative of typical vehicle use.

In order to ensure more reasonable shift schedules in the future, EPA defined acceptable shift schedules in Advisory Circular No. 72. This Advisory Circular provides that the allowable shift schedules are the 15-25-40 mph schedule originally presented in the regulations, a shift schedule based on a percentage of maximum recommended engine rpm, or any other recommended shift schedule based on typical vehicle use data.

II. Comments

Question 1: "In 1974 and separately in 1975, what percentages of your product line were represented by test vehicles shifted at speeds other than the 15-25-40 mph schedule?"

Volkswagen: "VW and Audi have always used 15-25-40 mph shifting schedules throughout their entire model line."

Toyota: "All 1974 and 1975 MY vehicles utilized the 15-25-40 mph schedule."

Chrysler: "In 1974 and 1975, 100 percent of Chrysler's certification vehicles were shifted according to the following schedules:

3-speed: 15-25,
4-speed: 15-25-40."

Ford: "For model years 1974 and 1975, Ford certified and measured fuel economy on all its manual transmission vehicles (passenger cars and light trucks) using the 15-25 mph shift schedule for its 3-speed manual transmissions and 15-25-40 mph for its 4-speed manual transmissions."

General Motors: "In MY 1974, GM used a 15-25-40 miles per hour manual transmission shift schedule for all light-duty vehicles. Beginning with MY 1975, GM recommended manual transmission shift schedules in the owners manual for improved driveability and fuel economy with any selected powertrain."

American Motors: "In the 1974 model year 20 percent of our carlines were equipped with manual transmissions and all had recommended shift speeds slightly different than 15-25-40 mph. In the 1975 model year 15-25 was recommended.

All 1974 and 1975 model year Jeep CJ's were equipped with manual transmissions. In the 1974 model year all Jeep CJ's had recommended shift speeds slightly different than 15-25-40 mph. In the 1975 model year 7 percent had recommended shift speeds slightly different than 15-25-40 mph."

Question 2: "For those vehicles shifted at other than the 15-25-40 mph schedule, what shift speed schedules were used?"

General Motors: "A tabulation from the MY 1975 GM owner's manuals summarizing our then recommended shift schedule is shown in Figure A-1."

American Motors: The AM 1974 and 1975 MY shift schedules are shown below.

1974 Model Year

Typical Shift Points	Transmission	Vehicle Type
18-40 mph	M-3	Passenger cars (LDV)
18-30 mph	M-3	Jeep vehicles (LDT)
18-30-40 mph	M-4	Jeep vehicles

1975 Model Year

15/18-25-30	M-3	Passenger cars
15-25	M-3	Jeep vehicles
10-20-40	M-4	Jeep vehicles

Question 3: "What data are available to indicate that the alternate shift schedules requested in 1975 were more representative of consumer use than the 15-25-40 mph schedule?"

Ford: "For model years 1974 and 1975, Ford certified and measured fuel economy on all of its manual transmission vehicles (passenger cars and light trucks) using the 15-25 mph shift schedule for its 3-speed manual transmissions and 15-25-40 mph for its 4-speed manual transmissions. Ford, however, recognized the in-use fuel economy improvement possible using alternate shift schedules and advised its customers of this opportunity in the owner's manual, recommending a shift range schedule of 10-15/20-30/above 30 mph." See following excerpts from the Ford Owner's Manual.

Upshifts	Shift speeds	Downshifts	Shift Speeds
1st to 2nd	10 to 15 mph	4th to 3rd	55 to 25 mph
2nd to 3rd	20 to 30 mph	3rd to 2nd	35 to 12 mph
3rd to 4th	Above 30 mph	2nd to 1st	20 to 0 mph

Economy Driving Tips

To operate your car as economically as possible, use the following driving suggestions:

1. Always keep your tires inflated to the recommended pressure for longer tire life and fuel economy.

2. Accelerate moderately; but do not creep. Get into high gear quickly so that the engine can operate economically.

3. Avoid speeding up and slowing down. Maintain a level pace and flow with the traffic for good fuel economy.

4. Try to time the traffic signals so that you stop as little as possible. Idling and acceleration are times of greater fuel consumption.

5. Maintain a moderate speed on the highway. Gasoline consumption per mile rises sharply with speed increase.

6. Keep your engine tuned up and keep other maintenance work on schedule for longer life of all parts and lower operating costs.

7. Keep the required distance from other cars and be alert to avoid sudden stops. This will greatly reduce wear on your brake linings.

8. If your car is equipped with the optional fuel monitor warning light, all of the preceding tips will help you to adjust your driving habits to keep the light from glowing.

General Motors: "GM has not intentionally recommended manual transmission shift speeds that adversely affect customer satisfaction or that are difficult to implement. However, we believe that it is our obligation to recommend customer operation of the vehicle that is both practical and efficient."

American Motors: "The Jeep Owner's Manual recommended slightly lower 1-2 and 2-3 shift points because they were appropriate for off-road 4-speed manual transmission Jeep CJ's."

Question 4: "What typical shift schedule changes have been used since 1975?"

Toyota: The following shift schedules were used:

Model Year	Shift Schedule
1976	All vehicles utilized the 15-25-40 mph schedule.
1977-1978	LDV - Approximately 60% of manual transmission (M/T) vehicles used the alternate schedule. LDT - Approximately 90% of M/T vehicles used alternate schedules.
1979	Due to EPA's policy change approximately 90% of the vehicles with M/T used the 15-25-40 mph schedule.
1980	Approximately 92% of all vehicles with M/T utilize the 15-25-40 mph shift schedule."

Chrysler: "Chrysler's shift schedules used for certification vehicles after 1975 are as follows:

1976 -	3-speed	15-25
	4-speed	15-25-40
1977 -	3-speed	15-25
	4-speed	15-25-40
1978 -	Federal	15-25-40
	California	20-35-45
	Omni/Horizon	15-25-30
1979 -	3-speed	15-25
	4-speed	15-25-40."

Ford: "Passenger Car and light truck shift schedules used through the 1979 model year are tabulated in Exhibits II and III."

Ford Exhibits II and III are included as our Figures A-2 and A-3.

General Motors: "A tabulation from the MY 1975 GM owner's manuals summarizing our then recommended shift schedules is shown in Figure A-1. No significant departures from the 15-25-40 schedule are found in this table for MY 1975 and the same is true through MY 1978."

American Motors: "The 1976 model year used essentially the same shift schedule as the 1975 model year (note response to question 2)."

1977 Model Year

Typical Shift Points (mph)			Vehicle Type
1-2	2-3	3-4	
15-18*	25-30*		Passenger cars
10-15*	20-25*	30-40*	Passenger cars
15	25		Jeep vehicles
10	20	40	Jeep vehicles

* Shift whenever a cruise within the specified range has been reached.

1978 and 1979 Years

Same as 1977	Passenger cars
Same as 1977	Jeep vehicles
**-15-25	Jeep vehicles

** The 4-speed manual transmission is synchronized in second, third and fourth gears. First is designed primarily for increased pulling power on grades and during towing or plowing operations. Normal starting uses second gear."

Question 5: "What effect has the use of these post-1975 shift changes had on specific vehicle fuel economies?"

Toyota: "As a typical example, the table below indicates the effect on fuel economy due to the shift schedule change. These data are derived from the 1977 MY Corolla with 2T-C engine.

Shift Schedule	City Fuel Economy
15-25-30 mph	23.8 mpg
15-22-30 mph	26.8 mph (13% up)

If an alternate shift schedule is used, generally speaking, we can realize a city fuel economy increase of approximately 10% of that at the 15-25-40 mph schedule. However, this shift schedule change has no significant effect on the highway fuel economy. Accordingly, a combined fuel economy increase of approximately 6% can be realized."

Chrysler: "We have not determined the effects on fuel economy of any difference."

Ford: "Ford's estimate of the individual vehicle and average passenger car fuel economy effects of the alternate manual shifts schedules used in the 1978 model year are shown in Exhibit IV. The 1979 Courier manual transmission calibrations used the 1978 shift schedule of 10/20/35/45 mph (with 3rd-4th shift at 25 during cruise. The 1979 shift schedule restrictions caused this shift schedule to be revised to 15/26/37/57 (with no cruise shift), resulting in 8% fuel economy degradation for Couriers."

Ford Exhibit IV is included herein as our Figure A-4.

General Motors: "The effect of specific shift schedules upon specific fuel economy can be very significant and has been reported to EPA in a letter to Mr. Harrington on January 17, 1978 (Attachment 6). This letter cites individual fuel economy losses on certain models of our product line that resulted from incorporating the shift schedule guidelines set forth in Advisory Circular No. 72 in place of our recommended alternate shift schedules."

The complete letter is included as Attachment A-1 at the end of this appendix. The following is an excerpt of this letter containing the relevant portions of the Attachment.

"A series of tests were performed on available representative vehicles with 1979 calculations as known at this stage of development.

The changes under consideration represent substantial investments of development time and money; the fuel economy losses on our manual transmission products, due to this late and unilateral rule change, are considerable and could affect our corporate average fuel economy. Evaluation efforts involved the city schedule; however, we expect some effect on highway fuel economy as well. Tests were performed on a 151 L-4, 4-speed; a 301 V-8, 4-speed; a 260 V-8, 5-speed; and a 400 V-8, 4-speed using present GM recommended and EPA proposed shift schedules. City fuel economy losses, as a result of the propsed EPA schedule, ranged from 1.4 to 2.6 miles per gallon and represented percentage losses of from 6.4 to 17.8 percent (Table 1 of the Attachment). These losses are due to higher EPA proposed shift speeds being imposed on modern engines specifically designed to run smoothly at lower RPM's."

American Motors: "The only manual transmission shift change that had a fuel economy impact on our vehicles was Advisory Circular No. 72 . . . and it resulted in passenger car and Jeep vehicles manual transmission fuel economy losses of about 1.0 mph (composite)."

Question 6: "What effect has the use of these post-1975 shift changes had on your corporate average fuel economy?"

Toyota: "The table below indicates the improvement rates on 1977 and 1978 MY CAFE for LDV and LDT separately, which are based on a rough estimation, when the alternate shift schedule is used."

	1977 MY	1978 MY
LDV	+2.0%	+1.9%
LDT	+4.9%	+5.0%

Chrysler: "We have not determined the effects on fuel economy of any differences."

Ford: "Ford's estimate of the individual vehicle and average passenger car fuel economy effects of the alternate manual shift schedules used in 1978 model year are shown in Exhibit IV (Figure A-4). This also shows the effect on 1979 corporate average fuel economy. The 1979 [LDT] CAFE impact of the reduced Courier fuel economy was a loss of 0.13 mpg.

The estimated 1979 LDV CAFE effect was about 0.06 mpg reduction in measured fuel economy."

General Motors: "The estimated effect of this substitution upon the GM passenger car Corporate Average Fuel Economy (CAFE) was a loss of 0.08 miles per gallon."

American Motors: "The light truck fleet average fuel economy penalty was estimated to be 0.6 mpg and the passenger car fleet average penalty was estimated to be 0.3 mpg.

Additionally, 5-speed transmission programs as well as optimization of 3- and 4-speed transmissions have been deferred."

Question 7: "What data can you present that these post-1975 shift schedules are more representative of consumer vehicle use than the 15-25-40 mph schedule?"

Toyota: "The only relevant data we can present are those which were contained in attachment to our '1979 MY Part I LDV Revision Letter #14,' dated February 16, 1978, demonstrating representativeness of an alternate shift schedule, meeting A/C 72.E.3.C., for the 1979 MY Corolla model included in the 3K-C(F) engine family."

Ford: "In addition to the marketing research findings supplied to EPA betwen June and October, 1978 (attached), supporting Ford's revised shift schedule ('H') on the 1979 2.3L (non-turbo) vehicles (approved for use by EPA in its letter to Mr. D. L. Kulp of October 31, 1978), Ford is presently conducting similar research on its other engine families offered with a manual transmission."

General Motors: "A tabulation from the MY 1975 GM owner's manuals summarizing our then recommended shift schedules is shown in Figure A-1. No significant departures from the 15-25-40 schedule are found in this table for MY 1975 and the same is true through MY 1978. GM has not intentionally recommended manual transmission shift speeds that adversely effect customer satisfaction or that are difficult to implement. However, we believe that it is our obligation to recommend customer operation of the vehicle that is both practical and efficient."

American Motors: "AM's post-1975 shift schedules are basically equivalent to the 15-25-40 mph shift schedules, therefore, questions 7 and 8 do not require our response."

Question 8: "What data can you present to demonstrate that the fuel economy improvements obtained with the post-1975 shift schedules were obtained in consumer use of the vehicles?"

Chrysler: "We have not used different shift schedules in the post-1975 period..."

"Calculated fuel economy effects indicate that if manual transmission shift schedules were optimized for the EPA cycle, the fuel economy for these vehicles would be from 2 to 4.5 percent better than for the 'default' shift schedule. Since any survey of consumer driving patterns is not likely to show them shifting at the true optimum, the potential gain over the default schedule would be some fraction of the 2 to 4.5 percent obtainable."

Ford: "While Ford has no data segregating the in-use fuel economy improvement of the revised manual transmission shift schedules from the overall fuel economy improvement realized by its vehicles from model year to model year (i.e., Ford does not introduce new vehicles with a shift schedule being the only change), we believe intuitively that our customers are witnessing the same comparative gain seen during testing on CVS-CH and HWFET cycles."

Question 9: "As more efficient automatic transmissions are phased in, what will the relationship between manual and automatic equipped vehicles be with respect to EPA measured fuel economy?

a. Using 1975 shift schedules.

b. Using post-1975 shift schedules."

Volkswagen: "No specific data is available in regard to more efficient automatic in comparison to manual transmissions.

As a comparison, we are providing you with the a table (see figure A-5) that compares the fuel economy between manual and automatic transmission certification vehicles."

Toyota: "Our 4-speed automatic transmission,without lock-up unit, is more efficient than our 3-speed one because of over-drive usage. According to our 1979 MY certification data and experimental data, the relationships between manual and automatic equipped vehicles, with respect to fuel economy, can be expressed as in the following matrix.

The figures in the matrix denote the average percentage of fuel economy for automatic equipped vehicles to that for manual equipped vehicles."

	15-25-40 mph Fuel Economy with 5 M/T			Alternate Shift Schedule used for 1977 and 1978 MY Fuel Economy with 5 M/T		
Shift Schedule	City	HWFET	Combined	City	HWFET	Combined
Fuel economy with 3 A/T	100	84	94	91	84	88
Fuel economy with 4 A/T	99	93	97	90	93	91

Chrysler: "As automatic transmissions become more efficient through utilization of lockup devices and parasitic loss reduction, it is fully expected the fuel economy differential between automatic and manual transmissions will be reduced."

Ford: "Ford presently expects its future model year manual transmission calibrations to achieve an average 8-12% higher fuel economy than comparable vehicle configurations equipped with automatic transmissions.

In 1975, manual transmissions achieved approximately 10-15% better fuel economy than automatic transmissions on a similar car (based on a review of 4,000 mile test data)."

General Motors: "New improvements for added efficiency in our automatic transmissions can be expected to narrow the fuel economy difference between manual and automatic transmission equipped small vehicles."

American Motors: "AM does not expect to see the 10 percent fuel economy advantage (combined city/highway) that manual shift transmissions currently possess over automatic transmisions to be overcome in the foreseeable future."

Question 10: "What data can you present to indicate manual transmissions will be more or less efficient in actual vehicle use compared with more efficient automatic transmissions?"

Volkswagen: "No specific data is available in regard to more efficient automatic in comparison to manual transmissions."

Chrysler: "Although relatively little consumer 'in-use' data exists, that which does supports an average fuel economy advantage of about 11.5 percent for manual transmission vehicles over similar vehicles with automatic transmissions. These data were derived from a 1974 study of Chrysler's executive lease vehicles. The manual transmission vehicles were concentrated in subcompact imports and light-duty trucks. This result is in close agreement with Chrysler Proving Grounds road tests using the SAE-J1082 test cycles. Proving Grounds results on 1977 through 1979 corporate vehicles indicated that manual transmission vehicles average about 10.5 percent better fuel economy than automatics.

As automatic transmissions become more efficient through utilization of lockup devices and parasitic loss reduction, it is fully expected that the fuel economy differential between automatic and manual transmissions will be reduced. As an example, the lockup torque converters are currently expected to improve automatic transmission fuel economy by about 2 percent. This improvement, which occurs principally during highway operation, is expected to reduce the 'in-use' benefits of manual transmissions to the general driving public from about 10 to about 8 percent."

Ford: "We have no in-vehicle, back-to-back data that quantifies difference in efficiency of automatic transmissions versus manual transmissions. However, manuals will always be more efficient than automatics due to the inherent pump losses, bands and clutch drag and torque converter slip (in lower gears) of automatic transmissions."

General Motors: "New improvements for added efficiency in our automatic transmissions can be expected to narrow the fuel economy difference between manual and automatic transmission equipped small vehicles."

Question 11: "Do you have any programs underway to optimize automatic transmission shift schedules to the EPA test cycles? If so please describe."

Toyota: "We have developed a simulation model to obtain automatic transmission optimized curves for better fuel economy for various driving modes. Please refer to 'Automatic Transmission Optimization for Better Fuel Economy' written by T. Ishihara, A. Numazawa, K. Suzuki, and T. Yokoi which is contained on pages 1331 to 1342 of the 17th FISITA CONGRESS REPORT (June, 1978)."

Chrysler: "Current automatic transmission shift schedules were chosen for best overall performance and customer acceptance. We have no programs underway to change these schedules."

Ford: "No. Automatic transmission shift schedules are not optimized for the EPA test schedule. Shifts schedules are dictated by customer acceptance of acceleration performance. Our experience is that customers complain if shifts are unevenly spaced, too early or delayed, or too sensitive to torque demand."

American Motors: "We are continuously working with our suppliers (both manual and automatic transmissions) to improve and optimize these transmissions and their shift schedules."

Question 12: "The existing shift schedule restrictions allow you to use any manual transmission shift schedule that you can demonstrate is or will be in typical use. Do you intend to encourage your vehicle purchasers to use alternative shift schedules so that those schedules can be used during fuel economy testing? Will this action be accompanied by transmission changes, such as the use of additional or wide ratio gears? What fuel economy benefits do you expect?"

Volkswagen: "No."

Toyota: "We think that the alternate shift schedule to obtain better fuel economy should be allowed even though demonstration data to represent the typical consumer use is not provided. it should be, however, acceptable for most consumers from a common sense standpoint and, further, we should encourage purchasers to use it with more practicable and effective manner than a recommendation in the owner's manual approved for the past certification. Unfortunately, at this time, we have no effective ideas."

Chrysler: "Although we will continue to encourage good driving habits, we have no plans to determine alternative shift schedules."

Ford: "If alternative shift schedules offer improved fuel economy and performance opportunities, Ford will endeavor to encourage the customer to use these schedules. We do not, however, presently plan any such revised shift schedule changes. We are, through market research, trying to determine how people actually shift so we can share that information EPA."

General Motors: "GM intends to pursue the use of alternate manual transmission shift schedules that result in efficiency improvements for our customers while meeting emissions and driveability requiremnts. The same is true for product design improvements, such as wide ratio transmission gears. The potential fuel economy gains from manual transmission improvements cannot be recognized with the current EPA certification procedures. The impact of this on light truck CAFE is significant because manual transmissions have about 20% sales penetration. Therefore, GM is not projecting any measurable improvement in passenger car or light truck fuel economy with improved manual transmissions because of the constraints contained in A/C 72."

American Motors: "At this time we do not plan on pursuing this type of an in-use approach. We, therefore, cannot answer this question.

We are studying and planning to use wide ratio gear sets in our future manual and automatic transmissions."

General Motors Co.

Figure A-1

GM MY 1975 Owners Manual Shift Schedules 1/

	1-2	2-3	3-4
Buick			
Apollo-Skylark			
L-6 3-speed	20	30	
V-6 3-speed	20	35	
Oldsmobile			
Omega 3-speed	20	20	
Starfire 4-speed	20	30	40
Cutlass			
L-6 3-speed	20	30	
V-8 3-speed	25		
		25-40 2/	
Chevrolet			
Light Truck 3-speed	20	30	30
4-speed	10	15	
Van 3-speed	20	30	
Chevelle 3-speed	20	30	
Monza			
L-4 3-speed	20	30	
L-4 4-speed	15	25	40
V-8 4-speed	20	25	30
Camaro 3-speed	20	30	
4-speed	20	30	40
Vega 3-speed	20	30	
4-speed	20	30	40
Corvette 4-speed	20	30	40
Nova 3-speed	20	30	
4-speed	20	30	40

NOTES:

1/ Pontiac did not recommend an alternate shift schedule in its owner's manual.

2/ Shift whenever a cruise within the specified range has been reached.

Ford Motor Co. Exhibit II

Figure A-2

Passenger Automobile Manual Tranmission Shift Schedules

4-Speed M/T

Shift	F 4/	H 5/	N 2/	P 2/	Q 3/	R	U 1/	W 1/	X 1/	Y 1/	Z
1-2	16	13	10	10	20	5	10	10	10	15	15
2-3	27	24	20	15	30	15	20	20	25	25	25
3-4	38	31	30	25	40	25	30	30	35	40	40

3-Speed M/T

Shift	Q 3/	S	T	Z
1-2	20	10	10	15
2-3	30	20	25	25

1/ Shift directly into fourth gear once vehicle is stabilized at or above 25 mph.

2/ Omit first gear when driving an unloaded vehicle with first gear ratio greater than 5:1.

3/ For 3-speed transmission, shift directly into third gear once vehicle is stabilized at or above 25 mph, for overdrive shift into fourth gear at recommended speed.

4/ Based on A/C #72 "percent rated engine RPM" methodology which includes "cruise" shifts at 12/20/32.

5/ Per EPA approved customer survey.

Vehicle Engine Identification Codes (in^3 or liters)

1976	1977	1978	1979
W 2.8	R 1.6	R 1.6	F 1.6
X 2.3	T 200 or 250	T 200	H 2.3
Y 2.3	U 1.6	U 1.6	Z 2.3 or 2.8; 200, 250, or 302
Z 2.8	V 250	V 250	
	W 1.6 or 2.8	W 2.8; 302	
	X 2.3; 302	X 2.3; 302	
	Y 2.3	Y 2.3 or 2.8	
	Z 2.3 or 2.8; 200		

Ford Motor Co. Exhibit III

Figure A-3

Light Truck Shift Schedules (0-600# GVW)

Model	1974-5	1976	1977	1978	1979
Courier	15/25/40	10/20/35/45	10/20/35*/45 *cruise = 25	10/20/35*/45 *cruise = 25	2.0L: 15/26/37/57 2.3L: 15/26/38/57
F100	15/25/40			15/25/40 except: CA/4.91/M3: 20/30 49S/5.8L/M3: 10/25	15/25/40
E100				15/25/40 except: CA/4.9L/M3: 20/30 4.9L/5.0L/M3: 10/20	15/25/40
Bronco	15/25/40				

Ford Motor Co. Exhibit IV

Figure A-4.

Estimated Fuel Economy Effect of Alternate Shift Schedules for Manual Transmissions

Vehicle	Engine	Trans	Axle	Shift 1/ Schedule Code	Estimated 1979 Fuel Economy Effect Versus 15/25/40 mph Shift Speeds (mpg)
Fiesta	1.6L	M4-3.58	3.58	R	2.14
Pinto Sedan	2.3L	HM4WR	2.73	X	0.63
Pinto S.W.	2.3L	HM4WR	3.08	W	1.23
Mustang	2.3L	HM4WR	3.08	Y	0.58
Fairmont Sedan	2.3L	HM4WR	3.08	Y	0.47
Fairmont S.W.	2.3L	HM4WR	3.08	Y	0.49
Mustang	2.3L-T	HM4WR	3.45	Z	0.00
Mustang	2.8L	SROD	3.45	Y	0.21
Fairmont Sedan	3.3L	SROD	2.73	X	0.51
Fairmont S.W.	3.3L	SROD	3.08	X	0.51
Granada	4.1L	SROD	3.00	V	1.58
Mustang	5.0L	SROD	3.08	X	0.80
Fairmont Sedan	5.0L	SROD	3.08	X	0.55
Fairmont S.W.	5.0L	SROD	3.08	X	0.56
Granada 2 dr.	5.0L	SROD	3.00	X	0.58

Estimated CAFE Effect -0.0591
(Based on 1979 Projected
Sales Volumes as of Dec., 1977)

1/ Proposed for 1979 prior to Advisory Circular #72 -- applicable to 1979 MY and beyond which restricted shift schedule usage.

Volkswagen Co.

Figure A-5

Volkswagen Fuel Economies

	City		Highway		Combined	
	Manual	Automatic	Manual	Automatic	Manual	Automatic
	16.7	17.3	24.5	20.0	19	18
	16.8	14.8	22.7	18.5	19	16
	26.8	24.0	38.5	34.1	31	28
	24.3	23.4	37.8	32.6	29	27
	24.0	22.1	36.5	31.1	28	25
	16.7	18.3	25.4	22.6	20	20
	23	20	37	29	28	23
	22	22	35	30	27	25
	16	17	26	24	19	20
	16	16	26	22	19	18
	17	17	32	24	22	19
	17	18	29	25	21	20
	11	12	18	17	13	14
Average	19.0	18.6	29.9	25.4	22.7	21.0
Absolute difference	0.4		4.5		1.7	
Percent difference	2		18		8	

General Motors Co. Attachment 6

Attachment A-1

GM's letter of January 17, 1978 to R. E. Harrington (EPA)
on "Manual Transmission Shift Speeds."

FE: 1267

Environmental Activities Staff
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

January 17, 1978

Mr. R. E. Harrington, Director
Light Duty Vehicle Branch
Certification Division
Mobile Source Air Pollution Control
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105

Dear Mr. Harrington:

Manual Transmission Shift Speeds

The purpose of this letter is to supplement our Mr. M. R. Wilson's letter to you of December 1, 1977 on the same subject by providing information relative to the fuel economy effects on specific General Motors light-duty vehicles using EPA's recently defined manual shift schedules presently being considered for Advisory Circular publication. A series of tests were performed on available representative vehicles with 1979 calibrations as known at this stage of development. These evaluations did, of course, divert test/development resources from their intended use in evolving 1979 product definition.

General Motors is always willing to contribute test information relative to the promulgation of new rules under consideration by EPA. However, as we have indicated on many occasions in the past, proposed changes having a substantial impact on the product should be addressed at a less critical point in the certification program. You must realize that a manufacturer must carefully plan and, in pursuing these plans, must have confidence that the agency considers the potential disruption that could be caused by contemplated program changes. That does not appear to be the case here; manufacturers first learned of your concern in this area at the November 18, 1977 EPA-Industry meeting but were not prior or subsequently officially contacted for comments and/or information.

The changes under consideration represent substantial investments of development time and money; the fuel economy losses on our manual transmission products, due to this late and unilateral rule change, are considerable and could affect our corporate average fuel economy. This situation could have been moderated if your concerns over representativeness of shift schedules had been shared with the industry when they were first recognized by EPA.

Evaluation efforts involved the city schedule; however, we expect some effect on highway fuel economy as well. Tests were performed on a 151 L-4 4 speed, 301 V-8 4 speed, 260 V-8 5 speed and 400 V-8 4 speed using present GM recommended and EPA proposed shift schedules. City fuel economy losses, as a result of the proposed EPA schedule, ranged from 1.4 to 2.6 miles per gallon and represented percentage losses of from 6.4 to 17.8 percent (Table I). These losses are due to the higher EPA proposed shift speeds being imposed on modern engines specifically designed to run smoothly at lower RPM's.

General Motors has never recommended manual transmission shift speeds that would adversely affect customer satisfaction or that are difficult to implement. They are tailored to average driving conditions as represented by the Federal Test Procedure and provide acceptable vehicle driveability under these conditions. We understand your concern that recommended shift schedules be representative and we do not question EPA's authority to promulgate new rules concerning this subject. From the data supplied thus far by EPA, however, General Motors has no reason to believe that EPA's planned shift schedules are any more representative of the "real world" than our current recommendations. Our key objection is the timing of substantive changes of this type at this point in the 1979 certification program, and we question EPA's authority to implement this type of change without proper notice of rulemaking and orderly analysis and consideration of manufacturers' comments.

We are continuing to evaluate the proposed shift schedules on other GM manual transmission/engine combinations with the expectation that this information will be useful in commenting on proposed rulemaking in this area for use not sooner than the 1980 model year. General Motors still awaits your reply to Mr. Wilson's letter of December 1, 1977.

Very truly yours,

T. M. Fisher, Director
Automotive Emission Control

SJS/aaf/t/040

cc: E. O. Stork

Table 1

City Fuel Economy Effects of
EPA Proposed Manual Transmission Shift Schedule (66% Rated Engine rpm)
(Current Recommended Shift Schedule Used as Base)

Inertia Wt	Engine	Manual Transmission	Fuel Economy (MPG) Shift Schedule Current	Fuel Economy (MPG) Shift Schedule Proposed	Loss	Percent Loss
3000	151 L-4 2 bbl	4-speed	22.1	20.7	1.4	6.4%
3500	260 V-8 2 bbl	5-speed	20.0	17.7	2.3	11.5%
3500	301 V-8 4 bbl	4-speed	16.6	14.0	2.6	15.7%
4000	301 V-8 4 bbl	4-speed	16.1	14.6	1.5	9.3%
4000	400 V-8 4 bbl	4-speed	12.9	10.6	2.3	17.8%
4000	400 V-8 4 bbl	4-speed	12.7	10.7	2.0	15.8%

Note: 301 and 400 V-8 tests were run on two (each) representative vehicles

Appendix B

ALTERNATE DYNAMOMETER ADJUSTMENT COMMENTS

I. Introductory Statement

"EPA has always provided the option that a manufacturer may request, for specific vehicles, dynamometer adjustments which are different from the values contained in EPA regulations. A request for such alternate dynamometer power adsorptions must be supported by road test data demonstrating the appropriateness of the request. In 1975, the regulations implied the manifold pressure measurements were the required method of generating acceptable road data. Later the manifold pressure approach was deleted, and subsequently the coastdown technique has become the prevalent method of generating supporting data for alternate dynamometer power adsorption requests. An acceptable coastdown procedure has been provided to the industry as an EPA Recommended Practice which has been distributed as an Attachment to Advisory Circular No. 55B."

