LDTP 78 - 08

Technical Report

Investigation of the Requested Alternate Dynamometer Power Absorption for the Ford LTD

by

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Abstract

Concern about the EPA fuel economy measurements has focused greater attention on the dynamometer and the dynamometer adjustment. Specifically, the alternate procedures for determining the dynamometer power absorption to simulate the vehicle road experience affords an opportunity for both greater precision and possible abuse. Because of the possibility for abuse, it was decided to occasionally check the appropriateness of the alternate dynamometer power absorptions requested by vehicle manufacturers.

The question of the representativeness of the requested dynamometer power absorption for the Ford LTD was first raised during the summer of 1977. This report collects and summarizes the pertinant available data which have been generated by the EPA Emission Control Technology Division, the EPA Certification Division, and by Ford Motor Company.

It is concluded that a dynamometer power absorption of 12.3 horsepower simulates the typical road experience of the Ford LTD. The dynamometer power absorption requested by Ford, 9.5 horsepower, is inappropriate for this vehicle. Some of this discrepancy occurred because of the increased inflation pressures used by Ford during their road tests of this vehicle. These tire pressures are considered unrepresentative of anticipated consumer use of the vehicle because they exceed the typical inflation pressures used in dealer preparation of the vehicle for consumers. Even with the increased road tire inflation pressures, the recent road data indicate a dynamometer power absorption of 10.8 horsepower is required to simulate the road experience of this vehicle.

The data also indicate that the rear axle load of at least one of the certification vehicles was unrepresentatively low compared to the axle loads of the production LTD vehicles. This axle load significantly affects the tire energy dissipation during the dynamometer test, and consequently the total energy required from the vehicle during the EPA tests.

The unrepresentative nature of the EPA tests of the LTD resulted in reduced NOx emissions measurements for the vehicle and in significantly increased vehicle fuel economy. The predicted increase in NOx emissions, if the vehicle were tested with appropriate dynamometer adjustment, is estimated to be 0.07 gm/mi. The increased dynamometer power absorption would be expected to decrease the urban fuel economy measurements of the vehicle by 0.26 mi/gallon. The predicted decrease in the highway fuel economy would be 0.6 mi/gallon, or about 3 percent.

I. Purpose

The question of the representativeness of the test vehicle and the requested dynamometer power absorption for the Ford LTD was first raised during the summer of 1977. This report collects and summarizes the pertinent available data which have been generated by the EPA Emission Control Technology Division, the EPA Certification Division, and by Ford Motor Company.

II. Background

During the summer of 1977, ECTD personnel became aware of several requests for alternate dynamometer power absorption which appeared to be anomalously low. One of these was the 9.5 horsepower requested by Ford Motor Company for the Ford LTD. This vehicle was certified in both the 4500 and 5000 pound inertia weight classes. The requested alternate dynamometer power absorption was 3.2 horsepower below the 12.7 horsepower specification for a 4500 pound inertia weight vehicle and 3.9 horsepower below the 13.4 horsepower specified for a 5000 pound vehicle in the current Federal Register table. This large difference seemed particularly questionable since there is no obvious reason, such as exceptional aerodynamics, to expect this large discrepancy for a conventional front engine, rear axle drive vehicle.

The concern over the appropriateness of this requested dynamometer adjustment resulted in an ECTD test program which was conducted in August 1977. The report of this program concluded that the alternate dynamometer power adjustments requested for this vehicle did not appropriately reflect the road experience of the vehicle as reported by Ford. In addition, this report questioned the representativeness of the certification vehicle with respect to the production vehicle. The report of August 1977, which is attached as Appendix A, has been the basis for the additional investigations which have been conducted.

III. Discussion

Since the original EPA report, two additional investigations have been conducted. Ford Motor Company conducted road and dynamometer tests on one production LTD to support their original request. In October 1977, when the 1978 model year vehicles became available in the rental car fleet, EPA rented a Ford LTD and performed road coastdowns on this vehicle at the Transportation Research Center of Ohio (TRC) test track. The vehicle was then brought to EPA for the dynamometer coastdown tests.

This report considers all of the available data first based on the original coastdown time submitted by Ford for the prototype certification vehicle, secondly based on the road coastdown obtained by Ford from the production vehicle, and finally based on the coastdown time obtained by EPA from the rental vehicle.