II. Comments

Question 1: "To what extent were alternate dynamometer adjustments used in 1974, in 1975? To what extent are they currently used?"

Volkswagen: "1974 models - 2 models out of a total of 9 had alternate Dyno adjustment.

1975 models - 4 models out of a total of 9 had alternate Dyno adjustment.

1980 models - 6 models out of a total of 8 had alternate Dyno adjustment."

Toyota: "We did not adopt the use of alternate DPA (Dynamometer Power Absorption) for certification and fuel economy testings in 1974 or 1975 MY. However, alternate DPA adjustments were used for approximately 40 percent of our LDV models in the 1979 MY. Further, in the 1980 MY, alternate DPA adjustments are intended to be used for approximately 75 percent of our LDV models."

Chrysler: "In 1974 and 1975, Chrysler tests were conducted only at the specified dynamometer loads; that is, no alternate methods were developed, proposed or used. For the 1980 model year we presently are involved in certifying all passenger cars with an alternate 'coastdown' horsepower while trucks are being certified with both the specified horsepower and alternate horsepower."

Ford: "For model years 1974 and 1975 Ford Motor Company did not use alternate dynamometer adjustments primarily because the available procedure (manifold vacuum measurements at a 50 mph steady state speed) was not sufficiently precise to reflect improvements over the formula power absorption settings. For model year 1979 the alternate adjustments were approved for 87% of our passenger cars and 100% of our light trucks sold as complete vehicles."

General Motors: "GM did not use alternate dynamometer adjustments during MY 1974 or MY 1975. We anticipate that approximately 64% of our light duty vehicles manufactured in MY 1979 and 96% in MY 1980 will be represented by fuel economy tests using alternate horsepower."

American Motors: "Alternate dynamometer adjustments were not used in 1974 or 1975. They are not currently used but we do plan to use the coast-down procedure on one light-duty truck and one car engine family on vehicles that come equipped with radial tires in 1980."

Question 2: "To what extent has the increased use of alternate dynamometer power absorptions improved your corporate average fuel economy compared to your corporate average fuel economy which would have been obtained if dynamometer power absorptions from the equation contained in the current regulations were used exclusively? If dynamometer power absorptions from the inertial weight based table of the 1975 regulations were used exclusively? If the use of alternate dynamometer power absorptions were restricted to the extent they were used in 1974, in 1975?"

Toyota: "The following data, which are insufficient and therefore, may not be accurate, indicate whether the increase usage of the alternate DPA has improved CAFE in the 1979 MY as compared to CAFE which would be obtained if the DPA from the equation contained in the current regulations were used exclusively, or if the DPA from the inertia weight-based table of the 1975 regulations were used exclusively.

Comparison to CAFE with Exclusive Use of DPA from Equation	Comparison to CAFE with Exclusive Use of DPA from Inertial Weight-Based Table
+0.8%	+2.6%

Since we opted to use the DPA from the inertia weight-based table for all 1974 and 1975 MY vehicles, as shown above, 2.6 percent fuel economy loss in the 1979 MY CAFE is expected."

Chrysler: "In order to demonstrate the effect of changes in dynamometer adjustment, it would be desirable to test a fleet of vehicles (cars, 4x2 trucks, and 4x4 trucks) using the 1975 table weights and then repeat the tests using 1979 alternate adjustments. Chrysler has not conducted such a test program and because of the considerable amount of testing required, does not plan to conduct such a program. At this point, we believe the revision in dynamometer adjustment no longer hurts our fleet average fuel economy."

Ford:

	"Fuel Economy higher/(lower) than Base Car	Truck
1979 CAFE with alternate power absorptions	Base	Base
1979 CAFE impact if power absorptions were restricted to the 1979 formula CAFE	(0.4)	(0.3) mpg
1979 CAFE impact if power absorptions were restricted to the pre-1979 inertial table PAU	(0.5)	1.3 mpg

Alternate dynamometer power absorptions were not used in 1974 or 1975."

General Motors: "GM estimates that, for MY 1979, the fuel economy of GM vehicles is about 1 1/2% better when using alternate horsepower rather than frontal area horsepower or the inertia weight table. It should be noted that this improvement was included in the GM 11 car test program (Attachment 1) which indicated a 0.6 mpg CAFE loss. If alternate absorber settings were restricted to MY 1974 and 1975 procedure, there would be no recognized benefit (EPA results) of aerodynamic or rolling resistance improvements."

General Motors Attachment 1 is not included herein.

American Motors: "Because we have not used coast-down the answer is none.

The 1979 passenger car fleet average fuel economy would not be significantly affected if the inertia weight based table values were used exclusively. The 1979 light truck fleet average fuel economy decrease is estimated to be 0.1 to 0.4 mpg in addition to the 8 percent credit that was incorporated into the 1979 nonpassenger automobile standard by the NHTSA. This large penalty is derived from the large increase in dynamometer power absorptions, 30 to 36 percent from 1978 to 1979, and the associated recalibration requirements to maintain essentially constant emission control."

Question 3: "To what extent does current EPA policy (applicable advisory circulars) on alternate dynamometer adjustment restrict your ability to make improvements in vehicle fuel economy which would be observed in consumer use of the vehicles? Please describe."

Volkswagen: "Undetermined."

Toyota: "We do not think that the current EPA policy on alternate DPA specifically restricts the ability to make improvements in vehicle fuel economy which would be observed in consumer use."

Chrysler: "There are a number of ways in which EPA policy as expressed in advisory circulars on alternate dynamometer adjustments is restrictive of our efforts to improve fuel economy.

The first consideration in discussing alternate dynamometer horsepower is to recognize that 'this is the only means for assuring that all technological improvements will show up as improvements in fuel economy during both testing and customer use. When a manufacturer makes a major effort to improve actual customer use fuel economy by improving aerodynamics, reducing tire rolling resistance, improving chassis friction loss, etc., there could be zero measurable benefits on the EPA test cycle unless the manufacturer 'elects' to use the alternate dynamometer procedures. However, when this step is taken, procedures must be developed, reviewed and approved by EPA; extensive road testing is required and EPA requires extensive confirmation and cross checking. Nevertheless, we very strongly believe that these actual customer improvements should be reflected in our test results.

A second area involves tires. For the 4x2 0-8500 GVW trucks using 16.5" tires in the heavier GVW range, we frequently find that there is no benefit in using 'coastdown' (ref: R. R. Love, Chrysler, December 6, 1978 response to R. L. Strombotne, NHTSA, regarding Question 6). And, in the case of 4x4 0-8500 GVW trucks, most tires are the 'off road' type which also show no coastdown benefit. Many of these tires cannot even be used for the EPA dynamometer test because of the extensive heat build-up in the artificial laboratory environment (i.e., tire flex on twin rolls with inadequate air flow). Yet, EPA and NHTSA continue to project improvements requiring techniques that only show up on coastdown testing.

Third, the fuel economy standards and testing procedures are intended to reflect a fleet average under a standardized test, yet many aspects are significantly biased to reduce that average. For example, a number of options (e.g., station wagon luggage racks, station wagon rear window vane deflectors, outside mirrors, etc.) interfere with air flow and reduce vehicle fuel economy. As such, they must be taken into consideration. However, EPA rules do not consider the option average level (mean or the fifty percent level). Rather, EPA always requires 'options with projected sales of more than 33 percent

In addition to requiring dynamometer power settings to reflect a 33% option rate, other areas also are involved. Dynamometer power must be increased 10% for air conditioning if air conditioning installation rate exceeds 33% (ref: 40 CFR 86.129). Any option over three pounds must be included in the vehicle weight if its installation rate is over 33% (ref: 40 CFR 86.080-24). If 'representative' (or average) results are truly desired, all of these items should be calculated on the basis of actual volume usage.

The EPA test procedure very clearly specifies that the acceptable laboratory temperature is the range of 68°F to 86°F (ref: 40 CFR 86.130). For 1979, Chrysler very logically submitted coastdown results for the midpoint or 77°F. EPA rejected this and requested that data be adjusted to 68°F. (Note: As testing temperature is reduced, fuel economy declines.)

Fourth, and even more important than the above very serious considerations, our major objection to EPA's approach to this subject is their practice of continually making late changes, interpretations, and confirmations of requirements. Also, so many details are involved in the Advisory Circulars that EPA must provide an extensive amount of interpretation. For last year's certification, the process of change and interpretation lasted roughly from August 1977 to June 1978. It should also be noted that EPA is not satisfied with the data from Chrysler's coastdown test, even though they are invited to observe these tests. Rather, EPA insists on independent tests (for which we must pay, provide vehicles and supply transportation). Furthermore, a high degree of confirmation correlation is required with extremely tight tolerances."

Ford: "It is disingenuous for EPA to characterize the coastdown test procedure as an option to be elected by the manufacturer when NHTSA's maximum feasible standards are established using an assumption of improved aerodynamics.

Current EPA policy on coastdown procedures restricts our ability to make both mid-model year and specific car/truck model aerodynamic improvements by requiring substantially increased test requirements that cannot always be contained from a workload standpoint nor justified economically. This was particularly true in the 1979 model year when EPA was changing requirements or delaying confirmation testing until after 1979 model production was underway.

In other instances, we are not properly credited for improvements that we do make on items which are never tested by EPA. For example, we are not credited in our CAFE for improvements made to items like optional outside mirrors unless the particular mirror represents the expected worst contributor aerodynamic drag. Similarly, we are not credited for certain improvements made in optional tires or option weight reductions. The present EPA confirmation procedures for the manufacturer's coastdown test results further inhibit the early implementation of improved product actions."

General Motors: "In many cases, it would be necessary to produce several horsepower settings to cover all options that could affect road load. The added test and administrative burden does not justify the small estimated fuel economy gain which causes the manufacturer to accept a less favorable setting in order to reduce testing requirements."

American Motors: "Current EPA policy (and practice) does not restrict AM from making improvements. It denies AM the necessary time to understand and apply these optional procedures to our development programs and then to our pre-certification program.

For example, the latest alternate dynamometer procedure, Advisory Circular 55-B, was issued on December 6, 1978 and applied to the 1980 model year vehicles some of which had already started durability testing.

We are also unable to acquire any useful certification experience with these procedures because they apply to a single model year. It would therefore be an exercise in futility for AM to speculate on the consumer-use impact of these procedures because we are spending all of our energy in trying to catch up and apply these procedures to our basic certification program."

Question 4: "Have the administrative procedures implemented since 1975 become burdensome to the point that time and money considerations preclude their use in some instances as compared to using the standard Federal Register procedures? Provide details."

Volkswagen: "Yes, to the extent that their net benefit provided does not exceed that of the standard procedure."

Toyota: "As compared to the use of DPA from the inertia weight-based table, the use of alternate DPA has required additional testing, such as coastdown testing and/or intake manifold vacuum measurement. The intake manifold vacuum measurement method, which was acceptable until 1978 MY, requires at least 22 man-hours/test vehicle to obtain the alternate DPA. The coastdown method, which has been acceptable after 1978 MY, requires at least 30 man-hours/test vehicle to obtain the alternate DPA. Except for the normal test burdens above, it cost us much time and money to develop our original coastdown test procedure and test instruments. Additionally, since the coastdown method depends on weather conditions, it takes more time to complete the coastdown testing than we expect. Therefore, we feel that establishing an alternate DPA is indeed burdensome. However, manufacturers are continually striving for reductions in actual road load in their search for better fuel economy; and it appears to us that the alternative DPA is the proper method for evaluating the manufacturer's efforts."

Chrysler: "In our efforts to keep up with the increasingly more stringent fuel economy standards, Chrysler has had to make choices that were not always the most cost-beneficial design alternative or capital investment alternatives. Our choice of the 'coastdown' alternate dynamometer procedure falls within the same category, i.e., we recognize the time and expense penalty compared to using the frontal area formula, but we believe that attaining the higher fuel economy value is a more important consideration."

Ford: "The effective timing of administrative procedures since 1975 have become burdensome, but have not yet precluded use of the alternate procedures. As mentioned previously, changes in the 1979 alternate dynamometer setting procedure by EPA were made at such a late time relative to our development/certification program timing requirements that we were unable to use the procedure on all of the eligible vehicles for Job #1. This produced an unrecoverable CAFE loss because subsequent vehicle fuel economy run at reduced PAU values had to be harmonically averaged with the original formula (Job #1) vehicle fuel economy.

Further, new vehicle introductions require engineering prototypes to be dedicated solely to the coastdown program. This is not only costly, but due to limited availability of engineering prototypes, can seriously disrupt other essential programs. An additional risk is the option in the Advisory Circular for EPA to require additional engineering prototypes for confirmation procedures.

One of the most burdensome administrative procedures is EPA's Advisory Circular #72 on alternate manual transmission shift schedules. The existing procedure in the Federal Register on this subject (42FR16397, 16409) specifies that only the manufacturer's recommended shift speeds be used during compliance testing. EPA's Advisory Circular, however, specifies three alternatives available to the manufacturer, one of which is to shift according to an EPA determined percent of rated engine rpm, and the others are to use either 15-25-40 mph shift points or to conduct an elaborate in-field research study to determine exactly how customers do shift their vehicles.

As we stated in response to the shift schedules, Question #7, Ford did conduct a research program to determine the appropriate shift schedule for its 1979 non-turbocharged 2.3L engine vehicles. This program took about 3 months to complete, (data attached), it cost approximately $100,000 to conduct, and was far more sophisticated than required by Advisory Circular #72. Nevertheless, EPA repeatedly requested additional data during the more than 4 months it took to receive approval of the revised shift schedule."

General Motors: "Manufacturers presently cannot use their own facilities to confirm horsepower values but must deliver their vehicles to an independent test site and incur a cost of at least $3000 per test. This results in a significant amount of time lost from other test programs while expensive prototypes are being transported and/or are awaiting regulatory tests. Thus, alternate horsepower values that are close to frontal area numbers are often not submitted to EPA because of the added burden resulting from potential confirmatory testing. The small 7% 'quick-check' tolerance is equivalent to the dyno-to-dyno variations reported for the EPA laboratory. The risk of exceeding this tolerance is significant since it has the potential of disqualifying emission data vehicles or fuel economy data vehicles after a significant investment of time and resource.

The demonstration requirements necessary to justify an approved alternate shift schedule are so burdensome that the effort cannot be justified for a relatively low volume manual transmission vehicle, despite the fact that this configuration may offer better in-use fuel economy."

American Motors: "This has always been a problem for American Motors but it has proliferated during the last three years due to numerous changes being made and without regard to the lead-time needs of the manufacturers. The burden of implementing alternate procedures that may be valid for only a single model year is often considered prohibitive."

Appendix C

ACCESSORY COMMENTS

I. Introductory Statement

"EPA now uses a carline/truck designation rather than an engine family designation for assigning accessory load. Additionally, carline and truckline have been redefined to some degree. Other than this no apparent changes have been made in the EPA test procedure which would affect the simulation of vehicle accessories."

II. Comments

Question 1: "Has the carline/truckline approach for assigning accessory load had an effect on your corporate average fuel economy? How? To what extent?"

Volkswagen: "No."

Toyota: "Even though some carlines/trucklines exist in the same engine family, the expected air conditioning installation percentage base on the engine family approach does not differ so greatly as compared to that based on the carline/truckline approach. Therefore, the carline/truckline approach for assigning air conditioning load had no effect on CAFE."

Chrysler: "The switch from engine family to carline for assigning accessory loading has not had a significant effect on Chrysler's CAFE. However, the switch from truck engine family accessory loading to truckline accessory loading in 1980 has a -0.10 mpg fleet effect on 4x2 and essentially a zero (-0.01 mpg) effect on 4x4 light truck fuel economy."

Ford: "The 1980 accessory selection rule which determines the 33% option criterion by carline rather than by engine family causes the effective test weight to increase slightly for 1980 passenger cars. This, and some resultant additional power absorber penalties for air conditioning, cause an approximate net 0.1 mpg decline in 1980 measured CAFE. In Ford's January 9, 1979, Position Paper to Ms. Joan Claybrook, this 0.1 mpg appears as the difference between the 0.3 mpg finer test weight/options-by-car line penalty and the 0.2 mpg finer test weight penalty.

The total effect of these selection changes on Ford's 1980 light truck fuel economy is the same as the carline effect (i.e., 0.3 mpg CAFE loss) and was reported to NHTSA in Ford's January 17, 1979 response to NHTSA's NPRM on reconsideration of the 1981 light truck fuel economy standards."

General Motors: "The carline/truckline approach for assigning accessory load has not significantly affected our passenger carlines on the average. However, while the effect on our total truck fleet average is not currently known, some individual truck models have gained 500 to 750 lbs. This is due to the effect of the heavier truck accessories, e.g., optional fuel tank, step bumper and rear air conditioner."

American Motors: "Since the EPA has adopted carline/truckline designations rather than an engine family designation for assigning options (accessory loads), AM has not found a net fleet average penalty or benefit. Individual vehicles have increased while others have decreased causing the 1980 net impact to be insignificant."

Question 2: "Do you believe that there have been other changes made in the EPA test procedure which affect the simulation of the load imposed on the engine by the vehicle accessories? What changes? What effect?"

Volkswagen: "No."

Chrysler: "We are not aware that other changes in the EPA test procedure may have changed the simulated effects of vehicle accessories."

Ford: "Ford knows of no other test procedure changes that have adversely affected accessory load simulation."

General Motors: "GM is not aware of other changes made in the EPA test procedure that affect the road load simulation."

American Motors: "It is possible that the interaction of Advisory Circular 55-B (coast-down procedure for 1980) with the carline/truckline approach would have some effect, but this has not been observed or determined at this time."

Question 3: "There appears to be increasing use of accessories, such as air conditioning, in small vehicles. Is the current EPA simulation of air conditioning (10 percent increase in the dynamometer power absorption) adequate for this simulation since such smaller vehicles generally would have reduced dynamometer power absorptions?"

Volkswagen: "We find that the 10% increase in dyno horsepower for air conditioning adequately represents the actual load."

Toyota: "Though we do not have enough data to indicate the relationship between the engine power consumed by air conditioning in consumer use and the DPA value set on the chassis dynamometer for fuel economy testing, data are available which demonstrate that a 5 to 10 percent loss on the fuel economy for Celica models with 20R engines appears when the air conditioning is activated at maximum capacity during actual vehicle driving as compared to when the air conditioning is in the OFF condition. Certainly, this effect on the fuel economy is larger than that due to the 10 percent increase in DPA on the chassis dynamometer, because the latter loss is 2 to 4 percent according to 1979 MY certification data for Celica models with the 20R engine. This tendency will be found in large vehicles as well as small vehicles.

However, judging from the fact that the air conditioning is not always activated with the maximum capacity, we believe that the current EPA simulation of air conditioning load is adequate for this simulation."

Chrysler: "The determination of average fuel economy effects of accessory operation (i.e., on a nationwide year-round basis) also involves much more complex issues than whether or not the system's operation is being properly simulated. Air conditioning losses, for example, vary with ambient temperature, humidity, time of day (i.e., sun load), driving speeds, acceleration rates, etc., all of which are in turn affected by geographic variables. To calculate an average effect, one would have to determine a nationwide vehicle weighted operating condition and determine the variability of the system's operation over the range of operating conditions.

EPA's current practice of applying a 10 percent dynamometer horsepower penalty to carlines with air conditioner installation rates of greater than 33 percent results in a fuel economy penalty of about 2 percent. This penalty is relatively invariant with horsepower; for instances, it is about 1.7 percent on larger vehicles and up to about 2.3 percent fuel economy on smaller vehicles. This rule results in subcompacts being more heavily penalized than larger vehicles.

To illustrate this point, using published air conditioning installation rates on 1977 models and EPA's vehicle classes from their fuel economy booklet, the following average installation rates are:

Average Air Conditioning Installation Rate

Subcompact	Compact	Intermediate	Full Size
48.7%	75.3%	80.2%	95.6%

An examination of these numbers gives a clear indication that the average subcompact fuel economy is being excessively penalized for use of air conditioning when this option is used on less than one-half of the volume produced."

Ford: "Depending upon the ambient conditions, the current simulation for air conditioning use (10% increase in PAU setting) may not adequately account for the effect it has on fuel consumption. EPA has estimated that the average fuel economy penalty for air conditioning, when operational at FTP ambient conditions is about 9% in an on-versus-off comparison. The 10% power absorber increase in the dynamometer simulation leads to a 2% fuel economy penalty for large cars and a 3% fuel economy penalty for small cars. This is because the PAU constitutes a larger fraction of the work requirement for small cars. Therefore, the 10% increase in PAU impacts smaller cars relatively more than it does larger cars and is consistent with the question's implication that air conditioning affects smaller cars' fuel economy more than that of larger cars. More accurately, it affects lower power-to-weight vehicles relatively more than high power-to-weight vehicles. The simulation is consistent and proper for both types of vehicles.

It was mentioned at the outset that the 10% PAU increase is an expedient and leads to a 2%-3% fuel economy decrease rather than the observed 9% decrease during air conditioner operation. There are two factors which tend to make this expedient more accurate than it first appears. First, the EPA selected rules require a vehicle to be tested with the air conditioning penalty if only 33% or more of that model contains air conditioners. Second, when the national average duty cycle of air conditioner operation is considered, the gross effect on consumption is reduced far below the 9% figure cited above. Air conditioning is seldom used in northern areas and is seldom used at night in all areas. It is not difficult to reconcile the 9% figure to a figure of 2% or below when the actual over-all operation of air conditioning is considered."

General Motors: "The current EPA air conditioning (A/C) adjustment factor appears to be an adequate simulation regardless of vehicle size."

American Motors: "We believe the 10 percent factor is an adequate simulation in small vehicles and may be slightly high for some full-size vehicles that use fuel-saving cycling compressors."

Question 4: "What would be the effect of a more realistic simulation of air conditioning load on your corporate average fuel economy?"

Volkswagen: "No detailed data available, however, would contribute to further complication of test procedures."

Toyota: "We do not have a more realistic simulation of air conditioning load than the current EPA simulation."

Chrysler: "Modifying EPA test procedures to further refine these effects would certainly add complication to an already complicated situation and would require more precision than the EPA test can ever hope to accomplish.

The determination of average fuel economy effects of accessory operation (i.e., on a nationwide year-round basis) also involves much more complex issues than whether or not the system's operation is being properly simulated. Air conditioning losses, for example, vary with ambient temperature, humidity, time of day (i.e., sun load), driving speeds, acceleration rates, etc., all of which are in turn affected by geographic variables. To calculate an average effect, one would have to determine a nationwide vehicle weighted operating condition and determine the variability of the system's operation over the range of operating conditions."

Ford: "As explained in the preceding answer, the present air conditioner simulation is probably realistic when duty cycle or actual air conditioning operation in the field is taken into account. The question implies that this is not the case but certainly the alternative of testing the air conditioner actually operational is less realistic. To properly account for air conditioning's fuel economy impact would require at least two tests (on/off) and a duty cycle weighted average of the two results.

Establishing the actual weighting would have to involve extensive studies of different areas of the country with different climate conditions with recognition of variations in climate conditions on a year to year basis. This would lead to the same result presently obtained but with a huge almost non-containable effort.

In addition, a duty-cycle characterizing actual air conditioner use would have to be established, velocity proportional air flow around the vehicle would have to be provided to assure representative convective cooling, and representative humidity levels would have to be determined and regulated during testing to assure proper condenser efficiency. The cost impact of all these additional conditions make the adoption of such a procedure prohibitive."

General Motors: ". . . GM believes that the current method of accounting for air conditioning load is a reasonable assessment of the average penalty the customer experiences."

American Motors: "We believe the current 10 percent increase in the dynamometer power absorption for carlines/trucklines is reasonably representative, consequently we have not considered other more-realistic simulations."

Question 5: "What would be the effect of more realistic simulation of other engine-driven accessories which are not fully utilized in the EPA test procedure (i.e., power steering, engine cooling fan, electrical system load) on your corporate average fuel economy?"

Volkswagen: Refer to answer of question 4.

Toyota: "Other engine-driven accessories such as engine cooling fan and alternator, except power steering, are operated on the chassis dynamometer in the same manner as encountered during the consumer use. With respect to the power steering, since only the engine power loss at a straight-driving is reflected in the current FTP, it is expected that the EPA measured fuel economy is slightly better than the fuel economy encountered during the consumer use including curve-driving. However, at this time, we are not aware of a practicable and more realistic simulation of power steering."

Chrysler: "In most instances, accessory operations on the EPA cycle are yielding results of a reasonable order of magnitude. Modifying EPA test procedures to further refine these effects would certainly add complication to an already complicated situation and would require more precision than the EPA test can ever hope to accomplish.

There is one area where added refinements might be made which would not complicate testing unnecessarily. That would be in providing sufficient air flow to obtain underhood and underbody temperature environments corresponding with highway operating conditions.

The determination of average fuel economy effects of accessory operation (i.e., on a nationwide year-round basis) also involves much more complex issues than whether or not the system's operation is being properly simulated. Air conditioning losses, for example, vary with ambient temperature, humidity, time of day (i.e., sun load), driving speeds, acceleration rates, etc., all of which are in turn affected by geographic variables. To calculate an average effect, one would have to determine a nationwide vehicle weighted operating condition and determine the variability of the system's operation over the range of operating conditions. The same analysis would be required for analyzing the operation of most other accessory systems."

Ford: "Power steering is fully simulated by the present procedure. This is because the increased pump load during steering maneuvers is negligible compared to the pump load that is constantly present. A more realistic simulation of power steering (e.g., movement of the steering wheel back and forth), therefore, would have negligible effect on fuel economy.

Operating the electrical systems such as headlights, defrosters, etc., would reduce measured fuel economy."

General Motors: "GM has not conducted studies to indicate the penalty of each accessory under all operating conditions."

American Motors: "AM is unable to respond to this question because we are unaware of the need to simulate the engine-driven accessories more realistically than the current procedures provide."

Question 6: "Has the lack of accurate representation of accessory loading precluded or inhibited your development of more efficient accessories or accessory drives?"

Volkswagen: "No."

Toyota: "In spite of whether or not the simulation of engine-driven accessories is reflected in the current FTP realistically, we are making every effort to reduce engine power loss caused by the various engine-driven accessories, which is encountered during consumer use. Therefore, the lack of accurate representation of accessory loading does not inhibit our development of more efficient accessories."

Chrysler: "Despite the lack of provisions in the regulations for accurate representation of accessory loading, Chrysler will continue to develop more efficient accessories and accessory drives in order to improve consumer fuel economy."

Ford: "Ford is pursuing the development of every practicable accessory program offering any benefit in the improvement of efficiency."

General Motors: "GM has investigated the total vehicle to improve on-road fuel economy for the customer. Examples of accessory improvements which we investigated were included in our August 7, 1978 response to NHTSA (Attachment 4, pgs. 13-15). These devices have been under development regardless of EPA's accessory load procedure during dynamometer testing. As an example, GM has introduced accessory fuel economy improvements even though they cannot be recognized by the EPA test procedure."

Attachment 4 is not included herein.

Appendix D

INERTIA WEIGHT CHANGE COMMENTS

I. Introductory Statement

"Beginning with the 1980 model year, EPA reduced the increments of simulated inertia by approximately a factor of two (from 500 pounds to 250 pounds for vehicles over 4,000 pounds). This change was made to provide more accurate simulation of the test vehicle weight."

II. Comments

Question 1: "If the current test weight increments were applied to first the 1974 test vehicle fleet, then to the 1975 test vehicle fleet, what percentage of those vehicles would have been tested at higher simulated inertia? At lower simulated inertia?"

Volkswagen: "At the same 1974 model year curb weights, one model out of nine total would have been tested at a higher simulated inertia and one model at a lower.

At the 1975 model year curb weights there would be no changes in simulated inertia."

Toyota:

Test Vehicle MY	Test Vehicles Shifted to Higher Simulated Inertia	Test Vehicles Shifted to Lower Simulated Inertia
1974	6 of 22	2 of 22
1975	7 of 29	0

Chrysler: "The data for answering these questions is not readily available."

Ford: "As of 1975, the actual weights of Ford's passenger cars and light trucks were more or less randomly distributed within each inertia weight category (IWC). This was not by design, but rather reflects the absence of a strong external influence which would tend to cause a bias in one direction or another. Had the finer equivalent test weight (ETW) categories of the 1980 model year been applied to 1975 model year production configurations, the following changes in test weight would have occurred.

ETW vs IWC

	% Vehicle Configurations Tested at Higher Inertia	% Vehicle Configurations Tested at Same Inertia	% Vehicle Configurations Tested at Reduced Inertia
Car	28	41	31
Truck (0-6000)	19	63	18

General Motors: "This question has no bearing on the stated purpose of the questionaires."

American Motors: "AM does not believe the question relates to the issue because the 1981-1984 passenger car fuel economy standards were based primarily on the 1977 model year cars not the 1974-1975 model year cars. In addition, our carline mix has changed from a full-line manufacturer to a limited-line manufacturer causing us to question the practicality of even attempting to generate this information.

Our 1974-1975 light-duty truck fleet (0-6000 pounds GVWR) consisted of Jeep CJ's and AM General Postal Service vehicles. Applying the change to the 1974 model year Jeep CJ's would not have changed the simulated inertia, but in the 1975 model year 50 percent of our Jeep CJ's would have been tested at a higher simulated inertia weight.

Under the new increments 100 percent of the 1974 and 1975 Postal Service vehicles would have been tested at a higher simulated inertia weight."

Question 2: "If the current test vehicle fleet were tested using the pre-1979 inertia increments what percentage of vehicles would be tested at higher simulated inertia? At lower simulated inertia?"

Volkswagen: "No vehicle would be tested at a highter simulated inertia, all of them at lower simulated inertia."

Toyota:

Test Vehicle's MY	Percentage of Test Vehicles Shifted to Higher Simulated Inertia	Percentage of Test Vehicles Shifted to Lower Simulated Inertia
1980	30 of 35	11 of 35

Ford: "The passage of the Energy Policy and Conservation Act which established fuel economy standards and penalties for non-compliance, there arise a strong incentive to reduce weight to increase fuel economy. This is reflected, partly, in a biased toward the high end of the inertia weight categories. It occurred because vehicles with weights in the lower end of each category were lightened as much as possible....and were able to be recategorized into the next lower IWC.

The result of this externally motivated weight reduction, in 1980, is to cause a difference in average test weight as it would be calculated by the 1975 and 1980 classification rules. The percentage of vehicle configurations reclassified is shown below.

The percentage of trucks reclassified into heavier test weight classes was not as severe as with out passenger vehicles."

IWC vs ETW

	% Vehicle Configurations Tested at Higher Inertia	% Vehicle Configurations Tested at Same Inertia	% Vehicle Configurations Tested at Reduced Inertia
Cars	75	23	3
Truck	17	62	21

General Motors: "If the NY 1979 GM fleet were tested per the MY 1980 test procedure utilizing the smaller test weight classes (TWC) and options by carline, our fleet average test weight would increase by 112 lbs, as shown in Figure D1. This analysis considers 70% of GM's high volume MY 1979 vehicles (California, altitude and low volume configurations were omitted from this analysis) to determine the test weight penalty independent of vehicle mix and technology changes year-to-year."

American Motors: "The following tables have been simplified and have not been sales weighted to save time and effort. The carlines and Jeep vehicles (excluding CJ's) consider only 49-state automatic transmission vehicles, while the Jeep CJ's consider only 49-state manuals. These powertrain configurations were selected because they represent our largest volume groups.

American Motors Co's. Carline and Truckline Inertial & Test Weight Classes.

Carline		Average 1980 Vehicle IWC* According to 1979 Regs. (lbs)	Average 1980 Vehicle TWC* According to 1980 Regs. (lbs)	Average Test Change +/(-)
Spirit	4-Cyl	3000	3000	0
	6-Cyl	3000	3250	250
Concord	4-Cyl	3000	3250	250
	6-Cyl	3500	3500	0
Pacer	6-Cyl	3500	3687	187

Truckline

CJ5/7	4-Cyl	3000	3000	0
	6-Cyl	3000	3250	250
	8-Cyl	3500	3375	(125)
Wagoneer	8-Cyl	4500	4500	0
Cherokee	6-Cyl	4000	4250	250
	8-Cyl	4500	4500	0
Truck J10	6-Cyl	4500	4500	0
	8-Cyl	4500	4500	0
Truck J20	8-Cyl	4500	4750	250
Eagle	6-cyl	3750	3812	62

* IW = Inertia Weight Class; TWC = Test Weight Class.

The actual penalty of the change can be noted in all carlines and all trucklines (except the 8-cylinder CJ)."

Question 3: "What additional improvements in EPA measured fuel economies would have been obtained if this change in EPA inertia categories had not been made? What data exist to indicate that these measured fuel economy improvements would have been realized in consumer use?"

Volkswagen: "Undetermined."

Toyota: "According to our experimental data derived from the 1980 MY Celica with 20R engine, the inertia weight change has an influence on the fuel economy of 1.5 percent/125 lbs. inertia increment for city fuel economy and 1.0 percent/125 lbs. inertia increment for highway fuel economy, respectively. Therefore, the assumption in this question will yield 0.4 percent fuel economy loss on the 1980 MY CAFE because more test vehicles are shifted to the higher simulated inertia due to the implementation of test weight increments since 1980 MY, as shown in the answer to Question 2."

Chrysler: "When EPA first proposed to change the Inertia/Test Weight Increments (ref: NPRM publication in Federal Register, September 10, 1976 at 41 FR 38674, etc.), Chrysler made detailed projections and analyses of the 1978 passenger car fleet with the model line-up, vehicle weights, projected sales and fuel economy current at that point in time. Our response to the NPRM noted (ref: S. L. Terry, Chrysler, December 6, 1976 response addressed to R. E. Train, Administrator, EPA, pages 5, 6, and 7) that the proposed finer increments would increase the fleet average inertia weight by 65 lbs. and reduce the fleet average fuel economy by 0.28 mpg."

Ford: "As Ford reported in its Position Paper on the 1981-1984 passenger car fuel economy standards and in its response to the NHTSA NPRM regarding reconsideration of the 1981 light truck fuel economy standard, the revised inertia weight classifications (ETW vs IWC) for 1980 will reduce our otherwise expected CAFE by 0.2 mpg on passenger cars and 0.3 mpg on light trucks (including the effect of the revised procedure for determining option content).

These may be viewed as measured gains which were precluded by rule change. They are not, however, detectable to the consumer.

There is no way to determine whether, or to what extent, the actual in-use fuel economy of a given vehicle has been, or will be in the future, changed by the change in EPA's inertia categories."

<u>General Motors</u>: "Contrary to question 3, there would be no additional improvements by retaining the MY 1975 test weight procedures. Since the test weight class procedure was changed, GM has been penalized.

The basis for the MY 1981-84 standards was MY 1977 which had the same weight test procedure as MY 1975 through 1979. Therefore, a proper comparison is between MY 1979, with the original weight procedures, and MY 1980, with the revised weight procedures, In this case, the 112 lb penalty for the MY 1980 procedures, as indicated in response D2, results in approximately a 0.1 mpg loss in GM's CAFE. Therefore, if the test procedure change had not been made, GM would not have been penalized relative to the MY 1975 test procedure specificied in the Energy Policy and Conservation Act (EPCA). Since the vehicle did not change, the fuel economy realized by the consumer is not affected."

<u>American Motors</u>: "AM is not aware of any additional improvements in EPA measured fuel economy on our vehicles if this change in inertia categories had not been made. The change represents a low (0.1 to 0.3 mpg) car and truck fleet average fuel economy penalty over the past inertia categories because our vehicles had tended to group slightly toward the high end of each previous inertia weight category.

The change had no direct impact on in-use vehicle fuel economy, but it has caused additional testing and facilities expenditures that could have been diverted to fuel economy development."

<u>Question 4</u>: "What was the average difference between production vehicle weights and EPA simulated vehicle weights under the 1979 procedures? Under the pre-1979 procedures?"

<u>Volkswagen</u>: "No difference."

<u>Toyota</u>:

"Term	Number of Test Vehicles	Pre-1980 MY Inertia Weight Increment Procedure	1980 MY Test Weight Increment Procedure
A	35	79.5 lbs	43.9 lbs
B	35	27.9 lbs	-4.2 lbs

Note: "1980 MY test vehicles are used for this calculation. Term 'A' means the absolute average of designed production vehicle weight minus EPA simulated vehicle weight. Term 'B' means the average of designed production vehicle weight minus EPA simulated vehicle weight."

Ford: "Ford does not maintain a data base of average production and simulated weights."

American Motors: "The simulated inertia weight classes for pre-1979 and the 1979 models are the same and we are therefore not sure we understand the question.

AM does not have the information in the form that would show the average difference between production vehicle weights and EPA simulated vehicle weights."

Question 5: "Are the above claimed effects permanent or transitory? If transitory, what percentage of your fleet is affected and for how long? Please explain you answer."

Volkswagen: "Undetermined."

Toyota: "This is transitory because the sensitivity in the fuel economy is changeable due to the future vehicle weight reduction at model change and the future vehicle weight reduction at model change and the new emission control system to satisfy the future emission standards."

Chrysler: ". . . we have initiated a strong weight reduction program in order to place all high sales volume vehicles in the lowest test weight class which is reasonable. While we do not expect to completely offset the above noted potential loss, we do expect to minimize the loss in 1980. Eventually, as new vehicles replace old vehicles and future weight reductions achieved, the loss should approach zero."

Ford: "The effects of reducing the increments of simulated inertia are permanent."

General Motors: "The effects of the smaller test weight classes and options determined by carline rather than by engine families are permanent. In the redesign of our new carlines we must now account for the average 112 lb test weight penalty, described in response to Question 2, before we obtain any credit under the MY 1980 test procedures for weight reduction. Therefore, GM would use weight reduction technology at a considerable expense without realizing any fuel economy gain."

American Motors: "The effects of the EPA reduced increments of simulated inertia weight by a factor of two is a permanent test procedure penalty. We are unaware of any technique we could use that would permit it to be considered a transitory effect on our fleet average fuel economy. Our response to Question 2 of this section shows the impact of this penalty is fleet wide and slightly more significant with respect to our trucklines than our carlines."

General Motors Data

Figure D-1

Effect of MY 1980 Test Weight Class Realignment on GM Fleet

EPA Class	GM Car Line	Avg. IWC 1/ 79 Fleet 79 Regs.	Avg. TWC 2/ 79 Fleet 80 Regs.	Avg. Test Weight Change	Avg. TWC 3/ 80 Fleet 80 Regs.	Average TWC From 79 Fleet 80 Regs.
Midsize	A	3533	3725	+192	3723	-2
Large	B	4132	4269	+137	4160	-109
Large	C	4513	4638	+125	4481	-157
Midsize	E	4075	4256	+181	4178	-78
Sub-compact	F	4000	3940	-60	3907	-33
Sub-compact	H	3210	3230	+20	3209	-21
Compact/ Midsize	K	4500	4750	+250	4302	-448
Sub-compact	T	2435	2440	+5	2434	-6
Compact/ Midsize	X	3875	3875	-	2910	-965
Two-seater	Y	4000	3875	-125	3700	-175
Fleet Average Test Weight		3785	3897	+112	3680	-217
Fleet Avg. Loaded Vehicle Weight 4/		3868	3868	0	3700	-168

1/ Inertia Weight Class - MY 1979 definition of broad weight classes (250/500 lb increments).

2/ TWC - Test Weight Class - MY 1980 definition of weight, within an inertia weight class, at which a vehicle is tested based on its loaded vehicle weight (125/250 lb increments).

3/ Avg. MY 1980 TWC represents the effects of GM weight reduction program for B-C-K-X-Y car lines.

4/ Loaded vehicle weight - curb weight plus EPA options plus 300 lb.

Appendix E

EMISSION STANDARDS COMMENTS

I. Introductory Statement

"In the other areas of this questionaire it is important that the issue of test procedure changes is not confused with comments related to emission standards. However, since some manufacturers may wish to comment on issues related to emission standards the following questions are presented."

II. Comments

Question 1: "Has the imposition of the 0.41/3.4/1.0 emission standards (1981) inhibited the development of alternate engines and control strategies relative to conventional spark ignition (SI) engines?"

Volkswagen: "Yes."

Toyota: "To meet the 0.41/3.4/1.0 emission standards in gasoline-fueled engines, we believe that most of our models will need the final big measure (i.e., three-way catalyst with feedback control system). If the NOx standard were not so stringent, conventional engines (or stratified engines) with oxidation catalyst, which have been widely used, would not be excluded from the market. Considering diesel engines, the variation in the manufacturing process is expected to lead to the biggest difficulty; that of achieving the NOx standard of 1.0 g/mile."

Chrysler: "The imposition of the .41/3.4/1.0 emission standard for 1981 MY has inhibited the development of alternate engines and control strategies in several ways. With less stringent emission regulations, development efforts could be more intensely directed toward the improvement of fuel economy, optimization of efficiency and specific output, the minimization of cost, and the more effective use of capital resources.

For example, a spark ignited gasoline engine operating at extremely lean air/fuel ratios may be an attractive alternative to the stoichiometric, closed loop systems proposed for 1981. Both pre-chamber and open-chamber arrangements are expected to provide efficiency gains of several percent and substantial savings in cost and complexity. However, the allowable hydrocarbon level of 0.41 gm/mi is a severe limitation on maximum air/fuel ratio and thus on the attainable efficiency gain.

In the case of the diesel engine, there is a direct relation between efficiency and NOx, and an inverse relation between HC and NOx. Thus, the imposition of a rigid NOx standard will penalize efficiency to a substantial degree, while also making more difficult the attainment of low HC level. The use of EGR alters the magnitude of these relations, but not the basic trends. EGR may also contribute to increased particulate emissions.

Some of the less common alternative engines are also affected by restrictive emission standards. Stratified charge gasoline engines. especially the open chamber variety, are not only influenced, but ultimately efficiency-limited by restrictive HC and NOx standatds. The rotary Wankel is very sensitive to HC limits, and extensive redesigns have been developed to meet them.

The gas turbine and Stirling engines may adapt more readily to low emission requirements, but the attendant cost penalties may be significant."

Ford: "The manpower and capital requirements to meet the stringent 1981 emission standards have substantially impaired our ability to devote resources to alternate engines and various powertrain strategies. Our cessation of work on the Stirling engine is an example. Also, we would probably be further along on Turbo-Charging, PROCO, Diesels and Turbines if it were not for our all out effort to meet current emission and fuel economy standards.

In regard to control strategies for conventional spark ignition engines, Ford has increased its development work on various electronic control systems and is planning to increase usage of such systems."

General Motors: "The basic objective of GM's continuing alternative engine research and development programs has been to find and develop superior alternatives to the spark-ignition gasoline engine.

A prime alternative to spark-ignition engines is the diesel engine. However, simultaneously meeting the 0.41 HC and 1.0 NOx standards for MY 1981 has proven to be an extremely difficult challenge. At present levels of technology development, NOx levels of 1.0 g/mi would require the use of EGR which in turn would increase particulate emission levels and cause severe problems with engine durability. With today's technology the MY 1981 emission standards thus preclude the continued use of light-duty diesel engines, particularly in the larger vehicles."

American Motors: "Yes, these stringent emission standards require a total undiluted effort for AM to purchase and adapt the necessary conventional engine-emission control systems to our cars thereby excluding us from practically considering alternate engines and control strategies for the forseeable future."

Question 2: "On September 19, 1978, EPA distributed a draft Advisory Circular with regard to emissions at temperatures and operating conditions typical of the urban environment, such as vehicle operation at 50°F, but not specifically evaluated by the FTP. What effect would this draft Advisory Circular have on your present corporate average fuel economy? What effect would it have on your future ability to improve fuel economy as measured on the EPA tests and in consumer use? In particular, what would be the effect of this draft Advisory Circular on the use of electronics and on the use of other new types of fuel economy improvement technology such as turbocharging, and variable displacement engines? What data are available to support your response?"

Volkswagen: "Undetermined, but we expect a negative effect on CAFE."

Toyota: "At this time, we cannot even imagine what effect it would have on the fuel economy of each model and how our CAFE might change. We believe that the difficulty of conformity with the standard, not the effect on the CAFE, is the primary problem with this draft A/C."

Chrysler: "We have neither the time nor the facilities necessary to evaluate the effects on fuel economy of testing at temperatures other than those specified by the FTP. In tests conducted by the Canadian government at reduced ambient temperatures it was found that fuel consumption increases significantly as ambient temperature decreases. SAE paper 780935 'The Effects of Technology on Automobile Fuel Economy Under Canadian Conditions,' A.C.S. Hayden, 1978)."

Ford: "The ill-defined and open-ended nature of this draft Advisory Circular has precluded any definitive analysis as to its impact on fuel economy."

General Motors: "General Motors has previously reported low ambient temperature emission tests of oxidation catalyst equipped vehicles (SAE Paper No. 741052, Attachment 7). In comparison to non-catalyst vehicles the use of catalysts was shown to improve the warm-up emissions performance of the vehicle. In addition, General Motors also reported same tests of three-way catalyst equipped vehicles to EPA (FE-1400, July 19, 1978, Attachment 8, and FE-1535, December 20, 1978, Attachment 9).

We believe these tests indicate that present and future catalyst systems provide a considerable degree of emissions control under non-FTP test conditions. However, GM does not have data to allow us to assess the impact of the draft Advisory Circular on our entire product line. Consequently, it is not possible to estimate the effect of the requirements of the draft Advisory Circular on our present CAFE or on the use of the fuel economy improvement technology cited in this question."

General Motors Attachments 7, 8, and 9 are not included herein.

American Motors: "Fuel economy effects of this Advisory Circular could not be measured by AM because there were several major procedural elements which were not addressed by the EPA. The absence of such important test elements as tolerances for testing conditions, preconditioning of the vehicle, test fuel specifications and the applicability of deterioration factors made actual evaluation of these non-FTP standards impractical.

Should the EPA decide to impose such non-FTP standards in the future, there could be a negative fuel economy penalty for AM because the additional tasks will require diverting resources presently involved in basic fuel economy research into investigation of the impact of non-FTP emissions."

Question 3: "What effect did the change, by Congress, of the 1978 light-duty vehicle standards of 0.41 gm/mi HC, 3.4 gm/mi CO, and 0.4 gm/mi NOx to 0.41 gm/mi HC for 1980, to 3.4 gm/mi CO to 1981 (with possible waiver to 7.0), and 1.0 gm/mi NOx in 1981 have on your 1978 through 1985 corporate average fuel economies? Please answer separately for conventional SI engines, stratified charge SI engines and diesel engines."

Volkswagen: "Effects on CAFE not quantified, but an obvious positive effect is realized when considering the relaxed NOx requirements."

Toyota: "A system to meet the California 1983 MY NOx standard of 0.4 g/mile has not been developed. Therefore, it is not evident what effect the changes had and will have on our CAFE."

Chrysler: "We are presently working toward the research goal of 0.4 gm/mi NOx as established by Section 202(b)(7) of the Clean Air Act Amendments of 1977. Since we have thus far been unable to attain that goal, it is not possible for us to measure the effects of a 0.41/3.4/0.4 standard on fuel economy as compared with 0.41/3.4/1.0. At the present time, it appears that if known technology can be improved and refined to the point where the 0.4 gm/mi NOx level can be achieved, the necessary engineering design trade-off will result in a significant fuel economy penalty."

General Motors: "The emission control systems which shows the most promise of meeting the 0.41/3.4/0.4 standards employ catalytic treatment of all three pollutants. Our current test data indicates a 5% loss in fuel economy due to the MY 1980 emission standards and a 3% minimum loss for MY 1981 and beyond. In addition, EPA's failure to grant a MY 1981 NOx waiver and/or regulating stringent particulate standards could preclude the use of the diesel engine as a means of improving our CAFE. This loss would affect GM's CAFE by 0.4 mpg in MY 1982 and 0.8 mpg in MY 1985."

American Motors: "The 0.4 gram/mile NOx level was not technologically feasible for the 1978 model year. The change, by Congress, that established the 1.0 NOx level for the 1981 model year and reclassified the 0.4 NOx standard to a research goal was appropriate and does not directly impact our 1978 through 1985 fleet average fuel economy. Remember, the Energy Policy and Conservation Act car fuel economy standards were based on the 1975 emission standards.

The 0.41 HC, 3.4 CO and 1.0 NOx standards are estimated to result in a 1.0 to 1.5 mpg car fleet average fuel economy penalty over the 1.5 HC, 1.5 CO and 2.0 NOx standards (1977-1979)."

Question 4: "Are any synergistic effects present when simultaneous changes are made in emission standards and test procedures, which do not occur when one of those factors is changed alone? Explain."

Toyota: "When the lead time is the same, there are synergistic effects. We request that EPA synchronize revision of the test procedure with emission standard changes and allow adequate lead time to reduce the burden on the manufacturer which in turn may be expected to lead to synergistic effects."

Chrysler: "We are unaware of any synergistic technological effects on fuel economy, attributable to the combined effects of simultaneous changes in emission standards and test procedures."

Ford: "We are unable to identify any specific synergistic effect of simultaneous changes, however, we would hypothesize that the negative effect that would normally accompany changes to both emission standards and test procedures would be largely eliminated if adequate lead time were provided - which is usually not the case with regard to test procedure changes."

General Motors: "GM believes that the effects of simultaneous changes in emission standards and test procedures on fuel economy are synergistic. First, GM's 11 car study shows that the test procedure changes caused a significant emission penalty (0.028 gm/mi or 2% of MY 1979 standard for HC and 0.78 gm/mi or 5% of MY 1979 standard for CO). It is estimated that the recalibration required to account for this test procedure emission penalty will cause a negative impact on fuel economy. Second, the calibration change required to meet the stringent MY 1981 emission standards by itself is expected to cause a fuel economy penalty as indicated in the response to question 3."

American Motors: "AM does not believe there are inherent synergistic effects caused by simultaneously making changes to the standards and test procedures. However, we have observed many times over the past three years that changes of test procedures have caused an emissions increase that requires a recalibration to maintain constant emissions. Most of the items in Appendix A under the major significance column are of this
type."

The American Motors Appendix A has been included as Attachment E-1 at the end of this appendix.

American Motors

Attachmemt E-1

EPA TEST PROCEDURE CHANGES SINCE 1975

Items of Direct or Major Significance	1975 Model Year Procedure	New Procedure	First Model Year Affected	Estimated Negative Impact on FAFE -- MPG
Standard HP setting for test	Table value-function of inertia weight	HP based on aero-dynamic consider-ations	1979	0.1-0.4
Alternate dynamometer power ab-sorber (DPA) HP setting procedure via the EPA Advisory Circulars	Absolute maniford pres-sure or alternate ap-proved by the EPA	Recommended the coastdown method A/C 55, 3/26/76	1978	Low
"	"	A/C 55-A, 2/8/78 Revised A/C 55	1979	Low
"	"	A/C 55-B, 12/6/78 Revised A/C 55-A	1980	0-0.5
"	"	A/C 55-C. to revise A/C 55-B	1981	TBD
Procedures for setting road load control on dynamometer	Manual	Automatic	1977	Low
Test fuel specs.			1978	Low
octane	As required by mfgr.	93 min.		
lead	As required by mfgr.	0.05 max. gm/gal		
phosphorus	0.0	0.005 gm/gal		
sensitivity	not specified	7.5 min.		
Average absolute humidity during test in EPA lab.	48 grains/lb.(avg)	74 grains/lb.(avg)	1978	Low
Calibration gas accuracy	± 2% corporate standards	± 1% NBS traceable	1979	Low

American Motors — Attachment E-1 (Continued)

Items of Direct or Major Significance	1975 Model Year Procedure	New Procedure	First Model Year Affected	Estimated Negative Impact on FAFE -- MPG
Manual transmission shift schedules	15, 25 and 40 MPH shift points unless manufacturer recommends others	Technical amendment eliminates 15, 25 and 40 MPH shift points. Allows recommended shift points.	1977	None
"	"	A/C 72 changed the procedure to 15, 25 and 40; rated engine RPM or in-use survey data on 1/19/78.	1979	Large but difficult to estimate. It stifles 4 and 5 speed improvements. Use 0.6 MPG est.
"Failure to start" procedure for hot start portion of test	Not specified	Specified procedure	1978	Low
Manual transmission downshift procedures	None	New requirement	1980	Low
Parameter adjustment-idle mixture and choke	None	New requirement	1981	0.2-0.3
Parameter adjustment-idle speed and timing	None	New requirement	1982	0.2-0.4
Inertia weight	250/500 lb increment	125/250 lb increment	1980	Low
33% options by car line	None	Requirement	1980	Nil
Distance traveled	Noninal	Actual	1978	0.1-0.4
Evap test method	Carbon traps	SHED enclosure	1978	Low
SPECIFIC CALIFORNIA PROCEDURES				
Anti-tampering carburetor	None	New requirement	1980	Low
Reduction in allowable maintenance	CFR 86.078-25(a)(1)	All maintenance intervals extended	1980	Low

American Motors

Attachment E-1 (Continued)

Items of Direct or Major Significance	1975 Model Year Procedure	New Procedure	First Model Year Affected	Estimated Negative Impact on FAFE -- MPG
Numerator of fuel economy formula (constant)	2423	2421	1976	Nil
CO2 density	51.85 gm/ft.3	51.81 gm/ft.3	1980	(.01)
Use test vehicle to set dynamometer HP for prep	Allowed	Not allowed	1978	Nil
Vehicle pre-conditioning limits at EPA Lab (5-day prep A/C 50-A)	Not specified	5-day limit for double prep.	1978	*
Diurnal and hot soak ambient temperature requirements	76-86 deg F	68-86 deg F	1978	*
Heat build:				
start temp.	60 ± 2 deg F	60 ± 1 deg F	1978	*
completion temp.	84 ± 2 deg F (evap)	Temp rise 24±1 deg F		
time constraints	60 ± 10 minutes	60 ± 2 minutes		
Test time constraints:				
fuel fill--start prep	Not specified	1 hour maximum	1978	*
end prep--start soak	Not specified	5 mins. max run		
soak times	12 hours min.	12-36 hours		
end diurnal--start C/H CVS	Not specified	1 hour max.		
end C/H CVS--start hot soak	Not specified	5 mins. engine run max., 7 mins. max. total		
Test cell temperature measurement location	Not specified	Location must be representative of temperature experienced by vehicle.	1980	*
Sample collection	Constant volume sampler (CVS)	Critical flow venturi (CFV)	1978	Nil

* Unable to estimate

American Motors

Attachment E-1 (Continued)

Items of Direct or Major Significance	1975 Model Year Procedure	New Procedure	First Model Year Affected	Estimated Negative Impact on FAFE -- MPG
Calibration gases for NDIR analyzer curves	8 gases	6 gases	1978	Low
Calibration gases for HC and NOx	2 gases	6 gases	1978	Low
Analyzer curve fitting technique	Use best judgment in curve selection	Each data point within ± 2% of least-squares best-fit line	1978	Low
Analyzer response during sampling	Not specified	20% to 100% of full scale	1980	Low
Span gas concentration	Approximately 80% of full scale	At least 70% of full scale	1980	Low
Analyzers (CO2)	Beckman 315A	MSA-202	1978	Low
One-hour AMA	Required	LA-4	1978	Low
Evap. system pressure check	Required	Not allowed	1978	Nil
40% nominal tank fuel volume	Rounded to nearest 1.0 U.S. gallon	Rounded to nearest 0.1 U.S. gallon	1978	Nil
Temperature during soak (Evap. test)	1st hr (76-86 deg F) 10+ hr (60-86 deg F)	12-36 hr (68-86 deg F)	1978	Low
Total (sales weighted) estimate				1.6

FOOTNOTE:

Determining the individual effect of any single procedural change is difficult because of the related nature of the items. Where possible an actual or judgmental fuel economy figure has been provided. Whether an item is direct and major, or indirect and minor, all items are of significance because each has to be considered for its impact and adds to the engineering task. Time that could have been used in system development now must be allocated to the analysis of the impact of procedural and regulatory revisions. Emission standard and other general regulatory revisions which have direct or indirect fuel economy impact and further increase the burden of compliance are listed on the following pages.

Appendix F

GENERAL COMMENTS

I. Introductory Statement

"The following questions are not within the previous [or subsequent] question groups. However, since these questions address areas where some changes may have occurred, your comments are requested."

II. Comments

Question 1: "Emissions and fuel economy tests are performed on vehicles specially prepared by the manufacturer for these tests. Would there be an effect on your corporate average fuel economy if production vehicles were randomly selected for fuel economy testing? What effect do you estimate?"

Volkswagen: "No."

Toyota: ". . . vehicles from the assembly line might vary slightly from the [prototype] vehicles for [fuel economy] tests but results could further be complicated by production slippage, vehicle to vehicle variation at production, break-in effect between green engine and 4000 miles, etc. Consequently, we cannot estimate their effect."

Chrysler: "The effect on the corporate average fuel economy if production vehicles were used instead of prototype vehicles is unpredictable. Testing of production vehicles would not be consistent with the principle of applying good engineering practice to the design of the test program because of the variability associated with random production sampling of small samples."

Ford: "Because the certification fleet is biased toward the 'worst case' vehicles, we would expect a random, representative sample of our production vehicles would produce an average fuel economy slightly higher than the certification fleet. Additionally, the gross variability in fuel economy that exists between 'green' engines and stabilized engines would prohibit the drawing of any meaningful relationships between the two.

The necessity for a large statistically valid sample to obtain 'average' fuel economy values makes this [test procedure] so impractical as to render the comparison of approaches an unrealistic one."

General Motors: "GM has previously submitted a detailed analysis to EPA of our production vehicles as compared to their prototype counterparts in a December 20, 1978 letter to Mr. C. Gray, FE-1505 (Attachment 10). The suggestion of using production vehicles for fuel economy testing is not practical since 'production' cars are not available at the time most emission and fuel economy testing is required."

American Motors: "The idea that production vehicles could be used for fleet average fuel economy compliance is not considered practical or feasible for obvious reasons. If such vehicles were to be randomly selectd for fuel economy testing we would expect several effects to counter each other culminating in a random result. For example, we would expect that random vehicle selection would be to our advantage because it could not be penalized by the EPA 'worst case' data-car selection criteria, but this advantage would be offset by the higher friction and variability of vehicles that were not properly broken in prior to testing."

Question 2: "What data can you present to indicate that the fuel economy improvements measured on the EPA tests have also occurred in consumer vehicle use?"

Volkswagen: "Our experience, as well as EPA's test data, show that the Volkswagen-Audi Certification fuel economy data represent closely actual consumption of in-use vehicles."

Chrysler: ". . . we do not believe that the descrepancy between EPA fuel economy values and on-road values is so large as to cause undue concern or so great as a recent DOE report* would indicate. We see no reason why the difference between the EPA reported fuel economy ratings and driver-reported ratings now should be any different than in previous years.

Ford: "While it is generally recognized that average customer fuel economy has been increasing over the past several years, definitive customer data are difficult to obtain so that a precise, numerical relationship cannot be cited. One source of information that confirms the trend of increasing customer gas mileage of cars is that from a large leasing fleet.