A. Analysis of the Dynamometer Data Based on the Ford Road Data from the Prototype Vehicle

The original prototype vehicle used by Ford to collect the road data submitted to EPA in support of the request for an alternate dynamometer adjustment was a Ford LDT equipped with Uniroyal HR78X15 tires. The corrected road coastdown time reported for this vehicle was 18.58 seconds. The dynamometer power absorption reported for this coastdown time was 9.5 horsepower.

When the subsequent vehicles were tested at EPA and Ford, vehicle-dynamometer coastdown times were obtained for diverse dynamometer power absorptions. The data from the EPA measurements of the production vehicles are given in Appendix B. Plots of the vehicle-dynamometer coastdown times are presented for the EPA and Ford measurements in Appendices B and C respectively. The dynamometer adjustment corresponding to the original road coast down time of 18.58 seconds can be obtained from these plots. The average values of the dynamometer power absorptions from each series of measurements are summarized in Table 1.

Table 1

DYNAMOMETER POWER ABSORPTION CORRESPONDING TO THE ORIGINAL PROTOTYPE COASTDOWN TIME OF 18.58 SECONDS

Ford Original Request	9.5 hp
EPA Original Confirmatory Test (August 1977)	12.3 hp
Ford Production Vehicle Tests (November 1977, average of two dynamometers)	9.8 hp
EPA Production Vehicle Tests (average of four dynamometers)	9.4 hp

Table 1 indicates that for all tests, except those performed on the certification vehicle, 9.5 horsepower is a reasonable dynamometer power absorption corresponding to a coastdown time of 18.58 seconds. The test on the certification vehicle, however, required 12.3 horsepower to match the coastdown time of 18.58 seconds.

It is extremely unlikely that test variability could account for all of the apparent discrepancy of almost three horsepower. Therefore, the vehicle data were reviewed in an attempt to identify any vehicle differences.

The certification vehicle was significantly different from the other vehicles in the test series. The prototype and all production vehicles had an average rear axle load of 2104 pounds. The certification vehicle, however, had a rear axle load of only 1910 pounds. In addition, the certification vehicle was equipped with Michelin steel belted tires while all of the other vehicles were equipped with Uniroyal steel belted radial tires. In the case of the certification vehicle, the reduced rear axle loads would decrease the tire power dissipation by about 10 percent or approximately 0.7 horsepower. A recent EPA report indicated Michelin radial tires had a rolling resistance of about 15 percent lower than the rolling resistance of Uniroyal tires, at least for the tires investigated. If this difference was valid for the 1978 Ford vehicles, then the tire rolling resistance on the certification vehicle would have been 15 percent, or about 1.1 horsepower less than for the production vehicle.

The vehicle-dynamometer coastdown time is a measure of the power dissipation for the total vehicle and dynamometer system. If the vehicle tire energy dissipation is decreased, but the vehicle-dynamometer coastdown remains unchanged, then the dynamometer power absorption must be increased to compensate for the reduction in tire losses. In the case of the certification vehicle, it is estimated that approximately 1.8 horsepower or about two thirds of the discrepancy between the results of this vehicle and the remaining vehicles can be attributed to actual differences between the vehicles. The remaining 0.9 horsepower was probably induced by random variations in the vehicle and dynamometer system. This variability is much more consistant with the variability of about one horsepower observed during the EPA tests of the production vehicle and the variability of 1.4 horsepower observed by Ford during their production vehicle tests.

B. Analysis of the Dynamometer Data Based on the Ford Road Coastdowns of Production Vehicles

In November 1977, Ford Motor company conducted a series of coastdown tests on a production Ford LTD. The purpose of this investigation was to corroborate the original data used in support of the request for an alternate dynamometer adjustment. The corrected road coast time obtained from this vehicle was 17.47 seconds. Table 2 presents the dynamometer adjustments obtained for this coastdown time from each of the data sources given in the Appendices.

Table 2

DYNAMOMETER POWER ABSORPTION CORRESPONDING TO THE FORD PRODUCTION VEHICLE COASTDOWN TIME OF 17.42 SECONDS

EPA Original Tests (August 1977)	13.3 hp
Ford Production Vehicle Tests (November 1977)	11.0 hp
EPA Production Vehicle Tests (December 1977)	10.6 hp

Again, all of the results are in reasonable agreement at about 10.8 horsepower except those obtained from the Ford certification vehicle.

As before these differences are primarily attributed to the differences between this test vehicle and the production vehicles.

C. EPA Road Coastdown Tests

The major purpose of the road tests conducted by EPA on the rented production Ford LTD was to verify the road coastdown data submitted by Ford.