Shown in Exhibit V are the year-by-year average fuel economy figures for the Ford Motor Company cars in a large leasing fleet managed by Peterson, Howell and Heather (PH & H). This fleet consists of between about 5000 and 7500 Ford Motor Company cars each year.

Also shown in Exhibit V is the 1975-1978 trend line for Ford's annual CAFE figures, which of course are based of EPA test results. The two solid lines show a virtually parallel relationship, on a year-by-year percentage basis. The dashed line shown on Exhibit V is the Ford CAFE trend line for 1975-1979. This line indicates slightly greater convergence with the PH & H in-use fleet averages than the 1975-1978 CAFE trend line which reflects, in part, the changes made by EPA to the 1975 test procedure.

The mix of Ford Motor Company cars in the PH & H lease fleet does not cover Ford's entire product line up and production mix (PH & H tends to be midsize and large models), so the parallel relationship and absolute difference between the EPA CAFE values and PH & H values are not conclusive, but they do indicate corresponding improvements."

On-Road Fuel Economy Trends and Impacts, DOE Office of Conservation and Advanced Energy Systems Policy, February 17, 1979."

Ford Exhibit V is presented as Figure F-1 of this Appendix.

General Motors: "GM has recently submitted analysis in-use fuel economy experience to EPA, NHTSA, and DOE in the February 8, 1979 letter to Mr. B. McNutt (Attachment 11). It should be recognized that there is a non-linear relationship between fuel economy (mpg) and consumption (gal/mi). Since the EPA's goal was to same fuel, we believe when quantifying fuel economy improvements they should be measured in terms of consumption.

The following formula best expains GM's estimate for the relationship between in-use and EPA test procedure:

In-Use Consumption (gal/mi) = 0.01 + EPA 55/45 (gal/mi)

This equation is based on the GM postcard consumer surveys, as well a field fleet data. From MY 1975 to MY 1978 the fuel economy improvements measured on the EPA test procedure were also seen in actual consumer use. When the fuel saved over these years is measured in terms of consumption (gal/mi) there is not a divergence between EPA and actual in-use measurement; there is a constant .01 gal/mi offset as indicated by the formula."

American Motors: "AM does not possess such data and is unsure how this in-use question relates to the specific concern of this questionnaire."

Question 3: "Prior to the 1975 model year, all EPA fuel economy measurements were conducted on vehicles selected by EPA. Many of these vehicles were selected to be the 'worst cast' offenders from an exhaust emissions standpoint. Would these vehicles have tended to be 'worst case' vehicles from a fuel economy standpoint? Since 1975, EPA has allowed testing of vehicles selected by the manufacturer in the fuel economy program. To what extent has your corporate average fuel economy been improved since 1975 by the addition of these potentially favorable test vehicles?"

Volkswagen: "Due to limited model line of VW and Audi, there has been no actual change for us in the vehicles selected for emission and fuel economy testing."

Toyota: "We think that vehicles selected by EPA would also tend to have been 'worst case' vehicles from a fuel economy standpoint. We know that the CAFE has been improved by the additional test vehicles but we could not afford to supply the additional test vehicles because we had to perform the fuel economy tests under the limits of time, manpower, facilities and capital."

Chrysler: "'Worst case' vehicle selection for emissions testing also tend to be worst case fuel economy vehicle selections.

Chrysler's 1979 model year fuel economy data has been analyzed to illustrate the fleet average effect of voluntary fuel economy data vehicles in the following manner.

A fleet average calculation was performed using only the certification data and any additional data necessary to meet the EPA's minimum requirements. A second fleet average calculation was performed which included the previously identified data and also all voluntary fuel economy data submissions. The difference between these calculations showed an increase of 0.15 mpg on the fleet average attributable to inclusion of the voluntary fuel economy data submissions. Without the representation provided by voluntary data, the fleet average would be biased downward."

Ford: "Of the vehicles selected by EPA for emissions testing, a certain portion, chosen on the basis of high projected sales, provide essentially representative fuel economy. Conversely, the 'worst case' emission veicles, including running change certification vehicles, are worst case for fuel economy also -- their fuel economy understates that expected from the majority of vehicles of that model type. At the manufacturers option, are voluntary FEDV's -- they provide the manufacturer with an opportunity to represent some of the more fuel efficient configurations and thus partially offset the effect of the worst case emission vehicles.

Ford's 1978 CAFE was improved by .01 mpg due to testing of voluntary fuel economy data vehicles. This relatively small effect reflects the fact that Ford's CAFE was consistently 0.4 mpg above the 18.0 mpg standard during the 1978 model year and there was, therefore, no incentive to incur the incremental costs of additional testing on voluntary FEDV's. For 1979, Ford estimates that voluntary FEDV's will contribute +0.17 mpg to its final CAFE which is projected to be 19.0 mpg. These voluntary vehicles are necessary to partially counterbalance the effects of worst case emissions vehicles.

The above CAFE effects do not include any contribution due to required FEDV's since Ford has no option with respect to the submission of such data. Detailed estimates of the CAFE effect of voluntary FEDV's for model years 1975-1977 are not readily available. These effects are expected to be small (less than 0.1 mpg) since there are no CAFE standards for these years."

General Motors: "GM believes that 'worst case' vehicles from an exhaust emissions standpoint will also tend to be 'worst case' from a fuel economy standpoint.

We have also analyzed the effect of voluntary fuel economy data on our MY 1979 CAFE. The CAFE is 18.9721 mpg when computed using data required by EPA. The CAFE is 19.0308 mpg when computed with both required and voluntary data. The difference is 0.0587 mpg or 0.3% when comparing unrounded CAFE values."

American Motors: "Experience indicates that a 'worst case' selection for exhaust emissions is often a fuel economy penalty.

Resource limitations have prohibited AM from utilizing the voluntary fuel economy data vehicle option. We test what we must to comply with the regulation, which means that at least 90 percent of our sales volume is represented by our fleet average fuel economy, but some low-volume vehicle options are not represented for practical considerations."

Question 4: "How does EPA's selection process for fuel economy testing influence a manufacturer's capability to improve corporate average fuel economy? How does it influence the potential to make future improvements in fuel economy?"

Ford: "At the present time Ford has no major objection to the EPA selection criteria for either required or voluntary fuel economy data vehicles (FEDV's).

Ford's ability to incorporate running change fuel economy improvements across groups of vehicles (i.e., aerodynamic improvements, improved lubricants) is, however, limited by EPA running change fuel economy data requirements. For example, it may not be feasible to implement a fuel economy improvement running change late in the model year if this change affects a broad range of car line/engine combinations simply because the required fuel economy data would represent an excessive test burden at that stage of the model year. In such case EPA should allow manufacturers at their option, to substitute existing test data that understate the expected results. Further, CAFE improvements have been mitigated some what by the requirement to harmonically average a formula DPA value with a subsequently run alternative DPA. It has always been Ford's position that once a more representative DPA is available, all applicable vehicles subsequently produced should be credited with that new DPA, as opposed to being 'averaged' with a previous formula DPA."

American Motors: "AM must concentrate on high-volume vehicles and defer development of low-volume high-fuel-efficiency models. The influence of future improvements is also basically a volume consideration."

Question 5: "It has been a practice of EPA that if laboratory test results for a particular vehicle were within 10 percent of the manufacturer's data for the same vehicle, EPA would use the EPA data. Recently, however, EPA has used discretionary administrative actions to select 'official' test results upon which corporate average fuel economy is calculated. Has this improved or diminished your corporate average fuel economy? To what extent?"

Toyota: "The present data selection for CAFE has been applied to Toyota but EPA has tended to select lower test results of either EPA or our data. Therefore, we think that our CAFE has been diminished and the difference between the past and the recent has been about 0.4%."

Chrysler: "In exercising its judgment and administrative discretion, the EPA has tended to favor test results that lower Chrysler's fleet average. The effects of this discretionary action on Chrysler's fleet average for the 1978 and 1979 model years has been analyzed and found to be -0.03 mpg and -0.04 mpg respectively."

Ford: "In a letter to Mr. Richard E. Harrington, Director, Certification Division, MSAPC, EPA, on August 18, 1978, Ford stated that 'For the 1979 model year to date, EPA's 'engineering judgment' in this selection (of official test results), by our calculations, has cost us 0.07 mpg in corporate average fuel economy.'"

General Motors: "At the beginning of the MY 1979 programs, EPA adopted a change in policy to eliminate high test results. This change in EPA philosophy would not logically be expected to increase our CAFE."

American Motors: "Beginning in the 1979 model year the EPA personnel have used their discretionary judgment in selecting official test results in a manner that tends to be prone to exclusion of high-fuel-economy data. The EPA discretionary actions have not had a significant impact on our fleet average fuel economy, but we think some objective criteria are needed."

Question 6: "The EPA test is conducted with Indolene Clear test fuel having an octane rating of nearly 98 RON. Typical unleaded fuel available in the marketplace has an octane rating of 93 RON. To what extent is your corporate average fuel economy improved by the use of the higher octane fuel during fuel economy testing, especially with the utilization of knock sensors? What effect does this difference have on consumer use fuel economy, wherein retardation of spark timing may be necessary to avoid objectionable or harmful detonation? How has the Octane Requirement Increase (ORI) rating of your engines changed with the switch to unleaded fuel?"

Volkswagen: "Undetermined, however, any effect on CAFE would be extremely difficult to quantify.

VW and Audi do not employ knock sensors and we have not experienced Octane Requirement Increase with our engines."

Toyota: "All of our engines have been and are designed to use the required octane rating of 91 or less RON and utilize no knock sensor. Therefore, it has little effect on our CAFE to use 98 RON fuel. We believe that the ORI rating of our engines, with unleaded gasoline, is almost equal to or a little larger than with leaded gasoline under their stabilized conditions."

Chrysler: "Chrysler's corporate average fuel economy is not affected by the use of 98 RON fuel for emission testing. Consumer fuel economy should not be significantly affected by basic spark timing retardation within the allowable limit of two crank shaft degrees from the nominal setting. It is thought that the Octane Requirement Increase (ORI) has substantially increased with the switch to unleaded fuel."

Ford: "We are not aware of any effect of testing at 98 RON versus 93 RON within our present vehicle powertrains. If, however, knock sensors were used extensively across a manufacturer's product line, there is little doubt that a higher fuel economy value could be obtained with the 98 RON fuel versus the commercially available fuels.

Since Ford does not presently utilize knock sensors in any of its vehicles, it is difficult to quantify to what extent our CAFE would be improved because of their use. The company presently projects a 0.1 mpg CAFE improvement with the installation of such devices, however, this projection is based only on engineering judgment.

If retardation of the spark timing was necessary to avoid objectionable or harmful detonation, a reduction in fuel economy would occur. However, this condition only exists in varying degrees on approximately 5% of Ford's vehicles due to our octane policy, in which we have an EPA approved field fix to retard the spark advance and thereby improve these customer's satisfaction. If we were to insist on 100% satisfaction with 91 octane fuel, 95% of our customers would sacrifice fuel economy just to satisfy the remaining 5%.

ORI is strongly dependent on the specific engine design, its calibration and the severity of service, therefore, any general statement on the differences in ORI between leaded and unleaded fuel can be correct only directionally. With this in mind, all that one can state is that in general the ORI with unleaded fuel is slightly higher than with the leaded fuel and it stabilizes at somewhat higher mileage (6 to 12 thousand miles). As far as fuel economy measurement is concerned, ORI differences between leaded and unleaded gasoline should not be a factor because most fuel economy is measured at 4000 to 5000 miles."

General Motors: ". . . we do not believe the use of Indolene Clear test fuel during fuel economy testing on these vehicles had any impact on our corporate average fuel economy.

The specific question of the effect of Indolene Clear on the fuel economy of vehicles equipped with knock sensors has been addressed in responses to EPA in both 1978 and 1979 model years. In both of these years, GM produced turbocharged engines which were equipped with knock sensors. Tests were conducted in both model years with Indolene Clear and with 91 RON unleaded fuel. The results of these tests were previously provided to EPA (June 28, 1977, Attachment 12 and September 20, 1978, Attachment 13), and are summarized below.

Tests of Knock Sensor Equipped Vehicles

		Fuel Economy, mpg	
Vehicle No.	Fuel	City	Highway
57116	Indolene Clear	15.73	20.10
	91 RON	15.86	21.20
57164	Indolene Clear	16.70	20.30
	91 RON	16.79	19.70
94EC196	Indolene Clear	15.2	20.5
	91 RON	15.6	21.2

These data do not indicate that the use of the higher octane Indolene Clear test fuel during the EPA tests increased the measured fuel economy values determined for these knock sensor equipped vehicles.

The impact on consumer in-use fuel economy is thus minimized by restricting spark retard to only those few vehicles which require this adjustment. In addition, data provided to EPA on a running change request indicate little impact of spark retard on fuel economy, as evaluated in the EPA tests. The data provided in our October 27, 1978 request (Attachment 14), are summarized below:

Effect of Spark Retard on Fuel Economy

Vehicle No.	Basic Spark Timing °BTDC	Fuel Economy, mpg City	Highway
91WF102-1	18	26.2	33.8
	14	26.4	32.3
91FF56	12	18.0	27.1
	8	18.6	27.7
91GF96	10	17.8	23.8
	6	17.3	23.0

These data indicate that the impact of spark retard on consumer use fuel economy is minimal, especially in view of the many other factors of greater influence on fuel economy, such as consumer driving habits, weather, traffic conditions, etc. The implication that the use of Indolene Clear test fuel has a negative impact on consumer use fuel economy is not supported by the data available to GM.

The use of lead compounds in gasolines to improve octane quality was also recognized to cause vehicle octane requirements to increase with mileage, as combustion chamber deposits stabilized. In order to compare the influence of unleaded versus leaded gasolines on Octane Requirement Increase (ORI), General Motors participated with 14 other organizations in a Coordinating Research Council (CRC) program in 1970-71. The results of the program were summarized in an SAE publication ('ORI in 1971 Model Cars - With and Without Lead', H. A. Bigley and J. D. Benson, SAE paper No. 730013, Attachment 15). In an effort to further define the influence of selected engine oil, fuel and driving schedule variables on combustion chamber deposits and ORI, General Motors conducted a vehicle fleet test of 1971-75 GM vehicles ('Some Factors Which Affect Octane Requirement Increase', J. D. Benson, SAE paper No. 750933, Attachment 16).

In general, vehicle octane requirements stabilize more rapidly with leaded fuels. Unleaded fuels may require 15-20,000 miles of operation before the vehicle requirements stabilize. It is not uncommon for octane requirements to increase at lower mileages and then decrease as vehicle mileage accumulation continues. This has been observed for both leaded and unleaded fuels.

When commercial unleaded, low lead and leaded fuels were compared, there was no significant fuel effect on ORI. At least 12,000 miles were required with any fuel before the octane requirements stabilized.

Although the factors influencing vehicle ORI are not as well defined as might be desired, the major difference between unleaded and leaded ORI appears to be the rate of octane requirement increase, rather than the value of the final, stabilized octane requirement."

American Motors: "The use of 98 RON for the actual test has no relationship to AM's fleet average fuel economy because we design, manufacture and recommend to our customers that our engines should use fuel with at least an AKI (anti-knock index) of 87. Knock sensors are not used on any of our cars or light truck engines.

Initial and subsequent octane requirements of engines will vary slightly from engine to engine or vehicle to vehicle. Each of AM's carline and truckline power-train combinations is considered to fall within a narrow distribution band with respect to octane requirements. Minor adjustments have been possible, within the EPA-accepted specification ranges, to accommodate fuels of octane ratings either slightly higher or slightly lower than the ratings available most commonly. AM has taken care in the design and production of our engines to avoid customer complaints that would occur if the octane requirements of our engines were increased beyond the capability of commercially available fuel.

The question concerning Octane Requirement Increase (ORI) rating of our engines before and after the change to unleaded fuels is outside the scope of this questionnaire. However, we have not found the switch from leaded to unleaded fuels to significantly affect the numerical ORI level for our engines."

Question 7: "Certification tests are performed primarily on vehicles with a nominal accumulated distance of 4,000 miles. What was the actual average accumulated distance of the vehicles used in the 1975 test program, in your 1979 test program? Would you favor some other distance for certification testing?"

Volkswagen: "No difference."

Toyota: "The actual average accumulated distances of our vehicles used in the 1975 and 1979 test programs were 4,000 ± 250 miles. It seems that, for more stabilized fuel economy, the vehicles should run more distance, but it would be accompanied by problems of manpower, time schedule, facilities, and cost. Therefore, Toyota would not favor changing the distance of 4,000 miles."

Chrysler: "It is not possible for us to analyze the considerable amount of test data necessary to answer this question in the limited time alloted.

A reduction of the distance traveled to 2,000 miles or even 1,000 miles for certification testing would be preferred from the standpoint of efficiency of resource utilization. However, it should be recognized that fuel economy improves with mileage (because of reduced chassis friction) and that it would be appropriate to make some allowance in our CAFE for this phenomenon."

Ford: "Both as a result of requirements to retest our vehicles and to provide running changes for improved fuel economy, Ford's 1975 passenger car certification vehicles had an average accumulated test mileage of 4,300 miles. For 1979, this average increased to 4,800 miles, reflecting the magnitude of changes the company was required to run to meet the 1979 CAFE standard. We know of no reason to change the distance for certification testing."

General Motors: "Actual odometer readings for specific tests used in GM's MY 1975 and MY 1979 test programs are not readily retrieved from our records. For the MY 1975 test program the large majority of data was derived from certification and running change vehicles. Consequently, the average accumulated distance would occur in the range of 3750 to 4250 miles (calculated from the tolerance allowed by the regulations around the nominal 4000 mile test point). For the MY 1979 fuel economy program, approximate odometer readings are available. As can be seen from the attached histogram, Figure F7, the average accumulated distance will occur in or near the 3750-4250 mile range.

At the present time, there is no demonstrated need to change the distance for certification testing."

GM Figure F7 is presented as Figure F-2 of this Appendix.

American Motors: "The approximate range of AM's 1975 certification data vehicles (both cars and light-duty trucks) was 4160±150 miles. One light-duty truck fell outside this range with 4,455 miles.

The approximate range of AM's 1979 certification data vehicles (both cars and light-duty trucks) was 4020±175 miles. Seven cars fell outside this range with 4,541 miles being the highest.

AM believes that 3,800-4,800 miles is a practical range and does not recommend changing the current option which permits up to 10,000 miles for fuel economy testing even though we do not take advantage of this option."

Question 8: "Front-wheel drive is becoming an increasingly popular engineering option for producing space-efficient vehicles. Front-wheel drive vehicles typically have a higher percentage of their curb-weight on the driving wheels than do their rear-wheel drive counterparts. What effect does this have on the simulated road load curve and hence fuel economy? To what extent are alternate dynamometer power absorptions requested for your front-wheel drive vehicles? To what extent does this affect their measured fuel economy and benefit your corporate average fuel economy. How is the air conditioning affected by these alternate dynamometer adjustments and how does this affect your corporate average fuel economy?"

Volkswagen: "a) None.

b) All of our front wheel drive vehicles have alter nate dyno power absorption values.

c) Not quantified, but judged to have a positive effect.

d) Undetermined."

Toyota: "Since front-wheel drive vehicles generally have a higher percentage of their curb weight on the driving wheels than do their rear-wheel drive counterparts, the rolling resistances on the chassis dynamometer are increased and the dynamometer power absorption (DPA) for the F-F vehicle is smaller than that for the F-R vehicle in order to simulate the same driving resistance as on the road. The DPA is adjusted at 50 mph and regardless of the DPA, but the road load is approximately the same under the low speeds unrelated to DPA value because of the characteristics of the Clayton Chassis Dynamometer. Therefore, the front-wheel drive vehicles are at a disadvantage. We use the DPA simulated by coastdown method for front-wheel drive vehicles because they have, as mentioned above, lower DPA's than rear-wheel drive vehicles. We estimate that our CAFE may increase up to one percent. We could not understand your last question in this paragraph about air conditioner and we do not know of the effect on fuel economy."

Chrysler: "Chrysler is also concerned with the change in the dynamometer's 'road load' curve characteristics that may result from the increased load on the drive axle of front-wheel drive vehicles. However, in contrast to the suggested fuel economy 'benefit' relative to rear wheel drive, we feel that if there is a difference (after both are adjusted to the correct DPA settings) the effect will be detrimental with respect to the front wheel drive system.

We have found that the 'coast-down' alternate road load procedures produce DPA settings that are significantly lower than the EPA frontal area formula values for all Chrysler front-wheel drive vehicles. Consequently, any advisory circular that would inhibit the establishment of alternate DPA's would have an increasingly larger detrimental effect on Chrysler's CAFE as our percentage of front-wheel drive vehicle increases.

The basic question of air conditioning load is answered in the 'Accessory' portion of this response."

Ford: "The greater fraction of vehicle weight on the driving wheels of a front-wheel drive (FWD) car causes it to be penalized on the EPA dynamometer test. In the example given below, a FWD vehicle of identical weight to a RWD vehicle experiences 3.5% less measured fuel economy if the frontal area formula is used to set the dynamometer power absorber unit (PAU) and 1% less measured fuel economy if the coastdown technique is used to set each PAU. That is, the reduced PAU of the FWD vehicle using coastdown does not completely offset the increase in its dynamometer rolling resistance. Both types of vehicles would have identical road fuel economy.

It is obvious from the above considerations that alternative settings are of crucial importance in partially offsetting the inherent testing disadvantage of a FWD vehicle. Alternative dynamometer settings determined by the coastdown technique are being used for Fiesta and will be used for the 1981 Pinto replacement.

The effect of . . . adverse testing characteristics on FWD vehicles on Ford's corporate average fuel economy cannot be exactly quantified because there is still a net benefit associated with the package efficiency. That is, a FWD vehicle can be made to weigh less than a RWD vehicle of equivalent interior volume and in spite of its testing handicaps, the effects on CAFE will be beneficial."

General Motors: "Front-wheel drive (FWD) vehicles when tested on the present twin roll dynamometer tend to be loaded higher than on the road throughout the speed range. GM currently uses alternate horsepower settings for all FWD vehicles since the frontal area equation misrepresents the actual road load. The fuel economy benefits of an alternate horsepower setting for our '80X FWD car were included in our March 20, 1979 letter to Mr. Finkelstein (Attachment 17).

Please refer to GM's Responses C3 and C4 in Section C, Accessories, for a discussion of the air conditioning loads."

Section C corresponds to our Appendix C.

American Motors: "Current AM vehicles are either rear-wheel-drive or four-wheel-drive. We do not have the information necessary to answer these questions."

Question 9: "The oil industry has recently developed new engine lubricants incorporating lower viscosity and/or additives with reduced friction. What would be the effect on your average fuel economy if these oils were approved for use? To what extent have they penetrated the replacement oil market? To what extent would the fuel economy of in-use vehicles be improved by the use of these oils?"

Toyota: "We estimate that our CAFE could be increased about 1.5 percent by the use of slippery oils and we think in-use vehicles would experience a similar result. We do not know to what extent these oils have penetrated the replacement oil market."

Chrysler: "On the basis of data available to Chrysler, we are led to conclude at this time that no clear cut advantage will be obtainable through the use of low friction 'slippery oils' in production vehicles. Our views on this issue were reported in a March 21, 1979 letter from S. L. Terry to Joan Claybrook [NHTSA] and a November 8, 1979 letter from S. L. Terry to R. L. Strombotne [NHTSA]."

Ford: "As Ford stated in its response to NHTSA's questionnaires on 1984-86 Passenger Car Fuel Economy Standards (August, 1978) and 1982-84 Light Truck Fuel Economy Standards (September 20, 1978), a test program comparing Ford's current factory-fill oil and several other oils with friction reducing additives indicated that an estimated 0.5% improvement in EPA metro-highway fuel economy is possible with the best of these improved lubricants that Ford has tested to date. The results of this program were reported in SAE Paper 780962, 'The Effects of Engine Oil Additives on Vehicle Fuel Economy, Emissions, Emission Control Components and Engine Wear.' November, 1978.

Ford has no information as to the extent to which these improved oils have penetrated the replacement market, nor the fuel economy benefit of actual in-use of these oils."

General Motors: "Improvements of about 1-3% in EPA fuel economy have been observed in a limited number of tests using commercial 'fuel-saving' oils. As indicated by our comments in the February 14, 1979 letter to Mr. Finkelstein (Attachment 2, ref. pg. 8 of attachment 1) GM still hopes to recommend use of friction modified oils which we project a fuel economy improvement of about 1%.

To our knowledge, there are 19 engine oils reported to improve fuel economy that are on the market in the U.S. and Canada.

It has been our experience that the on-road fuel economy improvements with 'fuel-saving' engine oils are equal to or greater than those measured on the EPA test."

American Motors; "AM believes the fleet average fuel economy (FAFE) benefit (car and light truck) realized through the use of new, 'improved' oils and rear axle lubricants would be low (0.1 to 0.2 mpg). This FAFE improvement is over our current factory-fill 10W30 engine oil and rear axle lube, which we believe is on a par with some of the so-called new improved products being advertised.

We do not track the replacement-oil market. We cannot predict the in-use improvement likely to be gained."

Question 10: "What effect has the EPA changes in dynamometer calibration (electronic feedback dynamometer control system and changes made to support automatic control features) had on your corporate average fuel economy?"

Chrysler: "All tests which have been run comparing automatic and manual horsepower control have shown no significant difference in emission levels or fuel economy as a result of changes in dynamometer calibration."

Ford: In summary, ". . . test analyses show that the estimated impact of the PAU exponent and the EPA Vehicle Factor Potentiometer changes on Ford's 1980 CAFE is a loss 0.1 mpg."

General Motors: "Directionally, the automatic feedback requirement on the dynamometer is expected to provide a loss in fuel economy as compared to the manual operation. This conclusion is based on a simulation (SAE paper No. 780287 Computer Simulation of Emissions and Fuel Economy, Attachment 18)."

American Motors: "We believe the effect of the automatic feedback dynamometer method over the previous manual operation method is a low 0.0 to 0.3 mpg fuel economy penalty (see Appendix A). We have not made a comparison study of the two methods to quantify our judgement."

American Motors Appendix A is included as Attachment E-1.

Question 11: "What effect has the change in average humidity level from 55 grains to 75 grains at the EPA test facility had on your corporate average fuel economy?"

Volkswagen: "Undetermined, but we expect a decrease in measured fuel economy."

Chrysler: "Our calculations show that the change in average humidity level from 55 grains to 75 grains has decreased our CAFE by 0.7 percent. (This was calculated on the basis of information in SAE paper 780287.)"

Ford: "In an EPA test report entitled 'An Evaluation of the Fuel Economy Performance of Thirty-One 1977 Production Vehicles Relative to their Certification Vehicle Counterparts,' dated January, 1978, prepared by F. Peter Hutchins and James Kranig, the conclusion was reached that the 20 grain increase in humidity at EPA caused a 'downward shift in fuel economy results of about one (1) to two (2) percent.'

In a subsequent Ford experiment conducted in July, 1978, using an environmentally controlled emission test cell, Ford found that the average metro-highway fuel economy effect was approximately a 1.1% decrease in fuel economy for a 20 grain increase in humidity (using Ford's 1978 model year sales mix). Considerable scatter in this data was observed, but all cars experienced a fuel economy loss of from 0.9 to 1.5%.

However, since only about 50% of Ford fuel economy results for 1979 are tests conducted at the EPA laboratory and the balance are conducted at Ford's laboratory where the humidity is maintained at approximately 55 grains H_2O per lb of dry air the actual effect on Ford's CAFE is a decrease in the range of 0.5 to 1.0%. The impact of this humidity change on 1979 (19 mpg) CAFE is 0.75% or 0.14 mpg CAFE decrease."

General Motors: "GM does not have data to specifically quantify the effect on our corporate average fuel economy of the change in average humidity level from 48 grains per pound to 74 grains per pound at the EPA test facility."

American Motors: See Attachment E-1.

Question 12: "What effect has the change from the use of the nominal vehicle distance traveled per test to the use of the actual measured vehicle distance traveled had on your corporate average fuel economy? What effect would this have on your future ability to improve your corporate average fuel economy as you shift to vehicles of lower power-to-weight ratios which cannot actually travel the nominal distance?"

Toyota: "When the fuel economies of our 1980 MY vehicles were determined by the use of actual measured vehicle distance traveled, it was evident that their values, as tabulated below, showed about 0.2 to 0.6% decrease.

Engine Displacement	Combined Fuel Economy Loss
1.5 liters	About 0.6%
1.8 liters	About 0.3%
2.2 liters	About 0.2%
2.6 liters	About 0.2%

Therefore, our CAFE resulted in about 0.25% decrease. In the case where a vehicle has too low a power-to-weight ratio to trace the FTP mode, the CAFE may decrease more."

Chrysler: "Our Proving Ground test data show that fuel economy was 0.91% lower on the urban cycle than would have been the case if nominal distances were used. This is based on a February 1978 survey of the measured distance results on 102 official certification tests run at the Chrysler Proving Grounds.

The same data showed successively lower measured distances as engine size decreased. When distances for twenty-five front-wheel drive vehicles were compared to the nominal of 7.5 miles, a fuel economy penalty of 1.26% was indicated."

Ford: "Ford's response to EPA's interim final rulemaking on 'Fuel Economy Testing; Calculation and Exhaust Emissions Test Procedures for 1977-1979 Model Year Automobiles' dated December 9, 1976, included a discussion of this distance travel change. Data were presented in this response which showed that this change would cause a negative 0.3% effect on metro-highway fuel economy. A subsequent study performed using data from Ford's 1978 and 1979 4000-mile certification vehicles showed that the fuel economy results in the Ford laboratory averaged 0.6% lower due to the use of actual versus theoretical driving distance.

Ford continues to believe that there is a systematic difference between fuel economy measured using actual dynamometer distance versus nominal distance, and the CAFE penalty will increase in future model years as a result of an increased mix of low power-to-weight vehicles that are most affected by this procedure change since they are more likely to be unable to accelerate at rates high enough to follow the time-speed driving trace. These vehicles, therefore, may travel less than the theoretical cycle distance, resulting in a lower calculated fuel economy when calculated on the basis of actual distance.

A 0.6% impact on a 19 mpg CAFE figure amounts to a fuel economy detriment of almost 0.12 mpg. This CAFE-lowering effect will become greater in future model years as a result of our plans to continue decreasing average power-to-weight ratio of Ford's vehicles."

General Motors: "Data from the eleven car GM MY 1975-1980 test procedure study, Attachment 1, were analyzed to note the actual distance traveled versus the nominal MY 1975 distance. The results of this eleven car study indicated that the actual distance contributes a 0.08 mpg loss on the city fuel economy test, no effect on highway fuel economy and a 0.05 mpg loss in the combined (55/45) fuel economy. This same analysis indicated that the difference due to actual versus nominal distance is not a function of the vehicle power-to-weight ratio."

American Motors: "An analysis of seven 1980 model year data sets using the nominal versus the actual distance traveled showed a .083 mpg (combined) penalty. We believe the fleet average fuel economy penalty to be about 0.1 mpg and that it may progressively increase as lower-power-to-weight vehicles struggle to keep up with the acceleration rates on the Federal Test Procedure."

Question 13: "What will be the effect of a requirement to couple the front and rear rolls of two-roll dynamometers on measured fuel economy and on your corporate average fuel economy?"

Toyota: "We cannot reply to this question because we have not investigated this effect."

Chrysler: "Coupling the front and rear rolls would increase the frictional horsepower absorbed by the dynamometer. An anticipated reduction in slippage between tires and rolls would logically be expected to increase the horsepower load on the vehicle and this would penalize the measured fuel economy."

Ford: ". . . we did conduct a test program to simulate the coupling of two rolls. This program consisted of running a 4000 lb I.W. and vehicle alternating the speed input to the driver's aid from the front to the rear roll. The speed trace off the rear roll duplicated normal test conditions and the speed trace off the front roll simulated the rolls being coupled together. Listed below are the test results from that program:

1978 CVS C/H Tests

	Grams/Mile HC	CO	NOx	Fuel Econ. MPG
Mean Values--Front Roll	1.82	8.95	2.88	12.99
Mean Values--Rear Roll	1.70	5.55	2.12	14.09
% Increase (Decrease)	7.06%	61.26%	35.85%	(7.81)%
Analysis of Variance (95% Confidence Limit)	NSD	SD	SD	SD

1978 HWFET Tests

	Grams/Mile HC	CO	NOx	Fuel Econ. MPG
Mean Values--Front Roll	.72	1.28	2.94	17.44
Mean Values--Rear Roll	.64	.61	2.32	18.54
% Increase (Decrease)	12.50%	109.84%	26.72%	(5.93)%
Analysis of Variance (95% Confidence Limit)	SD	SD	SD	SD

$$\% \text{ Increase} = \frac{\text{Front Roll} - \text{Rear Roll}}{\text{Rear Roll}} \times 100$$

NSD - No significant difference; SD - Significant difference

Based on the limited data available to Ford, this change in dynamometer test configuration from that used in 1975 would significantly . . . reduce fuel economy . . ."

General Motors: "GM believes that a requirement to couple the front and rear rolls of two-roll dynamometers is likely to introduce a loss in measured economy."

American Motors: "We judge that a slight loss in measured fuel economy and fleet average fuel economy will occur due to the slippage and other operational factors. This change will probably have the 'double fuel economy penalty' in that it not only directly penalizes economy but will probably increase emissions causing and additional fuel economy loss to be incurred to offset the emissions increase."

Question 14: "Do you know of any procedural changes other than those listed in previous questions which have already affected your corporate average fuel economy, or have increased or diminished your potential to make future improvements?"

Volkswagen: "No."

Toyota: "We do not think there are other procedural changes which have already affected our CAFE or have increased or diminished our potential to make future improvements."

Chrysler: "We are not aware of any additional changes that may have affected our corporate average fuel economy. It should be noted the process of instituting changes in procedures could have adverse effects on fuel economy if adequate lead time is not provided so that the revisions can be accomodated in our product development plans without unnecessary disruptions."

Ford: "In addition to the previously mentioned procedural changes which have reduced our tested fuel economy, Advisory Circular 24-2 has had a definite adverse effect on Ford's 1979 CAFE. This CAFE loss was the result of having to recalibrate those vehicles equipped with Ford's electronic engine control systems which have been designed to provide a lean cruise control (LCC) option. The metro-highway fuel economy benefit of this system was approximately 4%. In order to comply with .... new emission standards, Ford was compelled to recalibrate its original system. This recalibration reduced the fuel economy benefit of the LCC system from 4% to 1%. The following table presents the estimated CAFE effect due to this procedure change.

CAFE Impact of LCC System Recalibration

M-H F.E.	Projected Volume	1979 CAFE
-0.6 mpg	69974	-0.02 mpg

Therefore, the overall impact of this ruling goes far beyond the 1979 model year and, in fact, impacts Ford's ability to comply with the 1985 CAFE standards.

General Motors: "EPA often does not give sufficient lead time to the manufacturers when making changes in the policy and guidelines which affect the testing process.

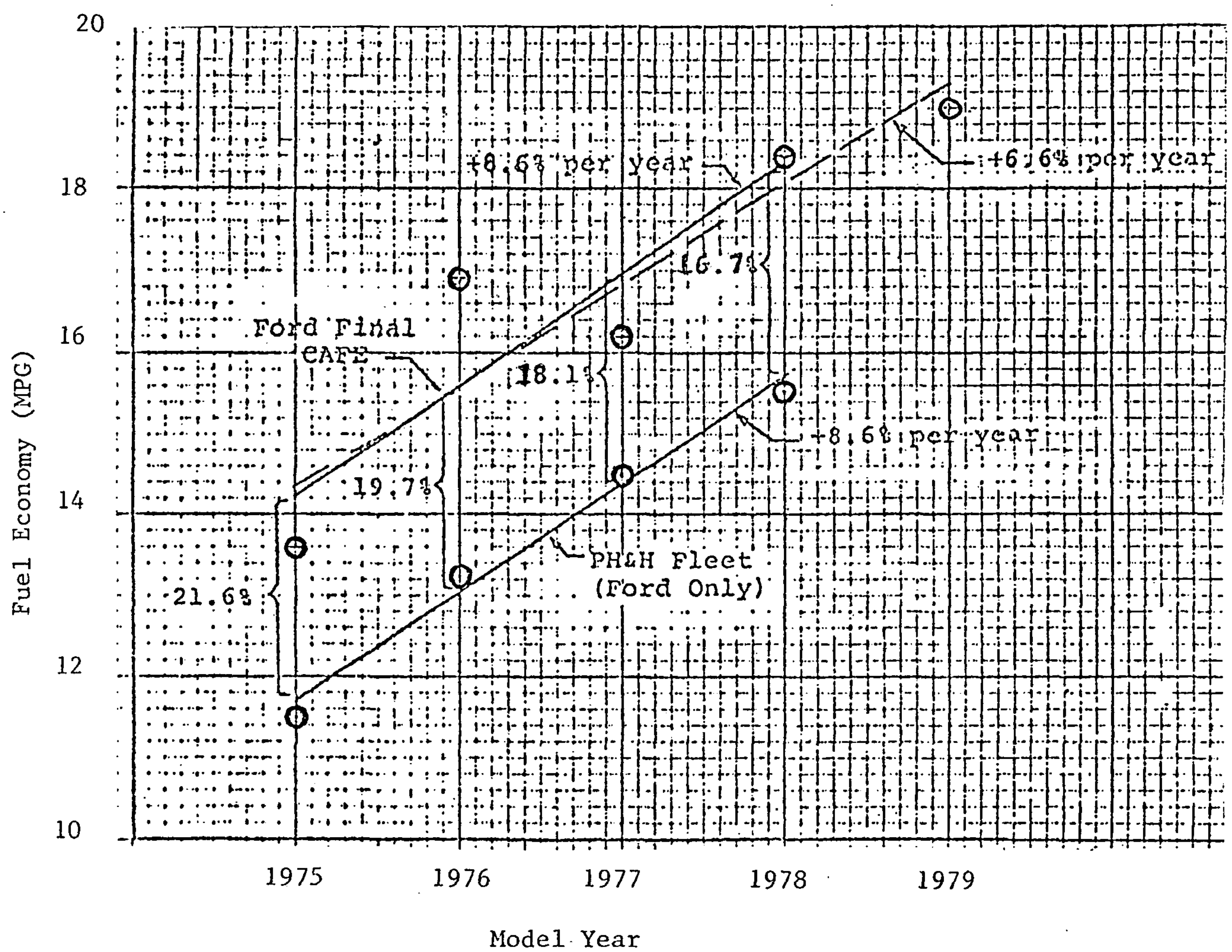
The highway NOx requirements, in EPA' Advisory Circular No. 24-2, may inhibit fuel economy optimization at highway speeds."

American Motors: "Yes, please refer to Appendix A (Attachment E-1) for a complete listing of these other changes."

Ford Motor Corporation

FIGURE F-1. Ford Final CAFE vs Average

Ford Fuel Economy in PH & H Fleet



General Motors
Figure F-7

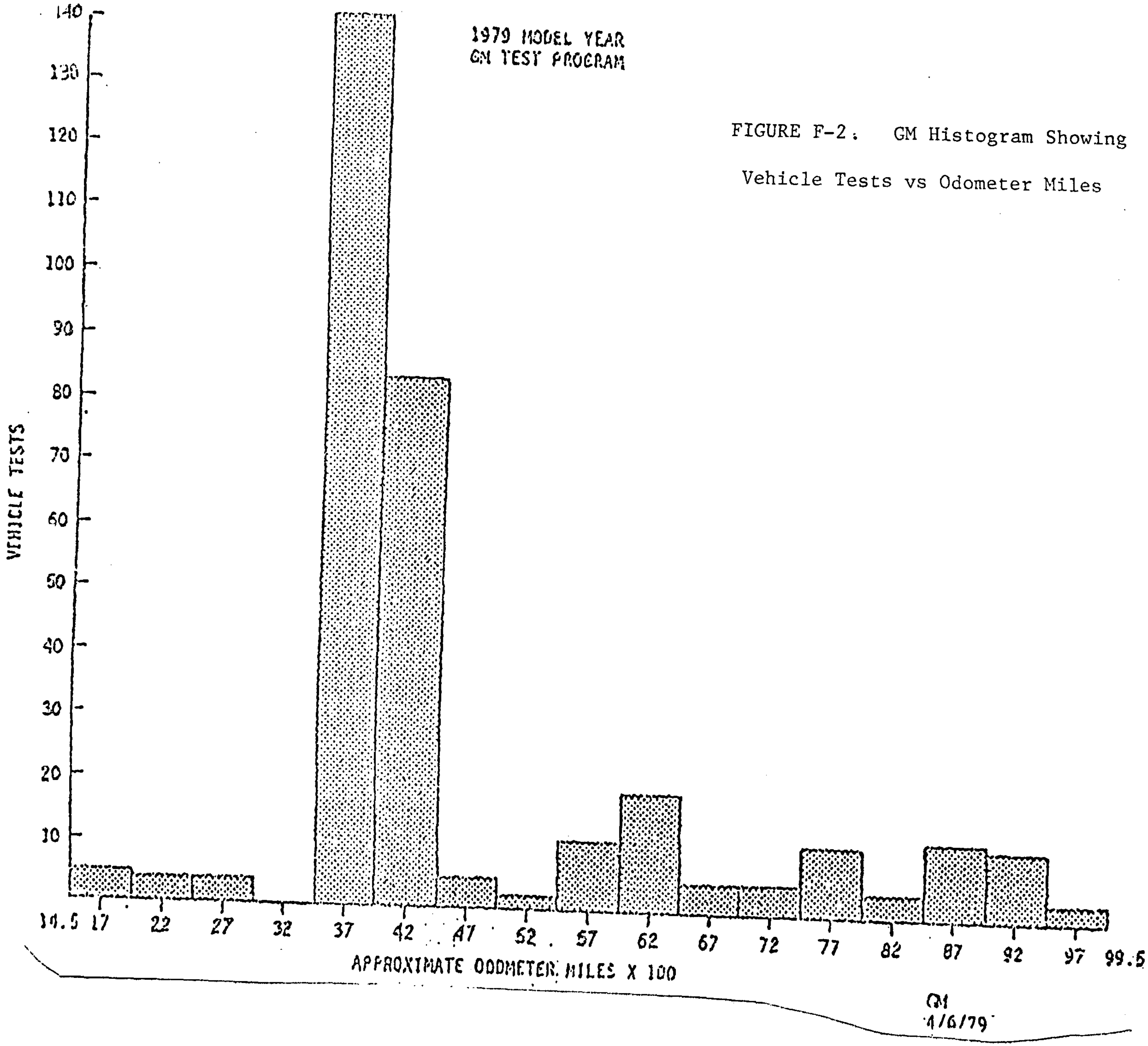


FIGURE F-2. GM Histogram Showing Vehicle Tests vs Odometer Miles

Appendix G

LIGHT-DUTY TRUCK ROAD LOAD COMMENTS

I. Introductory Statement

"In establishing the light-duty truck fuel economy standards for model years 1979 through 1981, the NHTSA allowed an 8 percent fuel economy penalty for procedural change in establishing road load horsepower for light-duty trucks which was effective in model year 1979."

II. Comments

Question 1: "Was the adjustment appropriate? If not, what should it be? What data are available to support your position?"

Toyota: "When it was used for the 1979 MY vehicles, it caused about a 7 percent reduction in our CAFE. Therefore, we believe that this adjustment of 8 percent fuel economy penalty was appropriate."

Chrysler: "While we generally believe the 8% allowance may be somewhat on the low side, it appears to be a reasonable allowance."

Ford: "No, an 8% adjustment was not adequate; based on Ford data the adjustment should have been 10% for test procedure changes alone... A detailed response to this question was provided in Ford's January 10, 1977 response to NHTSA on the NPRM on Average Fuel Economy Standards for the 1979 model year non-passenger automobiles."

General Motors: "As stated in GM's October 13, 1978 response to NHTSA's Light Truck Questionnaire (Attachment 5), GM agrees with NHTSA's adjustment to the MY 1979 standards for dynamometer HP test procedure changes. However, GM had submitted data that demonstrated the more stringent exhaust emission standards in MY 1979 and beyond result in a 5.1% fuel economy penalty. This penalty was not factored into the final MY 1979 and beyond light truck fuel economy standards."

American Motors: "AM considers the 8 percent adjustment to be a conservative adjustment, but we are disappointed that the NHTSA failed to consider the fuel economy penalty due to the increased stringency of the 1979 emission standards including the effect of increased NOx emissions from higher engine loading due to the revised test procedure. We believe an additional 5 to 8 percent penalty was overlooked by the NHTSA and should be reconsidered at this time."

Question 2: "When computing the above adjustment, alternate dynamometer power absorption requests were not considered. Should such alternate dynamometer power absorptions be allowed?"

Volkswagen: "Yes."

Toyota: ". . . we have no need to consider it at this time."

Chrysler: "It is important that alternate dynamometer power absorption setting determinations be allowed in order to encourage light-duty truck manufacturers to incorporate fuel economy improvement features for which they might otherwise receive no credit when restricted to formulas for determining DPA."

Ford: "Alternate dynamometer power absorptions provide a positive motivation for manufacturers to aerodynamically improve their vehicles."

General Motors: "The vehicles GM used to establish the MY 1979 light truck test procedure penalty in our previous submissions were MY 1976 and 1977 0-6000 lb GVWR two-wheel drive vehicles. EPA used a regression analysis of the actual coast data from these vehicles to establish the frontal area formula; therefore, it did not make any difference on these vehicles if the alternate (coastdown) procedure was used. GM does not currently have a complete analysis of the effects of test procedure . . . for the 0-8500 lb fleet."

American Motors: "Yes, because the alternate dynamometer power absorption method provides incentive for manufacturers to make aerodynamic improvements."

Question 3: "To what extent do you anticipate using alternate dynamometer power absorptions?"

Volkswagen: "On all models where a clear benefit is realized over the standard procedure."

Toyota: "We do not anticipate using alternate DPA."

Chrysler: "As Chrysler continues to improve vehicle aerodynamics and to investigate changes in tire construction and tread compounds, we would anticipate using alternate DPA settings for all vehicles."

Ford: "Ford will continue to use alternate DPA's wherever necessary to reflect improved aerodynamic characteristics. We expect most light trucks will use alternate DPA's in the future."

General Motors: "In MY 1980 GM intends to use the alternate (coastdown) dynamometer almost exclusively for our light-duty vehicles."

American Motors: "In the 1980 and 1981 model years we anticipate that one truckline out of six will use an alternate dynamometer power absorption value to reflect trucks equipped with radial tires."

Question 4: "Should the 8 percent correction factor be reduced to account for any reduction in the actual anticipated test dynamometer power absorptions?"

Volkswagen: "No data available."

Toyota: "We consider 8% to be a reasonable number."

Chrysler: "We do not believe that the 8 percent correction factor should be reduced. As stated above, any reduction in future EPA settings will be the results of product improvements for which manufacturers should receive full credit."

Ford: "No. Ford indicated in its response to the NPRM on 1979 Light Truck Fuel Economy Standards, that the proper correction factor should be 10% for procedural changes implemented in 1979."

General Motors: "GM believes that the 8% adjustment to the originally proposed standards should not be changed because the light truck fuel economy standards were based on projected fuel economy improvements which can only be measured using the alternate dynamometer horsepower setting procedure."

American Motors: "No, see the response to question 1 in this section."

APPENDICES

Table A-1

Vehicle Descriptions

Vehicle		Tires	
Test Vehicle ID	25001		
Manufacturer	Oldsmobile	Manufacturer	Firestone
Make/Model	Cutlass 1980	Model/Type	721 SBR
Body/Style	4 dr. Sedan	Size/Ratio	P195/75 R14
V.I.N.	3MG69RAM12836	Belt Fabric	2 Poly/2 Steel
Mileage (mi)	9937	Wall Fabric	2 Poly
Engine	260 CID V8	Veh. Mfg. Recommend, F/R	26/26 psi
Carburetor	2 bbl	Tire Pressure Adjusted to, F/R	26/26 psi
Ignition	Electronic		
Transmission	Auto		
Air Conditioning	Yes		
Curb Weight (lb)	3959		
Drive Axle Weight (lb)	1677		

Table A-2

Vehicle Descriptions

Test Vehicle ID 25002	**Tires**
Manufacturer Ford	Manufacturer Firestone
Make/Model Pinto 1980	Model/Type 721 SBR
Body/Style 2 dr. Hatchback	Size/Ratio BR 78-13
V.I.N. 0T11A106438	Belt Fabric 1 Poly/2 Steel
Mileage (mi) 12510	Wall Fabric 2 Poly
Engine 2.3L 4	Veh. Mfg. Recommend, F/R 24/24 psi
Carburetor 2 bbl	Tire Pressure Adjusted to, F/R 24/24 psi
Ignition Electronic	
Transmission Auto 3 Speed	
Air Conditioning Yes	
Curb Weight (lb) 3039	
Drive Axle Weight (lb) 1339	

Table A-3

Vehicle Descriptions

Test Vehicle ID	25003	**Tires**	
Manufacturer	Ford	Manufacturer	Firestone
Make/Model	Custom F-100 1981	Model/Type	721 SBR
Body/Style	Pickup	Size/Ratio	P215/75R15
V.I.N.	1FTCF10E513 UA/12153	Belt Fabric	2 Poly/2 Steel
Mileage (mi)	12535	Wall Fabric	2 Poly
Engine	4.9L I6	Veh. Mfg. Recommend, F/R	35/35 psi
Carburetor	1 bbl	Tire Pressure Adjusted to, F/R	35/35 psi
Ignition	Electronic		
Transmission	Auto 3 Speed		
Air Conditioning	Yes		
Curb Weight (lb)	3652		
Drive Axle Weight (lb)	1478		

Table A-4

Vehicle Descriptions

Vehicle		Tires	
Test Vehicle ID	25004		
Manufacturer	Chevrolet	Manufacturer	Goodyear
Make/Model	Citation 1980	Model/Type	Arriva SBR
Body/Style	3 dr.	Size/Ratio	P185/80 R13
V.I.N.	1X087AW124660	Belt Fabric	1 Poly/2 Steel
Mileage (mi)	20100	Wall Fabric	1 Poly
Engine	173 CID V6	Veh. Mfg. Recommend, F/R	26/26 psi
Carburetor	2 bbl	Tire Pressure Adjusted to, F/R	26/26 psi
Ignition	Electronic		
Transmission	Auto		
Air Conditioning	Yes		
Curb Weight (lb)	3108		
Drive Axle Weight (lb)	1993		

Table A-5

Vehicle Descriptions

Test Vehicle ID	25005	**Tires**	
Manufacturer	Ford	Manufacturer	Goodyear
Make/Model	Escort L 1981	Model/Type	Arriva SBR
Body/Style	3 dr. Hatchback	Size/Ratio	P165/80 R13
V.I.N.	1FABP0527BW112377	Belt Fabric	1 Poly/2 Steel
Mileage (mi)	21445	Wall Fabric	2 Poly
Engine	98 CID I4	Veh. Mfg. Recommend, F/R	35/35 psi
Carburetor	2 bbl	Tire Pressure Adjusted to, F/R	35/35 psi
Ignition	Electronic		
Transmission	Man 4 Speed		
Air Conditioning	Yes		
Curb Weight (lb)	2424		
Drive Axle Weight (lb)	1453		

Table A-6

Vehicle Descriptions

Test Vehicle ID	25006	Tires	
Manufacturer	Plymouth	Manufacturer	Firestone
Make/Model	Horizon 1981	Model/Type	721 SBR
Body/Style	4 dr. Sedan	Size/Ratio	P165/75 R13
V.I.N.	1P3BL28A1BD117347	Belt Fabric	Poly/Fiberglass
Mileage (mi)	18,739	Wall Fabric	Poly
Engine	1.7L I4	Veh. Mfg. Recommend, F/R	35/35 psi
Carburetor	2 bbl	Tire Pressure Adjusted to, F/R	35/35 psi
Ignition	Electronic		
Transmission	Auto 3 Speed		
Air Conditioning	Yes		
Curb Weight (lb)	2690		
Drive Axle Weight (lb)	1703		

Table A-7

Vehicle Descriptions

Test Vehicle ID 25007	**Tires**
Manufacturer AMC	Manufacturer Goodyear
Make/Model Concord 1981	Model/Type Arriva SBR
Body/Style 4 dr. Sedan	Size/Ratio P195/75R14
V.I.N. 1AMCA0557CR106107	Belt Fabric Poly/Steel
Mileage (mi) 11,610	Wall Fabric Poly
Engine 4.2L I6	Veh. Mfg. Recommend, F/R 28/28 psi
Carburetor 2 bbl	Tire Pressure Adjusted to, F/R 28/28 psi
Ignition Electronic	
Transmission Auto 3-Speed	
Air Conditioning Yes	
Curb Weight (lb) 3503	
Drive Axle Weight (lb) 1480	

Table A-8

Vehicle Descriptions

Test Vehicle ID 25008	**Tires**
Manufacturer Honda	Manufacturer Dunlop
Make/Model Civic 1982	Model/Type SP4N
Body/Style 3 dr. Hatchback	Size/Ratio 155 SR13
V.I.N. JHMSL5325CS002019	Belt Fabric Steel
Mileage (mi) 14,709	Wall Fabric Poly
Engine 1.3L 4	Veh. Mfg. Recommend, F/R 32/32 psi
Carburetor 1 bbl	Tire Pressure Adjusted to, F/R 32/32 psi
Ignition Electronic	
Transmission Man 5 Speed	
Air Conditioning Yes	
Curb Weight (lb) 2241	
Drive Axle Weight (lb) 1334	

Table B-1

Coastdown and Track Fuel Economy Instrumentation

Fifth Wheel - Labeco "Trac Test" 1877

Distance Readout - Labeco 5231

Data Logger - TI Silent 700, Model 765

Magnetic Tape Interface - Techtran 817-A

Chart Recorder - HP Recorder

Power Inverter - Nova Electric 2560-12

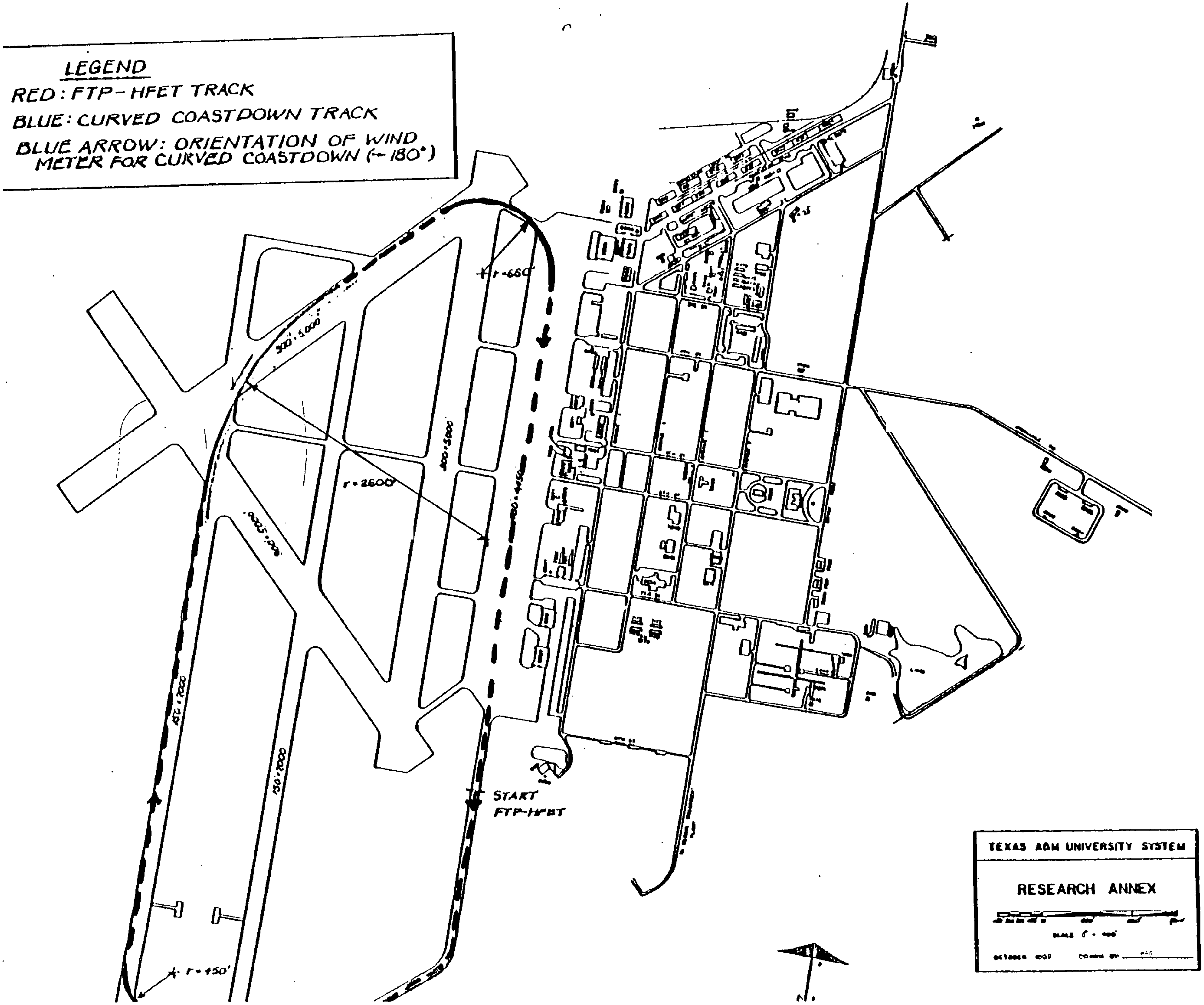
Flow Transducer and Display - Fluidyne Model 1240T

Temperature Recorder - Omega 5137-5M

Thermocouple Amplifier - Omega Omni - Amp 1

Thermocouple Reference Junction - Omega MCJ-J

Single Scanner - Omega Dataplex 10



LEGEND
RED: FTP-HFET TRACK
BLUE: CURVED COASTDOWN TRACK
BLUE ARROW: ORIENTATION OF WIND METER FOR CURVED COASTDOWN (← 180°)
r = 660'
r = 2600
r = 450'
START FTP-HFET
TEXAS A&M UNIVERSITY SYSTEM
RESEARCH ANNEX

Figure B-2

Table B-3

Fuel Specifications

	Federal Specifications	Indolene[1]	Howell[1]
API Gravity	None	57.5	58.0
Octane, min RON	93	97.1	94.1
Sensitivity, min.	7.5	8.6	7.8
Lead, g/gal	0.00-0.05	0.004	0.003
Phosphorous, g/gal max.	0.005	0.0003	Nil
Sulfur, wt % max.	0.10	0.011	--
Reid Vapor Pressure, lb/in^2	8.7-9.2	8.8	9.2
Distillation, °F			
IBP	75-95	86	86
10% pt	120-135	124	126
50% pt	200-230	219	221
90% pt	300-325	310	316
EP	415	401	369
Hydrocarbon Composition			
Olefins, % max.	10	3.3	Nil
Aromatics, % max.	35	33	30.2
Saturates	--	63.7	69.8

[1] Measured fuel specifications.

Table B-4

Dynamometer Fuel Economy Instrumentation

Dynamometer - Clayton CTE-50 (Arrangement B)

Roll Coupler - Clayton Mfg.

Chart Recorder - Horiba Video Monitor

Cooling Fan - Hartzel 22-24N24

Volumetric Sampler - Horiba CVS-20A CFV 350 CFM

Analytical System - Horiba FIA-21 HC
Horiba CLA-22 NOx
Horiba AIA-23 CO_2
Horiba AIA-23 (A-S) CO

Analytical Gases - Scott Environmental, 2% Accuracy

Timing System - HP, 0.1 msec. Accuracy

Test Fuel - EEE Clear Howell Hydrcarbons
- Amoco Indolene

Table C-1

Cutlass Fuel Economy Data

	Track Results (mpg)[2]	Coupled Roll Dynamometer Results (mpg)[1]		Uncoupled Roll Dynamometer Results (mpg)[1]	
		Volumetric[2]	Carbon Balance	Volumetric[2]	Carbon Balance
	FTP	FTP	FTP	FTP	FTP
	13.85	14.03	14.56	14.25	14.05
	13.73	14.03	14.62	14.05	14.96
	13.45	13.89	14.50	13.97	14.45
$\overline{x}$	13.68	13.98	14.56	14.09	14.49
s	0.21	0.08	0.06	0.14	0.46
$s/\overline{x}$(%)	1.5	0.6	0.4	1.0	3.2
	HFET	HFET	HFET	HFET	HFET
	19.47	20.30	20.74	20.00	20.12
	19.32	20.29	20.66	20.53	21.90
	18.78	20.09	20.76	20.39	20.64
$\overline{x}$	19.19	20.23	20.72	20.31	20.89
s	0.36	0.12	0.05	0.27	0.92
$s/\overline{x}$(%)	1.9	0.6	0.3	1.4	4.4

[1] Dynamometer adjustments based on straight track coastdown times.
[2] Fuel Economy results corrected for density variations due to temperature.

Table C-2

Pinto Fuel Economy Data

	Track Results (mpg)	Coupled Roll Dynamometer Results (mpg)		Uncoupled Roll Dynamometer Results (mpg)	
		Volumetric	Carbon Balance	Volumetric	Carbon Balance
	FTP	FTP	FTP	FTP	FTP
	16.86	18.23	19.76	18.53	19.40
	17.00	18.14	18.82	18.53	19.36
	17.25	18.17	19.50	18.30	19.64
$\overline{x}$	17.04	18.18	19.36	18.45	19.46
s	0.20	0.05	0.49	0.13	0.15
$s/\overline{x}$(%)	1.2	0.3	2.5	0.7	0.8
	HFET	HFET	HFET	HFET	HFET
	23.73	25.76	27.26	26.75	27.70
	23.26	25.50	26.06	26.72	27.62
	23.60	25.98	27.20	26.56	27.48
$\overline{x}$	23.53	25.75	26.84	26.68	27.60
s	0.24	0.24	0.68	0.10	0.11
$s/\overline{x}$(%)	1.1	0.9	2.5	0.4	0.4

Table C-3

Ford F-100 Data

	Track Results (mpg)	Coupled Roll Dynamometer Results (mpg)		Uncoupled Roll Dynamometer Results (mpg)	
		Volumetric	Carbon Balance	Volumetric	Carbon Balance
	FTP	FTP	FTP	FTP	FTP
	14.44	15.16	15.62	15.57	15.92
	14.76	15.15	15.24	15.84	15.96
	14.65	15.17	14.90	15.62	15.68
$\bar{x}$	14.62	15.16	15.25	15.68	15.85
s	0.16	0.01	0.36	0.14	0.15
$s/\bar{x}$(%)	1.1	0.1	2.4	0.9	1.0
	HFET	HFET	HFET	HFET	HFET
	18.23	20.52	20.24	21.48	21.63
	18.61	20.50	20.76	21.68	21.16
	18.58	20.51	20.26	20.63	21.08
$\bar{x}$	18.47	20.51	20.42	21.60	21.29
s	0.21	0.01	0.29	0.10	0.30
$s/\bar{x}$(%)	1.1	0.05	1.4	0.5	1.4

Table C-4

Citation Fuel Economy Data

	Track Results (mpg)	Coupled Roll Dynamometer Results (mpg)		Uncoupled Roll Dynamometer Results (mpg)	
		Volumetric	Carbon Balance	Volumetric	Carbon Balance
	FTP	FTP	FTP	FTP	FTP
	18.24	18.68	18.82	18.99	19.52
	18.72	18.82	19.00	18.78	19.24
	18.58	18.96	19.02	18.65	18.82
	18.50	18.86	18.90	18.77	18.82
	18.37	18.30	18.32	19.21	19.56
	19.22	19.21	19.18	18.51	18.88
	19.27	19.49	19.48	18.80	18.70
	19.23	19.39	19.40	18.99	19.10
	19.30	19.43	19.42	18.75	18.94
$\bar{x}$	18.83	19.02	19.06	18.83	19.06
s	0.43	0.40	0.37	0.21	0.31
$s/\bar{x}$(%)	2.3	2.1	1.9	1.1	1.7
	HFET	HFET	HFET	HFET	HFET
	26.43	28.28	27.70	29.32	27.90
	26.09	28.48	28.02	28.93	29.24
	26.87	28.18	27.74	29.60	29.24
	26.29	28.72	27.94	30.10	29.34
	25.77	29.03	28.44	29.78	29.14
	27.32	28.65	27.60	29.40	28.82
	26.55	29.28	29.34	29.08	28.62
	27.25	29.19	28.26	29.17	28.44
	27.76	29.30	28.82	29.48	28.96
$\bar{x}$	26.70	28.79	28.21	29.43	28.75
s	0.65	0.43	0.58	0.36	0.48
$s/\bar{x}$(%)	2.4	1.5	2.1	1.2	1.7

Table C-5

Escort Fuel Economy Data

	Track Results (mpg)	Coupled Roll Dynamometer Results (mpg)		Uncoupled Roll Dynamometer Results (mpg)	
		Volumetric	Carbon Balance	Volumetric	Carbon Balance
	FTP	FTP	FTP	FTP	FTP
	23.43	23.78	23.74	24.56	24.46
	23.45	23.93	24.04	24.64	24.96
	23.12	24.63	24.86	24.74	25.02
$\bar{x}$	23.33	24.11	24.21	24.65	24.81
s	0.19	0.45	0.58	0.09	0.31
$s/\bar{x}$(%)	0.8	1.9	2.4	0.4	1.2
	HFET	HFET	HFET	HFET	HFET
	35.50	39.01	38.24	40.50	39.76
	33.08	40.13	39.54	39.91	39.44
	34.85	40.65	39.84	41.30	40.70
$\bar{x}$	34.48	39.93	39.21	40.57	39.97
s	1.25	0.84	0.85	0.70	0.65
$s/\bar{x}$(%)	3.6	2.1	2.2	1.7	1.6

Table C-6
Horizon Fuel Economy Data

	Track Results (mpg)[2]	Coupled Roll Dynamometer Results (mpg)[1]		Uncoupled Roll Dynamometer Results (mpg)[1]	
		Volumetric	Carbon Balance	Volumetric	Carbon Balance
	FTP	FTP	FTP	FTP	FTP
	21.75	21.37	22.58	21.57	23.08
	18.17	21.82	23.20	22.64	23.42
	22.40			22.49	23.76
$\bar{x}$	20.77	21.60	22.89	22.22	23.42
s	2.28	0.32	0.44	0.57	0.34
$s/\bar{x}$(%)	10.9	1.5	1.9	2.6	1.5
	HFET	HFET	HFET	HFET	HFET
	31.03	33.34	33.16	33.46	33.54
	28.01	33.50	33.16	34.10	33.86
	31.50	32.27	32.80	34.06	34.06
$\bar{x}$	30.18	33.04	33.04	33.87	33.82
s	1.89	0.67	0.21	0.36	0.26
$s/\bar{x}$(%)	6.3	2.0	0.6	1.1	0.8

	Coupled Roll Dynamometer Results (mpg)[2]		Uncoupled Roll Dynamometer Results (mpg)[2]	
	Volumetric	Carbon Balance	Volumetric	Carbon Balance
	FTP	FTP	FTP	FTP
	21.31	22.38	21.64	23.26
	21.66	22.96	21.57	23.44
	20.98	22.42	21.92	22.96
$\bar{x}$	21.32	22.59	21.71	23.22
s	0.34	0.32	0.19	0.24
$s/\bar{x}$(%)	1.6	1.4	0.9	1.0
	HFET	HFET	HFET	HFET
	32.68	32.50	33.46	33.28
	33.26	32.98	33.39	33.42
	32.72	32.68	32.49	32.62
$\bar{x}$	32.89	32.72	33.11	33.11
s	0.32	0.24	0.54	0.43
$s/\bar{x}$(%)	1.0	0.7	1.6	1.3

[1] Dynamometer adjusted using straight track coastdown times.
[2] Dynamometer adjusted using curved track coastdown times.

Table C-7

Concord Fuel Economy Data

	Track Results mpg)	Coupled Roll Dynamometer Results (mpg)		Uncoupled Roll Dynamometer Results (mpg)	
		Volumetric	Carbon Balance	Volumetric	Carbon Balance
	FTP	FTP	FTP	FTP	FTP
	18.25	19.17	18.84	18.39	19.24
	18.27	18.37	18.82	18.83	19.54
	18.20	18.27	18.84	18.72	19.30
$\overline{x}$	18.24	18.60	18.83	18.65	19.36
s	0.04	0.49	0.01	0.23	0.16
$s/\overline{x}$(%)	0.2	2.7	0.1	1.2	0.8
	HFET	HFET	HFET	HFET	HFET
	27.93	28.65	28.52	29.64	29.78
	27.94	28.70	28.86	29.15	29.38
	28.37	28.55	29.10	29.19	29.00
$\overline{x}$	28.08	28.63	28.83	29.33	29.38
s	0.25	0.08	0.29	0.27	0.39
$s/\overline{x}$(%)	0.9	0.3	1.0	0.9	1.3

Table C-8

Civic Fuel Economy Data

	Track Results (mpg)[2]	Coupled Roll Dynamometer Results (mpg)[1]		Uncoupled Roll Dynamometer Results (mpg)[1]	
		Volumetric	Carbon Balance	Volumetric	Carbon Balance
	FTP	FTP	FTP	FTP	FTP
	32.30	35.06	36.02	36.86	38.02
	34.51	34.54	35.82	36.48	37.72
	33.17	32.50	33.98	36.51	37.90
$\bar{x}$	33.33	34.03	35.27	36.62	37.88
s	1.11	1.35	1.12	0.21	0.15
s/$\bar{x}$(%)	3.3	4.0	3.2	0.6	0.4
	HFET	HFET	HFET	HFET	HFET
	43.72	44.07	44.86	48.34	48.66
	43.45	43.61	43.82	48.36	48.88
	43.39	40.97	41.56	48.43	49.04
$\bar{x}$	43.52	42.88	43.41	48.38	48.86
s	0.18	1.67	1.69	0.05	0.19
s/$\bar{x}$(%)	0.4	3.9	3.9	0.1	0.4

	Coupled Roll Dynamometer Results (mpg)[2]		Uncoupled Roll Dynamometer Results (mpg)[2]	
	Volumetric	Carbon Balance	Volumetric	Carbon Balance
	FTP	FTP	FTP	FTP
		36.26	36.30	37.48
	34.83	36.00	33.58	34.78
	34.18	35.40	33.77	35.18
$\bar{x}$	34.51	35.89	34.55	35.81
s	0.46	0.44	1.52	1.46
s/$\bar{x}$(%)	1.3	1.2	4.4	4.1
	HFET	HFET	HFET	HFET
	44.11	44.34	47.69	48.76
	44.19	43.92	45.57	46.40
	44.98	45.60	45.94	46.32
$\bar{x}$	44.43	44.62	46.40	47.16
s	0.48	0.87	1.13	1.39
s/$\bar{x}$(%)	1.1	2.0	2.4	2.9

[1] Dynamometer adjusted using straight track coastdown times.
[2] Dynamometer adjusted using curved track coastdown times.

Table D-1

Oldsmobile Cutlass Data

Track Results - Volumetric Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.560	12.25	0.0816	3.896	13.81	0.0724	3.540	15.32	0.0653
	3.539	12.21	0.0819	3.789	13.56	0.0738	3.520	15.41	0.0649
	3.563	12.08	0.0828	3.887	13.34	0.0749	3.560	14.84	0.0674

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.996	13.85	0.0722	10.139	19.04	0.0525		10.217	19.47	0.0514
	10.848	13.73	0.0728	10.214	19.08	0.0524		10.205	19.32	0.0518
	11.010	13.45	0.0743	10.202	18.42	0.0543		10.196	18.78	0.0521
$\bar{x}$	10.951	13.68	0.0731				$\bar{x}$	10.206	19.19	0.0521
s	0.080	0.21	0.0011				s	0.011	0.36	0.0009
$s/\bar{x}$(%)	0.8	1.5	1.5				$s/\bar{x}$(%)	0.1	1.9	1.8

[1] Actual distance.
[2] Fuel economy.
[3] Fuel consumption.

Table D-2

Oldsmobile Cutlass Data

Dynamometer Results - Rolls Uncoupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.544	13.26	0.0754	3.806	13.72	0.0729	3.536	15.46	0.0647
	3.566	13.56	0.0737	3.834	14.72	0.0679	3.558	16.78	0.0596
	3.584	13.10	0.0763	3.862	14.14	0.0707	3.562	16.40	0.0610

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.886	14.05	0.0712	10.142	20.00	0.0500		10.122	20.12	0.0497
	10.958	14.96	0.0669	10.202	21.40	0.0467		10.188	21.90	0.0457
	11.008	14.45	0.0692	10.216	20.46	0.0489		10.220	20.64	0.0484
$\bar{x}$	10.950	14.49	0.0691				$\bar{x}$	10.177	20.89	0.0479
s	0.061	0.46	0.0022				s	0.050	0.92	0.0020
$s/\bar{x}$(%)	0.6	3.2	3.1				$s/\bar{x}$(%)	0.5	4.4	4.3

Table D-3

Oldsmobile Cutlass Data

Dynamometer Results - Rolls Uncoupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	12.65	0.0790	14.09	0.0710	15.73	0.0636
	12.18	0.0821	13.95	0.0717	15.85	0.0631
	12.22	0.0819	13.86	0.0721	15.71	0.0637

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	14.25	0.0702	20.04	0.0499		20.00	0.0500
	14.05	0.0712	20.07	0.0498		20.53	0.0487
	13.97	0.0716	20.02	0.0500		20.39	0.0490
$\bar{x}$	14.09	0.0710			$\bar{x}$	20.31	0.0492
s	0.14	0.0007			s	0.27	0.0007
$s/\bar{x}$(%)	1.0	1.0			$s/\bar{x}$(%)	1.4	1.4

Table D-4

Oldsmobile Cutlass Data

Dynamometer Results - Rolls Coupled, Carbon Balance Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.534	13.28	0.0753	3.806	14.04	0.0712	3.554	16.62	0.0602
3.540	13.52	0.0740	3.812	14.08	0.0710	3.548	16.58	0.0603
3.548	13.42	0.0745	3.808	14.20	0.0704	3.558	16.70	0.0599

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.896	14.50	0.0690	10.176	20.90	0.0478		10.170	20.76	0.0482
	10.900	14.56	0.0687	10.182	20.64	0.0484		10.164	20.74	0.0482
	10.914	14.62	0.0684	10.184	20.06	0.0416		10.162	20.66	0.0484
$\bar{x}$	10.903	14.56	0.0687				$\bar{x}$	10.165	20.72	0.0483
s	0.010	0.06	0.0003				s	0.004	0.05	0.0001
$s/\bar{x}$(%)	0.1	0.4	0.4				$s/\bar{x}$(%)	0.04	0.3	0.2

Table D-5

Oldsmobile Cutlass Data

Dynamometer Results - Rolls Coupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	12.63	0.0791	13.84	0.0722	15.50	0.0645
	12.63	0.0792	13.82	0.0724	15.62	0.0640
	12.47	0.0802	13.68	0.0731	15.53	0.0644

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	14.03	0.0713	19.85	0.0504		20.30	0.0493
	14.03	0.0713	19.87	0.0503		20.29	0.0493
	13.89	0.0720				20.09	0.0498
$\bar{x}$	13.98	0.0715			$\bar{x}$	20.23	0.0495
s	0.08	0.0004			s	0.12	0.0003
$s/\bar{x}$(%)	0.6	0.6			$s/\bar{x}$(%)	0.6	0.6

Table D-6

Ford Pinto Data

Track Results - Volumetric Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.593	13.27	0.0701	3.834	17.45	0.0573	3.582	17.95	0.0557
3.546	13.86	0.0721	3.810	17.20	0.0581	3.520	18.23	0.0548
3.508	14.60	0.0685	3.794	17.37	0.0576	3.509	19.02	0.0526

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	11.009	16.86	0.0593	10.203	22.81	0.0438		10.147	23.73	0.0421
	10.876	17.00	0.0588	10.099	22.81	0.0438		10.063	23.26	0.0430
	10.811	17.25	0.0580	10.143	23.73	0.0421		10.089	23.60	0.0424
$\bar{x}$	10.899	17.04	0.0587				$\bar{x}$	10.100	23.53	0.0425
s	0.101	0.20	0.0007				s	0.043	0.24	0.0005
$s/\bar{x}$(%)	0.9	1.2	1.1				$s/\bar{x}$(%)	0.4	1.1	1.1

Table D-7

Ford Pinto Data

Dynamometer Results - Rolls Uncoupled Carbon Balance Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.556	17.34	0.0577	3.848	20.10	0.0498	3.572	22.02	0.0454
3.568	17.04	0.0587	3.864	19.24	0.0520	3.570	21.88	0.0457
3.572	17.40	0.0575	3.868	19.82	0.0505	3.584	21.38	0.0468

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.976	19.64	0.0509	10.214	--	--		10.204	27.70	0.0361
	11.002	19.36	0.0517	10.212	26.64	0.0375		10.212	27.62	0.0362
	11.024	19.40	0.0515	10.232	26.90	0.0372		10.234	27.48	0.0364
$\bar{x}$	11.000	19.46	0.0514				$\bar{x}$	10.217	27.60	0.0362
s	0.024	0.15	0.0004				s	0.016	0.11	0.0002
$s/\bar{x}$(%)	0.2	0.8	0.8				$s/\bar{x}$(%)	0.2	0.4	0.4

Table D-8

Ford Pinto Data

Dynamometer Results - Rolls Uncoupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	15.77	0.0634	18.77	0.0533	19.32	0.0518
	15.67	0.0638	18.45	0.0542	20.23	0.0494
	15.70	0.0637	18.86	0.0530	20.29	0.0493

	FTP Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	18.53	0.0540	26.05	0.0384		26.75	0.0374
	18.53	0.0540	25.60	0.0391		26.72	0.0374
	18.30	0.0547	25.77	0.0388		26.56	0.0376
$\bar{x}$	18.45	0.0542			$\bar{x}$	26.68	0.0375
s	0.13	0.0004			s	0.10	0.0001
$s/\bar{x}$(%)	0.7	0.7			$s/\bar{x}$(%)	0.4	0.3

Table D-9

Ford Pinto Data

Dynamometer Results - Rolls Coupled, Carbon Balance Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.550	17.34	0.0577	3.812	19.66	0.0509	3.536	22.34	0.0448
3.554	16.42	0.0609	3.826	18.92	0.0529	3.536	20.92	0.0478
3.538	16.84	0.1188	3.814	19.88	0.0503	3.538	21.30	0.0469

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.898	19.76	0.0506	10.154	26.44	0.0378		10.136	27.26	0.0367
	10.916	18.82	0.0531	10.176	25.50	0.0392		10.158	26.06	0.0384
	10.890	19.50	0.0513	10.156	26.80	0.0373		10.156	27.20	0.0368
$\bar{x}$	10.901	19.36	0.0517				$\bar{x}$	10.150	26.84	0.0373
s	0.013	0.49	0.0013				s	0.012	0.68	0.0010
$s/\bar{x}$(%)	0.1	2.5	2.5				$s/\bar{x}$(%)	0.1	2.5	2.6

Table D-10

Ford Pinto Data

Dynamometer Results - Rolls Coupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	15.04	0.0665	18.76	0.0533	19.99	0.0500
	15.08	0.0663	18.06	0.0554	19.52	0.0512
	14.96	0.0668	18.58	0.0538	20.05	0.0499

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	18.23	0.0548	25.27	0.0396		25.76	0.0388
	18.14	0.0551	24.52	0.0408		25.50	0.0392
	18.17	0.0550	25.35	0.0394		25.98	0.0385
$\bar{x}$	18.18	0.0550			$\bar{x}$	25.75	0.0388
s	0.05	0.0002			s	0.24	0.0004
$s/\bar{x}$(%)	0.3	0.3			$s/\bar{x}$(%)	0.9	0.9

Table D-11

Ford Pickup Data

Track Results - Volumetric Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.678	12.47	0.0802	4.017	14.93	0.0670	3.678	15.19	0.0658
	3.682	13.45	0.0743	4.022	14.91	0.0671	3.711	15.54	0.0643
	3.657	13.10	0.0763	3.999	14.83	0.0674	3.697	15.58	0.0642

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	11.373	14.44	0.0692	10.526	17.73	0.0564		10.530	18.23	0.0548
	11.415	14.76	0.0678	10.645	19.30	0.0518		10.616	18.61	0.0537
	11.353	14.65	0.0683	10.613	18.44	0.0542		10.578	18.58	0.0538
$\bar{x}$	11.374	14.62	0.0684				$\bar{x}$	10.575	18.47	0.0541
s	0.036	0.16	0.0007				s	0.043	0.21	0.0006
$s/\bar{x}$(%)	0.3	1.1	1.1				$s/\bar{x}$(%)	0.4	1.1	1.1

Table D-12

Ford Pickup Data

Dynamometer Results - Rolls Uncoupled, Carbon Balance Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.546	14.26	0.0701	3.794	16.08	0.0622	3.534	17.08	0.0585
3.552	14.62	0.0684	3.820	16.14	0.0620	3.540	17.34	0.0577
3.534	14.02	0.0713	3.790	16.06	0.0623	3.540	17.30	0.0578

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.874	15.92	0.0628	10.124	20.93	0.0478		10.104	21.63	0.0462
	10.912	15.96	0.0627	10.130	20.88	0.0479		10.124	21.16	0.0473
	10.864	15.68	0.0638	10.138	20.74	0.0484		10.116	21.08	0.0474
$\bar{x}$	10.883	15.85	0.0631				$\bar{x}$	10.115	21.29	0.0470
s	0.025	0.15	0.0006				s	0.010	0.30	0.0007
$s/\bar{x}$(%)	0.2	1.0	1.0				$s/\bar{x}$(%)	0.1	1.4	1.4

Table D-13

Ford Pickup Data

Dynamometer Results - Rolls Uncoupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	13.88	0.0720	15.78	0.0634	16.60	0.0602
	14.04	0.0712	16.05	0.0623	16.99	0.0589
	13.58	0.0737	15.90	0.0629	16.84	0.0594

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	15.57	0.0642	20.79	0.0481		21.48	0.0466
	15.84	0.0631	20.98	0.0477		21.68	0.0461
	15.62	0.0640	20.87	0.0479		21.63	0.0462
$\bar{x}$	15.68	0.0638			$\bar{x}$	21.60	0.0463
s	0.14	0.0006			s	0.10	0.0003
$s/\bar{x}$(%)	0.9	0.9			$s/\bar{x}$(%)	0.5	0.6

Table D-14

Ford Pickup Data

Dynamometer Results - Rolls Coupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.536	13.62	0.0734	3.806	16.04	0.0623	3.546	16.62	0.0602
	3.558	13.26	0.0754	3.812	15.80	0.0633	3.542	16.00	0.0625
	3.540	13.08	0.0765	3.784	15.80	0.0633	3.530	16.18	0.0618

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.888	15.62	0.0640	10.142	19.68	0.0508		10.130	20.24	0.0494
	10.912	15.24	0.0656	10.128	19.80	0.0505		10.128	20.76	0.0482
	10.854	14.90	0.0671	10.124	19.96	0.0501		10.108	20.26	0.0494
$\bar{x}$	10.885	15.25	0.0656				$\bar{x}$	10.122	20.42	0.0490
s	0.029	0.36	0.002				s	0.012	0.29	0.0001
$s/\bar{x}$(%)	0.3	2.4	2.4				$s/\bar{x}$(%)	0.1	1.4	1.4

Table D-15

Ford Pickup Data

Dynamometer Results - Rolls Coupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	13.16	0.0760	15.51	0.0645	16.19	0.0618
	12.98	0.0771	15.62	0.0640	16.09	0.0622
	12.74	0.0785	15.52	0.0644	16.25	0.0615

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	15.16	0.0660	19.83	0.0504		20.52	0.0487
	15.15	0.0660	19.82	0.0505		20.50	0.0488
	15.17	0.0659	19.42	0.0515		20.51	0.0488
$\bar{x}$	15.16	0.0660			$\bar{x}$	20.51	0.0488
s	0.01	0.0001			s	0.01	0.0001
$s/\bar{x}$(%)	0.1	0.1			$s/\bar{x}$(%)	0.05	0.1

Table D-16

Chevrolet Citation Data

Track Results - Volumetric Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.541	16.00	0.0625	3.843	18.08	0.0553	3.554	20.51	0.0488
3.585	16.39	0.0610	3.904	18.64	0.0536	3.576	20.88	0.0479
3.589	16.03	0.0624	3.934	18.51	0.0540	3.608	20.91	0.0478
3.551	15.78	0.0634	3.866	18.51	0.0540	3.573	20.87	0.0479
3.643	16.15	0.0619	3.977	18.29	0.0547	3.632	20.43	0.0489
3.642	16.14	0.0620	4.016	19.50	0.0513	3.579	21.34	0.0469
3.636	17.61	0.0568	3.983	19.06	0.0525	3.617	21.09	0.0474
3.542	17.66	0.0566	3.859	18.80	0.0532	3.548	21.43	0.0467
3.557	17.55	0.0570	3.859	18.83	0.0531	3.558	21.77	0.0459

	FTP-Composite			Warm-Up HFET			HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	10.938	18.24	0.0548	10.217	25/80	0.0388	10.198	26.43	0.0378
	11.065	18/72	0.0534	10.289	25.65	0.0390	10.220	26.09	0.0383
	11.131	18.58	0.0538	10.314	26.43	0.0378	10.282	26.87	0.0372
	10.990	18.50	0.0540	10.236	25.95	0.0385	10.191	26.29	0.0380
	11.252	18.37	0.0544	10.396	25.39	0.0394	10.340	25.77	0.0388
	11.237	19.22	0.0520	10.300	27.00	0.0370	10.325	27.32	0.0366
	11.236	19.27	0.0519	10.372	26.31	0.0380	10.501	26.55	0.0377
	10.949	19.23	0.0520	10.241	26.74	0.0374	10.211	27.25	0.0367
	10.947	19.30	0.0518				10.218	27.76	0.0360
$\bar{x}$	11.083	18.83	0.0531				10.276	26.70	0.0375
s	0.134	0.43	0.0012				0.101	0.65	0.0009
$s/\bar{x}$(%)	1.2	2.3	2.3				1.0	2.4	2.4

Table D-17

Chevrolet Citation Data

Dynamometer Results - Rolls Uncoupled, Carbon Balance Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.542	17.76	0.0563	3.818	18.98	0.0527	3.546	22.40	0.0446
3.542	17.44	0.0573	3.826	18.80	0.0532	3.546	21.92	0.0456
3.542	16.96	0.0590	3.808	18.22	0.0549	3.544	22.00	0.0455
3.558	15.70	0.0637	3.808	18.66	0.0536	5.542	22.52	0.0444
3.550	17.38	0.0575	3.800	19.16	0.0522	3.542	22.60	0.0442
3.518	17.52	0.0571	3.762	18.08	0.0553	3.552	22.00	0.0455
3.530	17.46	0.0573	3.786	17.74	0.0564	3.532	22.06	0.0453
3.530	17.56	0.0569	3.792	18.48	0.0541	3.522	21.92	0.0456
3.538	17.58	0.0569	3.776	18.00	0.0556	3.538	22.44	0.0446

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.906	19.52	0.0512	10.162	28.20	0.0355		10.166	28.30	0.0353
	10.914	19.24	0.0520	10.190	28.12	0.0356		10.210	27.90	0.0358
	10.900	18.82	0.0531	10.156	28.36	0.0353		10.156	29.24	0.0342
	10.908	18.82	0.0531	10.154	28.80	0.0347		10.144	29.34	0.0341
	10.892	19.56	0.0511	10.146	28.90	0.0346		10.142	29.14	0.0343
	10.832	18.88	0.0530	10.088	28.36	0.0353		10.098	28.82	0.0347
	10.848	18.70	0.0535	10.132	27.90	0.0358		10.090	28.62	0.0349
	10.844	19.10	0.0524	10.092	28.34	0.0353		10.094	28.44	0.0352
	10.852	18.94	0.0528	10.118	28.26	0.0354		10.104	28.96	0.0345
$\bar{x}$	10.877	19.06	0.0525				$\bar{x}$	10.134	28.75	0.0348
s	0.033	0.31	0.0009				s	0.041	0.48	0.0006
$s/\bar{x}$(%)	0.3	1.7	1.7				$s/\bar{x}$(%)	0.4	1.7	1.7

Table D-18

Chevrolet Citation Data

Dynamometer Results - Rolls Uncoupled, Volumetric Measurements

Bag 1		Bag 2		Bag 3	
FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
16.17	0.0618	18.86	0.0530	21.74	0.0460
16.17	0.0618	18.51	0.0540	21.63	0.0462
15.98	0.0626	18.41	0.0543	21.47	0.0466
14.84	0.0674	19.00	0.0526	21.92	0.0456
16.28	0.0614	18.93	0.0528	22.42	0.0446
16.26	0.0615	18.45	0.0542	20.57	0.0486
16.42	0.0609	18.38	0.0544	21.86	0.0457
16.47	0.0607	18.65	0.0536	21.89	0.0457
16.44	0.0608	18.12	0.0552	22.13	0.0452

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	18.99	0.0527	28.14	0.0355		29.32	0.0341
	18.78	0.0532	28.03	0.0357		28.93	0.0346
	18.65	0.0536	28.20	0.0355		29.60	0.0338
	18.77	0.0533	28.76	0.0348		30.10	0.0332
	19.21	0.0520	28.70	0.0348		29.78	0.0336
	18.51	0.0540	28.25	0.0354		29.40	0.0340
	18.80	0.0532	28.25	0.0354		29.08	0.0344
	18.99	0.0527	28.39	0.0352		29.17	0.0343
	18.75	0.0533	28.50	0.0351		29.48	0.0339
$\bar{x}$	18.83	0.0531			$\bar{x}$	29.43	0.0340
s	0.21	0.0006			s	0.36	0.0004
$s/\bar{x}$(%)	1.1	1.1			$s/\bar{x}$(%)	1.2	1.2

Table D-19

Chevrolet Citation Data

Dynamometer Results - Rolls Coupled, Carbon Balance Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.526	17.18	0.0582	3.788	18.32	0.0546	3.534	21.42	0.0467
3.536	17.74	0.0564	3.796	17.96	0.0557	3.528	22.62	0.0442
3.546	17.92	0.0558	3.792	18.30	0.0546	3.530	21.70	0.0461
3.538	17.56	0.0569	3.810	18.20	0.0549	3.538	21.70	0.0461
3.530	14.86	0.0673	3.792	18.38	0.0544	3.532	21.98	0.0455
3.536	18.04	0.0554	3.800	18.52	0.0540	3.540	21.60	0.0463
3.540	18.12	0.0552	3.780	18.76	0.0533	3.518	22.42	0.0446
3.528	18.40	0.0543	3.792	18.46	0.0542	3.532	22.52	0.0444
3.532	18.34	0.0545	3.792	18.46	0.0542	3.532	22.74	0.0440

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.848	18.82	0.0531	10.130	27.50	0.0364		10.132	27.70	0.0361
	10.860	19.00	0.0526	10.122	27.72	0.0361		10.098	28.02	0.0357
	10.868	19.02	0.0526	10.128	27.46	0.0364		10.102	27.74	0.0360
	10.886	18.90	0.0529	10.114	28.02	0.0357		10.108	17.94	0.0358
	10.854	18.32	0.0546	10.124	28.12	0.0356		10.090	28.44	0.0352
	10.854	19.18	0.0521	10.122	27.88	0.0359		10.104	27.60	0.0262
	10.838	19.48	0.0513	10.090	28.44	0.0352		10.094	29.34	0.0341
	10.852	19.40	0.0515	10.112	28.34	0.0353		10.118	28.26	0.0354
	10.856	19.42	0.0515	10.100	28.62	0.0349		10.100	28.82	0.0247
$\bar{x}$	10.857	19.06	0.0525				$\bar{x}$	10.105	28.21	0.0355
s	0.014	0.37	0.0010				s	0.105	0.58	0.0007
$s/\bar{x}$(%)	0.1	1.9	1.9				$s/\bar{x}$(%)	0.1	2.1	2.0

Table D-20

Chevrolet Citation Data

Dynamometer Results - Rolls Coupled, Volumetric Measurements

Bag 1		Bag 2		Bag 3	
FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
16.46	0.0608	18.26	0.0548	21.51	0.0465
16.93	0.0591	18.22	0.0549	21.72	0.0460
17.01	0.0588	18.52	0.0540	21.57	0.0464
16.58	0.0603	18.43	0.0543	21.74	0.0460
14.01	0.0714	18.58	0.0538	21.75	0.0460
17.16	0.0583	18.87	0.0530	21.68	0.0461
17.29	0.0578	19.06	0.0525	22.31	0.0448
17.28	0.0579	18.91	0.0529	22.24	0.0450
17.45	0.0573	18.84	0.0531	22.37	0.0447

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	18.68	0.0535	27.69	0.0361		28.28	0.0354
	18.82	0.0531	27.80	0.0360		28.48	0.0351
	18.96	0.0527	27.43	0.0365		28.18	0.0355
	18.86	0.0530	28.15	0.0355		28.72	0.0348
	18.30	0.0547	28.22	0.0354		29.03	0.0345
	19.21	0.0520	27.94	0.0358		28.65	0.0349
	19.49	0.0513	28.50	0.0351		29.28	0.0341
	10.39	0.0516	28.60	0.0350		29.19	0.0343
	19.43	0.0515	28.72	0.0348		29.30	0.0341
$\bar{x}$	19.02	0.0526			$\bar{x}$	28.79	0.0347
s	0.40	0.0011	—		s	0.43	0.0005
$s/\bar{x}$(%)	2.1	2.1			$s/\bar{x}$(%)	1.5	1.5

Table D-21

Ford Escort Data

Track Results - Volumetric Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.593	21.17	0.0472	3.947	22.95	0.0436	3.600	26.39	0.0379
3.555	21.13	0.0473	3.898	22.81	0.0438	3.587	26.80	0.0373
3.563	20.25	0.0494	3.926	22.71	0.0440	3.580	26.49	0.0378

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	11.140	23.43	0.0427	10.246	34.91	0.0286		10.232	35.50	0.0282
	11.040	23.45	0.0426	10.262	34.22	0.0292		10.233	33.08	0.0302
	11.069	23.12	0.0433	10.289	34.05	0.0294		10.191	34.85	0.0287
$\bar{x}$	11.083	23.33	0.0429				$\bar{x}$	10.219	34.48	0.0290
s	0.051	0.19	0.0004				s	0.024	1.25	0.0010
$s/\bar{x}$(%)	0.5	0.8	0.8				$s/\bar{x}$(%)	0.2	3.6	3.6

Table D-22

Ford Escort Data

Dynamometer Results - Rolls Uncoupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.512	22.68	0.0441	3.800	23.24	0.0430	3.524	29.08	0.0344
	3.606	22.92	0.0436	3.886	24.18	0.0414	3.598	28.60	0.0350
	3.618	23.02	0.0434	3.866	23.92	0.0418	3.602	29.40	0.0340

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.836	24.46	0.0409	10.082	38.92	0.0257		10.080	39.76	0.0252
	11.090	24.96	0.0401	10.328	38.76	0.0258		10.310	39.44	0.0254
	11.086	25.02	0.0400	10.324	40.44	0.0247		10.306	40.70	0.0246
$\bar{x}$	11.004	24.81	0.0403				$\bar{x}$	10.232	39.97	0.0251
s	0.146	0.31	0.0005				s	0.132	0.65	0.0004
$s/\bar{x}$(%)	1.3	1.2	1.2				$s/\bar{x}$(%)	1.3	1.6	1.6

Table D-23

Ford Escort Data

Dynamometer Results - Rolls Uncoupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	21.01	0.0476	23.90	0.0418	29.17	0.0343
	21.66	0.0462	24.07	0.0415	28.44	0.0352
	21.65	0.0462	23.96	0.0417	29.14	0.0343

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	24.56	0.0407	39.23	0.0255		40.50	0.0247
	24.64	0.0406	38.92	0.0257		39.91	0.0251
	24.74	0.0404	40.77	0.0245		41.30	0.0242
$\bar{x}$	24.65	0.0406			$\bar{x}$	40.57	0.0247
s	0.09	0.0002			s	0.70	0.0005
$s/\bar{x}$(%)	0.4	0.4			$s/\bar{x}$(%)	1.7	1.7

Table D-24

Ford Escort Data

Dynamometer Results - Rolls Coupled, Carbon Balance Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.512	22.62	0.0442	3.802	22.60	0.0442	3.518	27.30	0.0366
3.520	23.38	0.0447	3.796	22.76	0.0439	3.534	28.68	0.0349
3.532	23.44	0.0427	2.798	23.62	0.0423	3.528	29.10	0.0344

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.832	23.74	0.0421	10.098	37.74	0.0265		10.128	38.24	0.0262
	10.852	24.04	0.0416	10.132	38.62	0.0259		10.122	39.54	0.0253
	10.858	24.86	0.0402	10.100	40.08	0.0250		10.112	39.84	0.0251
$\bar{x}$	10.847	24.21	0.0413				$\bar{x}$	10.121	39.21	0.0255
s	0.014	0.58	0.0010				s	0.008	0.85	0.0006
$s/\bar{x}$(%)	0.1	2.4	2.4				$s/\bar{x}$(%)	0.08	2.2	2.2

Table D-25

Ford Escort Data

Dynamometer Results - Rolls Coupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	21.40	0.0467	23.06	0.0434	27.35	0.0366
	21.03	0.0475	23.07	0.0434	28.38	0.0352
	22.03	0.0454	23.79	0.0420	28.71	0.0348

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	23.78	0.0421	37.65	0.0266		39.01	0.0256
	23.93	0.0418	38.88	0.0257		40.13	0.0249
	24.63	0.0406	40.04	0.0250		40.65	0.0246
$\bar{x}$	24.11	0.0415			$\bar{x}$	39.93	0.0250
s	0.45	0.0008			s	0.84	0.0005
$s/\bar{x}$(%)	1.9	1.9			$s/\bar{x}$(%)	2.1	2.1

Table D-26

Plymouth Horizon Data

Track Results - Volumetric Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.527	16.59	0.0603	3.709	22.97	0.0435	3.613	24.20	0.0413
3.641	14.73	0.0679	4.059	18.77	0.0533	3.574	20.03	0.0499
3.575	19.16	0.0522	3.908	23.22	0.0431	3.575	23.60	0.0424

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.849	21.75	0.0460	10.316	30.32	0.0330		10.281	31.03	0.0322
	11.274	18.17	0.0550	10.136	26.94	0.0371		10.121	28.01	0.0357
	11.058	22.40	0.0446	10.259	30.29	0.0330		10.252	31.50	0.0317
$\bar{x}$	11.060	20.77	0.0485				$\bar{x}$	10.218	30.18	0.0332
s	0.213	2.28	0.0056				s	0.085	1.89	0.0022
$s/\bar{x}$(%)	1.9	10.9	11.6				$s/\bar{x}$(%)	0.8	6.3	6.4

Table D-27

Plymouth Horizon Data

Dynamometer Results - Rolls Uncoupled, Carbon Balance Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.526	19.90	0.0503	3.792	23.12	0.0433	3.556	26.16	0.0382
3.562	20.14	0.0497	3.854	23.56	0.0424	3.556	26.36	0.0379
3.544	21.20	0.0472	3.802	23.56	0.0424	3.536	26.56	0.0377

	FTP-Composite			Warm-Up HFET			HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	10.874	23.08	0.0433	10.174	32.42	0.0308	10.156	33.54	0.0298
	10.972	23.42	0.0427	10.186	33.34	0.0300	10.170	33.86	0.0295
	10.882	23.76	0.0421	10.200	33.22	0.0301	10.174	34.06	0.0294
$\bar{x}$	10.909	23.42	0.0427				10.167	33.82	0.0296
s	0.054	0.34	0.0006				0.010	0.26	0.0002
$s/\bar{x}$(%)	0.5	1.5	1.4				0.1	0.8	0.7

Table D-28

Plymouth Horizon Data [1]

Dynamometer Results - Rolls Uncoupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.564	19.98	0.0501	3.824	23.36	0.0428	3.580	26.24	0.0381
	3.582	20.00	0.0500	3.840	23.70	0.0422	3.554	26.32	0.0380
	3.550	19.52	0.0512	3.828	23.12	0.0433	3.564	25.99	0.0385

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.991	23.26	0.0430	10.188	32.72	0.0306		10.150	33.28	0.0300
	10.976	23.44	0.0427	10.168	33.02	0.0303		10.174	33.42	0.0299
	10.942	22.96	0.0436	10.200	32.18	0.0311		10.164	32.62	0.0307
$\bar{x}$	10.970	23.22	0.0431				$\bar{x}$	10.162	33.11	0.0302
s	0.025	0.24	0.0005				s	0.012	0.43	0.0004
$s/\bar{x}$(%)	0.2	1.0	1.1				$s/\bar{x}$(%)	0.1	1.3	1.4

[1] Dynamometer adjusted using curved track coastdown times.

Table D-29

Plymouth Horizon Data

Dynamometer Results - Rolls Uncoupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	16.38	0.0610	23.03	0.0434	23.62	0.0423
	15.88	0.0630	24.49	0.0408	25.69	0.0389
	17.25	0.0580	23.27	0.0430	25.82	0.0387

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	21.57	0.0464	31.26	0.0320		33.46	0.0299
	22.64	0.0442	31.63	0.0316		34.10	0.0293
	22.49	0.0445	31.86	0.0314		34.06	0.0294
$\bar{x}$	22.22	0.0450			$\bar{x}$	33.87	0.0295
s	0.57	0.0012			s	0.36	0.0003
$s/\bar{x}$(%)	2.6	2.7			$s/\bar{x}$(%)	1.1	1.1

Table D-30

Plymouth Horizon Data [1]

Dynamometer Results - Rolls Uncoupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	16.69	0.0599	22.45	0.0445	24.56	0.0407
	16.34	0.0612	22.34	0.0448	25.54	0.0392
	15.93	0.0628	23.10	0.0433	25.37	0.0394

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	21.64	0.0462	31.56	0.0317		33.46	0.0299
	21.57	0.0464	31.26	0.0320		33.39	0.0299
	21.92	0.0456	30.70	0.0326		32.49	0.0308
$\bar{x}$	21.71	0.0461			$\bar{x}$	33.11	0.0302
s	0.19	0.0004			s	0.54	0.0005
$s/\bar{x}$(%)	0.9	0.9			$s/\bar{x}$(%)	1.6	1.7

[1] Dynamometer adjusted using curved track coastdown times.

Table D-31

Plymouth Horizon Data

Dynamometer Results - Rolls Coupled, Carbon Balance Measurements [1]

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.524	19.24	0.0520	3.844	22.66	0.0441	3.554	25.82	0.0387
3.548	20.68	0.0484	3.808	22.98	0.0435	3.544	25.96	0.0385

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.922	22.58	0.0443	10.172	32.66	0.0306		10.142	33.16	0.0302
	10.900	23.20	0.0431	10.166	32.72	0.0306		10.148	33.16	0.0302
	10.852	-----	------	10.172	31.82	0.0314		10.154	32.80	0.0305
$\bar{x}$	10.891	22.89	0.0437				$\bar{x}$	10.148	33.04	0.0303
s	0.036	0.44	0.0008				s	0.006	0.21	0.0002
$s/\bar{x}$(%)	0.3	1.9	1.9				$s/\bar{x}$(%)	0.1	0.6	0.6

[1] Third FTP test voided.

Table D-32

Plymouth Horizon Data [1]

Dynamometer Results - Rolls Coupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.530	19.24	0.0520	3.770	22.32	0.0448	3.546	25.50	0.0391
	3.540	20.16	0.0496	3.806	22.90	0.0437	3.556	25.72	0.0389
	3.552	19.24	0.0520	3.822	22.32	0.0448	3.550	25.80	0.0388

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.846	22.38	0.0447	10.166	32.12	0.0311		10.148	32.50	0.0308
	10.902	22.96	0.0436	10.200	32.64	0.0306		10.144	32.98	0.0303
	10.924	22.42	0.0446	10.186	32.64	0.0306		10.160	32.68	0.0306
$\bar{x}$	10.891	22.59	0.0443				$\bar{x}$	10.151	32.72	0.0306
s	0.040	0.32	0.0006				s	0.008	0.24	0.0003
$s/\bar{x}$(%)	0.4	1.4	1.4				$s/\bar{x}$(%)	0.1	0.7	0.8

[1] Dynamometer adjusted using curved track coastdown times.

Table D-33

Plymouth Horizon Data

Dynamometer Results - Rolls Coupled, Volumetric Measurements [1]

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	16.05	0.0623	22.80	0.0439	23.60	0.0424
	16.75	0.0597	23.00	0.0435	24.23	0.0413
					24.84	0.0403

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	21.37	0.0468	31.29	0.0320		33.34	0.0300
	21.82	0.0458	31.19	0.0321		33.50	0.0299
	-----	------	30.53	0.0328		32.27	0.0310
$\bar{x}$	21.60	0.0463			$\bar{x}$	33.04	0.0303
s	0.32	0.0007			s	0.67	0.0006
$s/\bar{x}$(%)	1.5	1.5			$s/\bar{x}$(%)	2.0	2.1

[1] Third FTP test voided.

Table D-34

Plymouth Horizon Data [1]

Dynamometer Results - Rolls Coupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	15.95	0.0627	22.07	0.0453	24.84	0.0403
	16.93	0.0590	22.75	0.0439	23.86	0.0419
	15.79	0.0633	22.05	0.0454	23.77	0.0421

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	21.31	0.0469	30.76	0.0325		32.68	0.0306
	21.66	0.0462	30.98	0.0323		33.26	0.0301
	20.98	0.0477	30.98	0.0323		32.72	0.0306
$\bar{x}$	21.32	0.0469			$\bar{x}$	32.89	0.0304
s	0.34	0.0008			s	0.32	0.0003
$s/\bar{x}$(%)	1.6	1.6			$s/\bar{x}$(%)	1.0	1.0

[1] Dynamometer adjusted using curved track coastdown times.

Table D-35

AMC Concord Data

Track Results - Volumetric Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.576	15.88	0.0630	3.974	18.43	0.0543	3.581	19.89	0.0503
	3.574	15.77	0.0634	3.929	18.37	0.0544	3.601	20.21	0.0495
	3.562	16.05	0.0623	3.942	18.64	0.0537	3.578	19.12	0.0523

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	11.131	18.25	0.0548	10.265	26.20	0.0382		10.274	27.93	0.0358
	11.104	18.27	0.0547	10.296	27.11	0.0369		10.272	27.94	0.0358
	11.082	18.20	0.0550	10.219	27.27	0.0367		10.128	28.37	0.0352
$\bar{x}$	11.106	18.24	0.0548				$\bar{x}$	10.225	28.08	0.0356
s	0.025	0.04	0.0002				s	0.084	0.25	0.0003
$s/\bar{x}$(%)	0.2	0.2	0.3				$s/\bar{x}$(%)	0.8	0.9	1.0

Table D-36

AMC Concord Data

Dynamometer Results - Rolls Uncoupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.568	17.62	0.0568	3.828	18.86	0.0530	3.576	21.54	0.0464
	3.574	18.40	0.0543	3.860	19.08	0.0524	3.574	21.54	0.0464
	3.588	18.02	0.0555	3.834	18.80	0.0532	3.576	21.52	0.0465

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.972	19.24	0.0520	10.190	29.14	0.0343		10.182	29.78	0.0336
	11.006	19.54	0.0512	10.228	29.12	0.0343		10.202	29.38	0.0340
	10.998	19.30	0.0518	10.216	29.12	0.0343		10.190	29.00	0.0345
$\bar{x}$	11.001	19.36	0.0517				$\bar{x}$	10.191	29.38	0.0340
s	0.005	0.16	0.0004				s	0.010	0.39	0.0005
$s/\bar{x}$(%)	0.04	0.8	0.8				$s/\bar{x}$(%)	0.1	1.3	1.3

Table D-37

AMC Concord Data

Dynamometer Results - Rolls Uncoupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	16.31	0.0613	18.49	0.0541	19.92	0.0502
	17.19	0.0582	18.56	0.0539	20.73	0.0482
	16.55	0.0604	18.56	0.0539	20.88	0.0479

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	18.39	0.0544	27.76	0.0360		29.64	0.0337
	18.83	0.0531	28.64	0.0349		29.15	0.0343
	18.72	0.0534	28.44	0.0352		29.19	0.0343
$\bar{x}$	18.65	0.0536			$\bar{x}$	29.33	0.0341
s	0.23	0.0007			s	0.27	0.0003
$s/\bar{x}$(%)	1.2	1.3			$s/\bar{x}$(%)	0.9	1.0

Table D-38

AMC Concord Data

Dynamometer Results - Rolls Coupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.570	17.74	0.0564	3.830	18.38	0.0544	3.538	20.82	0.0480
	3.598	17.70	0.0565	3.816	18.44	0.0542	3.568	20.66	0.0484
	3.586	17.48	0.0572	3.818	18.32	0.0546	3.552	21.24	0.0471

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.938	18.84	0.0531	10.180	28.48	0.0351		10.182	28.52	0.0351
	10.982	18.82	0.0531	10.184	28.56	0.0350		10.174	28.86	0.0347
	10.956	18.84	0.0531	10.192	28.64	0.0349		10.198	29.10	0.0344
$\bar{x}$	10.959	18.83	0.0531				$\bar{x}$	10.185	28.83	0.0347
s	0.022	0.01	0.0000				s	0.012	0.29	0.0004
$s/\bar{x}$(%)	0.2	0.1	0.0				$s/\bar{x}$(%)	0.1	1.0	1.0

Table D-39

AMC Concord Data

Dynamometer Results - Rolls Coupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	20.14	0.0496	18.24	0.0548	20.38	0.0491
	16.42	0.0609	18.32	0.0546	20.11	0.0497
	16.28	0.0614	17.98	0.0556	20.57	0.0486

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	19.17	0.0522	27.64	0.0362		28.65	0.0349
	18.37	0.0544	27.04	0.0370		28.70	0.0348
	18.27	0.0547	26.98	0.0371		28.55	0.0350
$\bar{x}$	18.60	0.0538			$\bar{x}$	28.63	0.0349
s	0.49	0.0014			s	0.08	0.0001
$s/\bar{x}$(%)	2.7	2.5			$s/\bar{x}$(%)	0.3	0.3

Table D-40

Honda Civic Data

Track Results - Volumetric Measurements

Bag 1			Bag 2			Bag 3		
AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
3.512	29.65	0.0337	3.929	32.64	0.0306	3.506	33.78	0.0296
3.521	30.51	0.0328	3.791	36.20	0.0276	3.519	34.74	0.0288
3.469	29.85	0.0335	3.732	34.31	0.0291	3.487	33.78	0.0296

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.947	32.30	0.0310	9.608	39.08	0.0256		9.884	43.72	0.0229
	10.831	34.51	0.0290	10.154	41.01	0.0244		10.145	43.45	0.0230
	10.688	33.17	0.0301	10.142	40.89	0.0245		10.089	43.39	0.0230
$\bar{x}$	10.822	33.33	0.0300				$\bar{x}$	10.039	43.52	0.0230
s	0.130	1.11	0.0010				s	0.137	0.18	0.0001
$s/\bar{x}$(%)	1.2	3.3	3.3				$s/\bar{x}$(%)	1.4	0.4	0.3

Table D-41

Honda Civic Data

Dynamometer Results - Rolls Uncoupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.578	35.38	0.0283	3.816	38.38	0.0261	3.530	39.76	0.0252
	3.574	35.32	0.0283	3.834	37.94	0.0264	3.530	37.44	0.0267
	3.584	35.52	0.0282	3.858	38.02	0.0263	3.552	39.70	0.0252

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.924	38.02	0.0263	10.120	46.16	0.0217		10.122	48.66	0.0206
	10.938	37.72	0.0265	10.168	46.54	0.0215		10.166	48.88	0.0205
	10.994	37.90	0.0264	10.182	46.66	0.0214		10.208	49.04	0.0204
$\bar{x}$	10.952	37.88	0.0264				$\bar{x}$	10.165	48.86	0.0205
s	0.037	0.15	0.0001				s	0.043	0.19	0.0001
$s/\bar{x}$(%)	0.3	0.4	0.4				$s/\bar{x}$(%)	0.4	0.4	0.5

Table D-42

Honda Civic Data[1]

Dynamometer Results - Rolls Uncoupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.576	35.60	0.0281	3.816	37.44	0.0267	3.538	39.10	0.0256
	3.556	31.94	0.0313	3.806	34.46	0.0290	3.550	37.82	0.0264
	3.546	32.86	0.0304	3.816	34.78	0.0288	3.522	38.10	0.0262

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.930	37.48	0.0267	10.160	46.76	0.0214		10.198	48.76	0.0205
	10.912	34.78	0.0288	10.176	44.40	0.0225		10.144	46.40	0.0216
	10.884	35.18	0.0284	10.138	45.34	0.0221		10.146	46.32	0.0216
$\bar{x}$	10.909	35.81	0.0280				$\bar{x}$	10.163	47.16	0.0212
s	0.023	1.46	0.0011				s	0.031	1.39	0.0006
$s/\bar{x}$(%)	0.2	4.1	4.0				$s/\bar{x}$(%)	0.3	2.9	3.0

[1] Dynamometer adjusted using curved track coastdown times.

Table D-43

Honda Civic Data

Dynamometer Results - Rolls Uncoupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	33.68	0.0297	37.58	0.0266	38.07	0.0263
	33.23	0.0301	37.50	0.0267	37.22	0.0269
	33.50	0.0299	37.22	0.0269	37.59	0.0266

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	36.86	0.0271	44.77	0.0223		48.34	0.0207
	36.48	0.0274	45.10	0.0222		48.36	0.0207
	36.51	0.0274	45.10	0.0222		48.43	0.0206
$\bar{x}$	36.62	0.0273			$\bar{x}$	48.38	0.0207
s	0.21	0.0002			s	0.05	0.0001
$s/\bar{x}$(%)	0.6	0.6			$s/\bar{x}$(%)	0.1	0.3

Table D-44

Honda Civic Data[1]

Dynamometer Results - Rolls Uncoupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	33.48	0.0299	36.65	0.0273	37.90	0.0264
	30.42	0.0329	33.62	0.0297	36.12	0.0277
	30.74	0.0325	33.86	0.0295	36.09	0.0277

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	36.30	0.0276	45.27	0.0221		47.69	0.0210
	33.58	0.0298	43.07	0.0232		45.57	0.0219
	33.77	0.0296	43.93	0.0228		45.94	0.0218
$\bar{x}$	34.55	0.0290			$\bar{x}$	46.40	0.0216
s	1.52	0.0012			s	1.13	0.0005
$s/\bar{x}$(%)	4.4	4.2			$s/\bar{x}$(%)	2.4	2.3

[1] Dynamometer adjusted using curved track coastdown times.

Table D-45

Honda Civic Data

Dynamometer Results - Rolls Coupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.556	33.60	0.0298	3.840	36.26	0.0276	3.542	37.78	0.0265
	3.460	33.48	0.0299	3.836	36.18	0.0276	3.554	37.06	0.0270
	3.564	32.06	0.0312	3.782	33.70	0.0297	3.538	36.26	0.0276

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.938	36.02	0.0278	10.124	42.92	0.0233		10.120	44.86	0.0223
	10.850	35.82	0.0279	10.124	42.20	0.0237		10.126	43.82	0.0228
	10.884	33.98	0.0294	10.152	40.74	0.0245		10.114	41.56	0.0241
$\bar{x}$	10.891	35.27	0.0284				$\bar{x}$	10.120	43.41	0.0231
s	0.044	1.12	0.0009				s	0.006	1.69	0.0009
$s/\bar{x}$(%)	0.4	3.2	3.2				$s/\bar{x}$(%)	0.1	3.9	4.0

Table D-46

Honda Civic Data[1]

Dynamometer Results - Rolls Coupled, Carbon Balance Measurements

	Bag 1			Bag 2			Bag 3		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)
	3.556	33.74	0.0296	3.820	36.34	0.0275	3.536	38.32	0.0261
	3.556	33.44	0.0299	3.816	36.34	0.0275	3.554	37.50	0.0267
	3.560	31.62	0.0316	3.824	36.00	0.0278	3.564	37.70	0.0265

	FTP-Composite			Warm-Up HFET				HFET		
	AD(mi)	FE(mpg)	FC(gpm)	AD(mi)	FE(mpg)	FC(gpm)		AD(mi)	FE(mpg)	FC(gpm)
	10.912	36.26	0.0276	10.150	42.28	0.0237		10.138	44.34	0.0226
	10.916	36.00	0.0278	10.130	42.48	0.0235		10.146	43.92	0.0228
	10.948	35.40	0.0282	10.152	42.26	0.0237		10.050	45.60	0.0219
$\bar{x}$	10.925	35.89	0.0279				$\bar{x}$	10.111	44.62	0.0224
s	0.020	0.44	0.0003				s	0.053	0.87	0.0005
$s/\bar{x}$(%)	0.2	1.2	1.1				$s/\bar{x}$(%)	0.5	2.0	2.1

[1] Dynamometer adjusted using curved track coastdown times.

Table D-47

Honda Civic Data

Dynamometer Results - Rolls Coupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	31.66	0.0316	35.55	0.0281	36.72	0.0272
	30.65	0.0326	35.48	0.0282	35.92	0.0278
	29.85	0.0335	32.53	0.0307	34.60	0.0289

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
	35.06	0.0285	41.48	0.0241		44.07	0.0227
	34.54	0.0290	41.28	0.0242		43.61	0.0229
	32.50	0.0308	39.75	0.0252		40.97	0.0244
$\bar{x}$	34.03	0.0294			$\bar{x}$	42.88	0.0233
s	1.35	0.0012			s	1.67	0.0009
$s/\bar{x}$(%)	4.0	4.1			$s/\bar{x}$(%)	3.9	4.0

Table D-48

Honda Civic Data[1]

Dynamometer Results - Rolls Coupled, Volumetric Measurements

	Bag 1		Bag 2		Bag 3	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)
	31.88	0.0314			36.54	0.0274
	31.52	0.0317	35.50	0.0282	36.27	0.0276
	29.77	0.0336	35.39	0.0283	35.61	0.0281

	FTP-Composite		Warm-Up HFET			HFET	
	FE(mpg)	FC(gpm)	FE(mpg)	FC(gpm)		FE(mpg)	FC(gpm)
			41.05	0.0224		44.11	0.0227
	34.83	0.0287	41.72	0.0240		44.19	0.0226
	34.18	0.0293	41.05	0.0244		44.98	0.0222
$\bar{x}$	34.51	0.0290			$\bar{x}$	44.43	0.0225
s	0.46	0.0004			s	0.48	0.0003
$s/\bar{x}$(%)	1.3	1.5			$s/\bar{x}$(%)	1.1	1.2

[1] Dynamometer adjusted using curved track coastdown times.

Table E-1

Coastdown Data

Vehicle: Oldsmobile Cutlass

Coastdown Type: Track-straight

Test Date: 10-22-80

Tire Pressure (psi): 26/26

Ambient Temp (°F): 60

Barometer (in Hg): 29.79

Test Weight (lbm): 3974

Drive Axle Wt. (lbm): 1702

Driving Rotating Equivalent (lbm): 72

Non-Driving Rotating Equivalent (lbm): 68

Total Weight (test wt. + rotating equivalent, lbm): 4113

Uncorrected Data

Coastdown Time (sec): 15.31

F_o (lbf): 45.1

F_2 (lbf-sec^2/ft^2): 0.0145

Corrected Data

Coastdown Time (sec): 15.97

F_o (lbf): 43.3

F_2 (lbf-sec^2/ft^2): 0.0139

Dynamometer Corrected Results

Mass Correction (lbm): 4072 (4000 + 72)

Dynamometer Coastdown Time (sec): 15.81

Table E-2

Coastdown Data

Vehicle Oldsmobile Cutlass

Coastdown Type Track-curved

Test Date 10-22-80

Tire Pressure (psi) 26/26

Ambient Temp (°F) 59

Barometer (in Hg) 29.80

Test Weight (lbm) 3953

Drive Axle Wt. (lbm) 1686

Driving Rotating Equivalent (lbm) 71

Non-Driving Rotating Equivalent (lbm) 67

Total Weight (test wt. + rotating equivalent, lbm) 4091

Uncorrected Data

Coastdown Time (sec) 14.74

F_o (lbf) 44.4

F_2 (lbf-sec^2/ft^2) 0.0152

Corrected Data

Coastdown Time (sec) 15.41

F_o (lbf) 44.0

F_2 (lbf-sec^2/ft^2) 0.0144

Dynamometer Corrected Results

Mass Correction (lbm) 4071 (4000 + 71)

Dynamometer Coastdown Time (sec) 15.34

Table E-3

Coastdown Data

Vehicle Oldsmobile Cutlass

Coastdown Type Dyno-straight, coupled

Test Date 3-9-81

Tire Pressure (psi) 45

Ambient Temp (°F) 68

Barometer (in Hg) 29.00

Test Weight (lbm) 4000 (3959)

Drive Axle Wt. (lbm) 1669

Driving Rotating Equivalent (lbm) 71

Non-Driving Rotating Equivalent (lbm) --

Total Weight (test wt. + rotating equivalent, lbm) 4071

Uncorrected Data

Coastdown Time (sec) 16.23

F_0 (lbf) 44.5

F_2 (lbf-sec^2/ft^2) 0.0131

Corrected Data

Coastdown Time (sec) 16.23

F_0 (lbf) 44.5

F_2 (lbf-sec^2/ft^2) 0.0131

Dynamometer Corrected Results

Mass Correction (lbm) 4071

Dynamometer Coastdown Time (sec) 16.23

Table E-4

Coastdown Data

Vehicle: Oldsmobile Cutlass

Coastdown Type: Dyno-straight, uncoupled

Test Date: 3-9-81

Tire Pressure (psi): 45

Ambient Temp (°F): 68

Barometer (in Hg): 29.00

Test Weight (lbm): 4000 (3959)

Drive Axle Wt. (lbm): 1669

Driving Rotating Equivalent (lbm): 71

Non-Driving Rotating Equivalent (lbm): --

Total Weight (test wt. + rotating equivalent, lbm): 4071

Uncorrected Data

Coastdown Time (sec): 16.34

F_o (lbf): 40.0

F_2 ($lbf\text{-}sec^2/ft^2$): 0.0138

Corrected Data

Coastdown Time (sec): 16.34

F_o (lbf): 40.0

F_2 ($lbf\text{-}sec^2/ft^2$): 0.0138

Dynamometer Corrected Results

Mass Correction (lbm): 4071

Dynamometer Coastdown Time (sec): 16.34

Table E-5

Coastdown Data

Vehicle Ford Pinto

Coastdown Type Track-straight

Test Date 10-19-80

Tire Pressure (psi) 24/24

Ambient Temp (°F) 56

Barometer (in Hg) 30.05

Test Weight (lbm) 3091

Drive Axle Wt. (lbm) 1341

Driving Rotating Equivalent (lbm) 56

Non-Driving Rotating Equivalent (lbm) 53

Total Weight (test wt. + rotating equivalent, lbm) 3200

Uncorrected Data

Coastdown Time (sec) 11.65

F_o (lbf) 59.3

F_2 (lbf-sec^2/ft^2) 0.0123

Corrected Data

Coastdown Time (sec) 12.33

F_o (lbf) 56.0

F_2 (lbf-sec^2/ft^2) 0.0116

Dynamometer Corrected Results

Mass Correction (lbm) 3056 (3000 + 56)

Dynamometer Coastdown Time (sec) 11.78

Table E-6

Coastdown Data

Vehicle Ford Pinto

Coastdown Type Track-curved

Test Date 11-19-80

Tire Pressure (psi) 24/24

Ambient Temp (°F) 50

Barometer (in Hg) 30.04

Test Weight (lbm) 3084

Drive Axle Wt. (lbm) 1338

Driving Rotating Equivalent (lbm) 56

Non-Driving Rotating Equivalent (lbm) 52

Total Weight (test wt. + rotating equivalent, lbm) 3192

Uncorrected Data

Coastdown Time (sec) 11.22

F_o (lbf) 59.7

F_2 (lbf-sec^2/ft^2) 0.0131

Corrected Data

Coastdown Time (sec) 12.12

F_o (lbf) 53.9

F_2 (lbf-sec^2/ft^2) 0.0124

Dynamometer Corrected Results

Mass Correction (lbm) 3056 (3000 + 56)

Dynamometer Coastdown Time (sec) 11.60

Table E-7

Coastdown Data

Vehicle: Ford Pinto

Coastdown Type: Dyno-straight, coupled

Test Date: 3-10-81

Tire Pressure (psi): 45

Ambient Temp (°F): 68

Barometer (in Hg): 29.00

Test Weight (lbm): 3000 (3091)

Drive Axle Wt. (lbm): 1294

Driving Rotating Equivalent (lbm): 56

Non-Driving Rotating Equivalent (lbm): --

Total Weight (test wt. + rotating equivalent, lbm): 3056

Uncorrected Data

Coastdown Time (sec): 11.32

F_o (lbf): 44.7

F_2 ($lbf\text{-}sec^2/ft^2$): 0.0136

Corrected Data

Coastdown Time (sec): 11.32

F_o (lbf): 44.7

F_2 ($lbf\text{-}sec^2/ft^2$): 0.0136

Dynamometer Corrected Results

Mass Correction (lbm): 3056

Dynamometer Coastdown Time (sec): 11.32

Table E-8

Coastdown Data

Vehicle Ford Pinto

Coastdown Type Dyno-straight, uncoupled

Test Date 3-10-81

Tire Pressure (psi) 45

Ambient Temp (°F) 68

Barometer (in Hg) 29.00

Test Weight (lbm) 3000 (3091)

Drive Axle Wt. (lbm) 1294

Driving Rotating Equivalent (lbm) 56

Non-Driving Rotating Equivalent (lbm) --

Total Weight (test wt. + rotating equivalent, lbm) 3056

Uncorrected Data

Coastdown Time (sec) 12.06

F_o (lbf) 38.4

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0134

Corrected Data

Coastdown Time (sec) 12.06

F_o (lbf) 38.4

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0134

Dynamometer Corrected Results

Mass Correction (lbm) 3056

Dynamometer Coastdown Time (sec) 12.06

Table E-9

Coastdown Data

Vehicle: Ford F-100

Coastdown Type: Track-straight

Test Date: 5-25-81

Tire Pressure (psi): 35/35

Ambient Temp (°F): 78

Barometer (in Hg): 29.62

Test Weight (lbm): 4153

Drive Axle Wt. (lbm): 1707

Driving Rotating Equivalent (lbm): 75

Non-Driving Rotating Equivalent (lbm): 71

Total Weight (test wt. + rotating equivalent, lbm): 4299

Uncorrected Data

Coastdown Time (sec): 12.56

F_o (lbf): 48.7

F_2 ($lbf\text{-}sec^2/ft^2$): 0.0201

Corrected Data

Coastdown Time (sec): 12.53

F_o (lbf): 49.7

F_2 ($lbf\text{-}sec^2/ft^2$): 0.0200

Dynamometer Corrected Results

Mass Correction (lbm): 4325 (4250 + 75)

Dynamometer Coastdown Time (sec): 12.61

Table E-10

Coastdown Data

Vehicle Ford F-100

Coastdown Type Track-curved

Test Date 6-18-81

Tire Pressure (psi) 35/35

Ambient Temp (°F) 79

Barometer (in Hg) 29.70

Test Weight (lbm) 4171

Drive Axle Wt. (lbm) 1726

Driving Rotating Equivalent (lbm) 75

Non-Driving Rotating Equivalent (lbm) 71

Total Weight (test wt. + rotating equivalent, lbm) 4317

Uncorrected Data

Coastdown Time (sec) 12.41

F_o (lbf) 55.0

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0194

Corrected Data

Coastdown Time (sec) 12.22

F_o (lbf) 57.8

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0193

Dynamometer Corrected Results

Mass Correction (lbm) 4325 (4250 + 75)

Dynamometer Coastdown Time (sec) 12.24

Table E-11

Coastdown Data

Vehicle Ford F-100

Coastdown Type Dyno-straight, coupled

Test Date 8-13-81

Tire Pressure (psi) 45

Ambient Temp (°F) 68

Barometer (in Hg) 29.00

Test Weight (lbm) 4250 (4214)

Drive Axle Wt. (lbm) 1735

Driving Rotating Equivalent (lbm) 76

Non-Driving Rotating Equivalent (lbm) --

Total Weight (test wt. + rotating equivalent, lbm) 4326

Uncorrected Data

Coastdown Time (sec) 13.10

F_o (lbf) 47.7

F_2 (lbf-sec^2/ft^2) 0.0190

Corrected Data

Coastdown Time (sec) 13.10

F_o (lbf) 47.7

F_2 (lbf-sec^2/ft^2) 0.0190

Dynamometer Corrected Results

Mass Correction (lbm) 4326

Dynamometer Coastdown Time (sec) 13.10

Table E-16

Coastdown Data

Vehicle Chevrolet Citation

Coastdown Type Dyno-straight, uncoupled

Test Date 6-11-82

Tire Pressure (psi) 45

Ambient Temp (°F) 68

Barometer (in Hg) 29.00

Test Weight (lbm) 3000 (3105)

Drive Axle Wt. (lbm) 2009

Driving Rotating Equivalent (lbm) 56

Non-Driving Rotating Equivalent (lbm) --

Total Weight (test wt. + rotating equivalent, lbm) 3056

Uncorrected Data

Coastdown Time (sec) 13.28

F_o (lbf) 35.8

F_2 (lbf-sec^2/ft^2) 0.0129

Corrected Data

Coastdown Time (sec) 3056

F_o (lbf) 35.8

F_2 (lbf-sec^2/ft^2) 0.0129

Dynamometer Corrected Results

Mass Correction (lbm) 3056

Dynamometer Coastdown Time (sec) 13.28

Table E-12

Coastdown Data

Vehicle Ford F-100

Coastdown Type Dyno-straight, uncoupled

Test Date 7-27-81

Tire Pressure (psi) 45

Ambient Temp (°F) 68

Barometer (in Hg) 29.00

Test Weight (lbm) 4250 (4175)

Drive Axle Wt. (lbm) 1732

Driving Rotating Equivalent (lbm) 75

Non-Driving Rotating Equivalent (lbm) --

Total Weight (test wt. + rotating equivalent, lbm) 4325

Uncorrected Data

Coastdown Time (sec) 13.05

F_o (lbf) 47.6

F_2 (lbf-sec^2/ft^2) 0.0194

Corrected Data

Coastdown Time (sec) 13.05

F_o (lbf) 47.6

F_2 (lbf-sec^2/ft^2) 0.0194

Dynamometer Corrected Results

Mass Correction (lbm) 4325

Dynamometer Coastdown Time (sec) 13.05

Table E-13

Coastdown Data

Vehicle Chevrolet Citation

Coastdown Type Track-straight

Test Date 10-16-81

Tire Pressure (psi) 26/26

Ambient Temp (°F) 87

Barometer (in Hg) 29.69

Test Weight (lbm) 3108

Drive Axle Wt. (lbm) 1989

Driving Rotating Equivalent (lbm) 56

Non-Driving Rotating Equivalent (lbm) 53

Total Weight (test wt. + rotating equivalent, lbm) 3217

Uncorrected Data

Coastdown Time (sec) 15.16

F_o (lbf) 32.2

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0121

Corrected Data

Coastdown Time (sec) 14.63

F_o (lbf) 34.9

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0122

Dynamometer Corrected Results

Mass Correction (lbm) 3056 (3000 + 56)

Dynamometer Coastdown Time (sec) 13.90

Table E-14

Coastdown Data

Vehicle Chevrolet Citation

Coastdown Type Track-curved

Test Date 2-11-82

Tire Pressure (psi) 26/26

Ambient Temp (°F) 59

Barometer (in Hg) 29.86

Test Weight (lbm) 3113

Drive Axle Wt. (lbm) 1978

Driving Rotating Equivalent (lbm) 56

Non-Driving Rotating Equivalent (lbm) 53

Total Weight (test wt. + rotating equivalent, lbm) 3222

Uncorrected Data

Coastdown Time (sec) 13.81

F_o (lbf) 36.6

F_2 (lbf-sec^2/ft^2) 0.0130

Corrected Data

Coastdown Time (sec) 14.54

F_o (lbf) 36.3

F_2 (lbf-sec^2/ft^2) 0.0121

Dynamometer Corrected Results

Mass Correction (lbm) 3056 (3000 + 56)

Dynamometer Coastdown Time (sec) 13.79

Table E-15

Coastdown Data

Vehicle: Chevrolet Citation

Coastdown Type: Dyno-straight, coupled

Test Date: 5-31-82

Tire Pressure (psi): 45

Ambient Temp (°F): 68

Barometer (in Hg): 29.00

Test Weight (lbm): 3000 (3101)

Drive Axle Wt. (lbm): 2005

Driving Rotating Equivalent (lbm): 56

Non-Driving Rotating Equivalent (lbm): --

Total Weight (test wt. + rotating equivalent, lbm): 3056

Uncorrected Data

Coastdown Time (sec): 13.29

F_o (lbf): 41.5

F_2 ($lbf\text{-}sec^2/ft^2$): 0.0118

Corrected Data

Coastdown Time (sec): 13.29

F_o (lbf): 41.5

F_2 ($lbf\text{-}sec^2/ft^2$): 0.0118

Dynamometer Corrected Results

Mass Correction (lbm): 3056

Dynamometer Coastdown Time (sec): 13.29

Table E-17

Coastdown Data

Vehicle: Ford Escort

Coastdown Type: Track-straight

Test Date: 4-26-82

Tire Pressure (psi): 35/35

Ambient Temp (°F): 80

Barometer (in Hg): 29.73

Test Weight (lbm): 2434

Drive Axle Wt. (lbm): 1444

Driving Rotating Equivalent (lbm): 44

Non-Driving Rotating Equivalent (lbm): 41

Total Weight (test wt. + rotating equivalent, lbm): 2519

Uncorrected Data

Coastdown Time (sec): 13.50

F_o (lbf): 25.0

F_2 ($lbf\text{-}sec^2/ft^2$): 0.0112

Corrected Data

Coastdown Time (sec): 13.74

F_o (lbf): 25.7

F_2 ($lbf\text{-}sec^2/ft^2$): 0.0108

Dynamometer Corrected Results

Mass Correction (lbm): 2544 (2500 + 44)

Dynamometer Coastdown Time (sec): 13.87

Table E-18

Coastdown Data

Vehicle Ford Escort

Coastdown Type Track-curved

Test Date 4-1-82

Tire Pressure (psi) 35/35

Ambient Temp (°F) 76

Barometer (in Hg) 29.81

Test Weight (lbm) 2428

Drive Axle Wt. (lbm) 1433

Driving Rotating Equivalent (lbm) 44

Non-Driving Rotating Equivalent (lbm) 41

Total Weight (test wt. + rotating equivalent, lbm) 2513

Uncorrected Data

Coastdown Time (sec) 13.19

F_o (lbf) 27.8

F_2 (lbf-sec^2/ft^2) 0.0110

Corrected Data

Coastdown Time (sec) 13.16

F_o (lbf) 28.8

F_2 (lbf-sec^2/ft^2) 0.0109

Dynamometer Corrected Results

Mass Correction (lbm) 2544 (2500 + 44)

Dynamometer Coastdown Time (sec) 13.32

Table E-19

Coastdown Data

Vehicle: Ford Escort

Coastdown Type: Dyno-straight, coupled

Test Date: 6-1-82

Tire Pressure (psi): 45

Ambient Temp (°F): 68

Barometer (in Hg): 29.00

Test Weight (lbm): 2500 (2422)

Drive Axle Wt. (lbm): 1462

Driving Rotating Equivalent (lbm): 44

Non-Driving Rotating Equivalent (lbm): --

Total Weight (test wt. + rotating equivalent, lbm): 2544

Uncorrected Data

Coastdown Time (sec): 12.98

F_o (lbf): 38.9

F_2 (lbf-sec^2/ft^2): 0.0094

Corrected Data

Coastdown Time (sec): 12.98

F_o (lbf): 38.9

F_2 (lbf-sec^2/ft^2): 0.0094

Dynamometer Corrected Results

Mass Correction (lbm): 2544

Dynamometer Coastdown Time (sec): 12.98

Table E-20

Coastdown Data

Vehicle	Ford Escort
Coastdown Type	Dyno-straight, uncoupled
Test Date	6-11-82
Tire Pressure (psi)	45
Ambient Temp (°F)	68
Barometer (in Hg)	29.00
Test Weight (lbm)	2500 (2422)
Drive Axle Wt. (lbm)	1453
Driving Rotating Equivalent (lbm)	44
Non-Driving Rotating Equivalent (lbm)	--
Total Weight (test wt. + rotating equivalent, lbm)	2544

Uncorrected Data

Coastdown Time (sec)	14.15
F_o (lbf)	33.1
F_2 (lbf-sec^2/ft^2)	0.0091

Corrected Data

Coastdown Time (sec)	14.15
F_o (lbf)	33.1
F_2 (lbf-sec^2/ft^2)	0.0091

Dynamometer Corrected Results

Mass Correction (lbm)	2544
Dynamometer Coastdown Time (sec)	14.15

Table E-21

Coastdown Data

Vehicle Plymouth Horizon

Coastdown Type Track-straight

Test Date 7-23-82

Tire Pressure (psi) 35/35

Ambient Temp (°F) 86

Barometer (in Hg) 29.80

Test Weight (lbm) 2695

Drive Axle Wt. (lbm) 1690

Driving Rotating Equivalent (lbm) 49

Non-Driving Rotating Equivalent (lbm) 46

Total Weight (test wt. + rotating equivalent, lbm) 2789

Uncorrected Data

Coastdown Time (sec) 13.99

F_o (lbf) 35.1

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0104

Corrected Data

Coastdown Time (sec) 13.48

F_o (lbf) 37.8

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0106

Dynamometer Corrected Results

Mass Correction (lbm) 2789 (2750 + 49)

Dynamometer Coastdown Time (sec) 13.52

Table E-22

Coastdown Data

Vehicle Plymouth Horizon

Coastdown Type Track-curved

Test Date 7-27-82

Tire Pressure (psi) 35/35

Ambient Temp (°F) 86

Barometer (in Hg) 29.84

Test Weight (lbm) 2708

Drive Axle Wt. (lbm) 1686

Driving Rotating Equivalent (lbm) 49

Non-Driving Rotating Equivalent (lbm) 46

Total Weight (test wt. + rotating equivalent, lbm) 2803

Uncorrected Data

Coastdown Time (sec) 13.46

F_o (lbf) 29.3

F_2 (lbf-sec^2/ft^2) 0.0123

Corrected Data

Coastdown Time (sec) 13.43

F_o (lbf) 29.2

F_2 (lbf-sec^2/ft^2) 0.0123

Dynamometer Corrected Results

Mass Correction (lbm) 2799

Dynamometer Coastdown Time (sec) 13.41

Table E-23

Coastdown Data

Vehicle Plymouth Horizon

Coastdown Type Dyno-straight, coupled

Test Date 8-20-82

Tire Pressure (psi) 45

Ambient Temp (°F) 68

Barometer (in Hg) 29.00

Test Weight (lbm) 2750 (2689)

Drive Axle Wt. (lbm) 1701

Driving Rotating Equivalent (lbm) 48

Non-Driving Rotating Equivalent (lbm) --

Total Weight (test wt. + rotating equivalent, lbm) 2798

Uncorrected Data

Coastdown Time (sec) 13.11

F_o (lbf) 37.4

F_2 (lbf-sec^2/ft^2) 0.0113

Corrected Data

Coastdown Time (sec) 13.11

F_o (lbf) 37.4

F_2 (lbf-sec^2/ft^2) 0.0113

Dynamometer Corrected Results

Mass Correction (lbm) 2798 (2750 + 48)

Dynamometer Coastdown Time (sec) 13.11

Table E-24

Coastdown Data

Vehicle Plymouth Horizon

Coastdown Type Dyno-straight, uncoupled

Test Date 8-26-82

Tire Pressure (psi) 45

Ambient Temp (°F) 68

Barometer (in Hg) 29.00

Test Weight (lbm) 2750 (2689)

Drive Axle Wt. (lbm) 1734

Driving Rotating Equivalent (lbm) 48

Non-Driving Rotating Equivalent (lbm) --

Total Weight (test wt. + rotating equivalent, lbm) 2798

Uncorrected Data

Coastdown Time (sec) 13.21

F_0 (lbf) 39.7

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0107

Corrected Data

Coastdown Time (sec) 13.21

F_0 (lbf) 39.7

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0107

Dynamometer Corrected Results

Mass Correction (lbm) 13.21

Dynamometer Coastdown Time (sec) 2798 (2750 + 48)

Table E-25

Coastdown Data

Vehicle AMC Concord

Coastdown Type Track-straight

Test Date 7-28-82

Tire Pressure (psi) 28/28

Ambient Temp (°F) 89

Barometer (in Hg) 29.81

Test Weight (lbm) 3508

Drive Axle Wt. (lbm) 1493

Driving Rotating Equivalent (lbm) 63

Non-Driving Rotating Equivalent (lbm) 60

Total Weight (test wt. + rotating equivalent, lbm) 3631

Uncorrected Data

Coastdown Time (sec) 15.20

F_o (lbf) 35.9

F_2 (lbf-sec^2/ft^2) 0.0137

Corrected Data

Coastdown Time (sec) 14.67

F_o (lbf) 39.0

F_2 (lbf-sec^2/ft^2) 0.0138

Dynamometer Corrected Results

Mass Correction (lbm) 3563 (3500 + 63)

Dynamometer Coastdown Time (sec) 14.39

Table E-26

Coastdown Data

Vehicle AMC Concord

Coastdown Type Track-curved

Test Date 7-27-82

Tire Pressure (psi) 28/28

Ambient Temp (°F) 79

Barometer (in Hg) 29.74

Test Weight (lbm) 3493

Drive Axle Wt. (lbm) 1488

Driving Rotating Equivalent (lbm) 63

Non-Driving Rotating Equivalent (lbm) 59

Total Weight (test wt. + rotating equivalent, lbm) 3615

Uncorrected Data

Coastdown Time (sec) 14.49

F_o (lbf) 37.4

F_2 (lbf-sec^2/ft^2) 0.0143

Corrected Data

Coastdown Time (sec) 14.31

F_o (lbf) 39.2

F_2 (lbf-sec^2/ft^2) 0.0142

Dynamometer Corrected Results

Mass Correction (lbm) 3563 (3500 + 63)

Dynamometer Coastdown Time (sec) 14.11

Table E-27

Coastdown Data

Vehicle	AMC Concord
Coastdown Type	Dyno-straight, coupled
Test Date	8-20-82
Tire Pressure (psi)	45
Ambient Temp (°F)	68
Barometer (in Hg)	29.00
Test Weight (lbm)	3508
Drive Axle Wt. (lbm)	1463
Driving Rotating Equivalent (lbm)	63
Non-Driving Rotating Equivalent (lbm)	--
Total Weight (test wt. + rotating equivalent, lbm)	3563

Uncorrected Data

Coastdown Time (sec)	13.50
F_0 (lbf)	32.1
F_2 ($lbf\text{-}sec^2/ft^2$)	0.0165

Corrected Data

Coastdown Time (sec)	13.50
F_0 (lbf)	32.1
F_2 ($lbf\text{-}sec^2/ft^2$)	0.0165

Dynamometer Corrected Results

Mass Correction (lbm)	3563
Dynamometer Coastdown Time (sec)	13.50

Table E-28

Coastdown Data

Vehicle AMC Concord

Coastdown Type Dyno-straight, uncoupled

Test Date 8-25-82

Tire Pressure (psi) 45

Ambient Temp (°F) 68

Barometer (in Hg) 29.00

Test Weight (lbm) 3508

Drive Axle Wt. (lbm) 1442

Driving Rotating Equivalent (lbm) 63

Non-Driving Rotating Equivalent (lbm) 60

Total Weight (test wt. + rotating equivalent, lbm) 3563

Uncorrected Data

Coastdown Time (sec) 13.55

F_o (lbf) 32.4

F_2 (lbf-sec^2/ft^2) 0.0164

Corrected Data

Coastdown Time (sec) 13.55

F_o (lbf) 32.4

F_2 (lbf-sec^2/ft^2) 0.0164

Dynamometer Corrected Results

Mass Correction (lbm) 3563

Dynamometer Coastdown Time (sec) 13.55

Table E-29

Coastdown Data

Vehicle Honda Civic

Coastdown Type Track-straight

Test Date 10-01-82

Tire Pressure (psi) 32/32

Ambient Temp (°F) 81

Barometer (in Hg) 29.78

Test Weight (lbm) 2277

Drive Axle Wt. (lbm) 1334

Driving Rotating Equivalent (lbm) 41

Non-Driving Rotating Equivalent (lbm) 39

Total Weight (test wt. + rotating equivalent, lbm) 2357

Uncorrected Data

Coastdown Time (sec) 12.65

F_o (lbf) 27.7

F_2 (lbf-sec^2/ft^2) 0.0107

Corrected Data

Coastdown Time (sec) 12.49

F_o (lbf) 29.8

F_2 (lbf-sec^2/ft^2) 0.0105

Dynamometer Corrected Results

Mass Correction (lbm) 2291 (2250 + 41)

Dynamometer Coastdown Time (sec) 12.14

Table E-30

Coastdown Data

Vehicle Honda Civic

Coastdown Type Track-curved

Test Date 10-04-82

Tire Pressure (psi) 32/32

Ambient Temp (°F) 80

Barometer (in Hg) 29.72

Test Weight (lbm) 2276

Drive Axle Wt. (lbm) 1332

Driving Rotating Equivalent (lbm) 41

Non-Driving Rotating Equivalent (lbm) 39

Total Weight (test wt. + rotating equivalent, lbm) 2356

Uncorrected Data

Coastdown Time (sec) 12.50

F_o (lbf) 24.6

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0115

Corrected Data

Coastdown Time (sec) 12.32

F_o (lbf) 25.9

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0115

Dynamometer Corrected Results

Mass Correction (lbm) 2291 (2250 + 41)

Dynamometer Coastdown Time (sec) 11.98

Table E-31

Coastdown Data

Vehicle Honda Civic

Coastdown Type Dyno-straight, coupled

Test Date 10-25-82

Tire Pressure (psi) 45

Ambient Temp (°F) 68

Barometer (in Hg) 29.00

Test Weight (lbm) 2250

Drive Axle Wt. (lbm) 1335

Driving Rotating Equivalent (lbm) 40

Non-Driving Rotating Equivalent (lbm) --

Total Weight (test wt. + rotating equivalent, lbm) 2290

Uncorrected Data

Coastdown Time (sec) 12.065

F_o (lbf) 25.8

F_2 (lbf-sec^2/ft^2) 0.0112

Corrected Data

Coastdown Time (sec) 12.065

F_o (lbf) 25.8

F_2 (lbf-sec^2/ft^2) 0.0112

Dynamometer Corrected Results

Mass Correction (lbm) 2290

Dynamometer Coastdown Time (sec) 12.065

Table E-32

Coastdown Data

Vehicle Honda Civic

Coastdown Type Dyno-straight, uncoupled

Test Date 10-12-82

Tire Pressure (psi) 45

Ambient Temp (°F) 68

Barometer (in Hg) 29.00

Test Weight (lbm) 2250

Drive Axle Wt. (lbm) 1334

Driving Rotating Equivalent (lbm) 40

Non-Driving Rotating Equivalent (lbm) --

Total Weight (test wt. + rotating equivalent, lbm) 2290

Uncorrected Data

Coastdown Time (sec) 12.07

F_o (lbf) 26.3

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0110

Corrected Data

Coastdown Time (sec) 12.07

F_o (lbf) 26.3

F_2 ($lbf\text{-}sec^2/ft^2$) 0.0110

Dynamometer Corrected Results

Mass Correction (lbm) 2290

Dynamometer Coastdown Time (sec) 12.07