The road test portion of the program was conducted by TRC personnel. The vehicle was first driven for about 250 miles for drive train component brake-in. The vehicle system was then allowed to equilibrate to ambient temperatures over night. Prior to the vehicle warm-up for the coastdown tests the vehicle tires were adjusted to the recommended cold inflation pressures. The vehicle was then warmed up for approximately one half hour at 50 mph. Twenty coastdowns were subsequently conducted, ten in each direction of the TRC track. Ten of the coastdowns, five in each direction, were started at approximately 60 mph. The remainder were started at approximately 40 mph. It was necessary to divide the coastdowns into these two speed ranges because of the relatively short, 1 km, section of constant grade track available on the TRC skid pad.

The data analysis was conducted in the manner described in the data analysis section of the EPA Recommended Practice for Road Load Determination except that a $\Delta v/\Delta t$ approximation was used for the vehicle deceleration during the coastdown.

A two term model of the acceleration versus velocity was chosen, that is:

$$A = a_0 + a_2 v^2 \qquad (1)$$

where:

A = the calculated deceleration of the vehicle
v = the vehicle velocity
a_0 and a_2 are coefficients to be fitted by the regression analysis.

Additional terms were added to equation 1 to account for the directional dependent effects caused by track grade and wind. The grade effect was assumed to be independent of velocity while the wind effect was assumed to be linearity dependent on the vehicle velocity.

The a_0 terms of the regression will contain a constant term introduced by the ambient wind. This correction to still air conditions was made using the measured value for the ambient wind. In addition, since the a_2 terms represents the aerodynamic drag, an air density correction was applied to this term to correct to the standard ambient conditions given in the EPA recommended practice. The corrected coefficients which were obtained are:

$$a_0^* = 0.3526 \text{ mi/hr-sec}$$

(2)

$$a_0^* = 0.0001225 \text{ hr/mi-sec}$$

The coefficients of equation 2 were used to calculate the total road force on the vehicle from the vehicle mass and the estimates of the rotational inertias of the rotating components of the vehicle. The 55 to 45 mph dynamometer coastdown time interval necessary to reproduce this force was then calculated by correcting for the difference between the total effective vehicle mass during the road coastdowns and the dynamometer simulated mass plus the rotational inertia of the drive train components. The final, dynamometer "target" coastdown time obtained from the EPA track measurements was:

$$\Delta T = 16.08 \text{ seconds} \tag{3}$$

The dynamometer adjustment results, based on this coastdown time are given in Table 3.

Table 3

DYNAMOMETER POWER ABSORPTION CORRESPONDING TO THE EPA PRODUCTION VEHICLE COASTDOWN TIME OF 16.1 SECONDS

Ford Production Vehicle Tests	12.7 hp
EPA Production Vehicle Tests	12.3 hp

The certification vehicle tests are not represented in Table 3 because no data were obtained for coast down times shorter than about 17.5 seconds.

IV. Analysis

This section analyzes the presented data to judge the most appropriate coastdown time and dynamometer adjustment for the Ford LTD. The effects of this dynamometer power absorption on exhaust emissions and fuel economy versus the power absorption used during the EPA tests are then investigated.

A. The Appropriate Dynamometer Power Absorption

The analysis of the data presented in Tables 1 through 3 require decisions on two basic questions:

1. What are the axle loads and tire combinations of the represented production vehicles?

2. Which coastdown time best represents the road experience of the vehicle?

In response to the first question, the original prototype vehicle and all production vehicles considered in this program were equipped with Uniroyal tires and had rear axle loads of approximately 2100 pounds. Only the certification vehicle, which was not equipped with a spare tire or jack, had a rear axle load less than 2000 pounds. Hopefully, Ford Motor Company intends to provide spare tires with the production vehicles, therefore the heavier configuration must be judged as most appropriate to represent the production vehicles.

Addressing the appropriate road coastdown times, the choices are the original prototype coast down time of 18.58 seconds, the Ford production vehicle coast down time of 17.42 seconds, and the EPA production vehicle coastdown time of 16.10 seconds. Since the question really pertains to the production vehicle coastdown time, the coast down time of the production vehicles should receive primary attention. There is further reason to disregard the original prototype coastdown time because Ford had the the greatest possible incentive to reproduce this value during their subsequent confirmatory tests, but obtained times more than one second slower. It is subsequently considered that the important evaluation is between the Ford and EPA coastdown times on the production vehicles.

The test data were reviewed to attempt to locate the reason for the discrepancy between the EPA and Ford results. An obvious difference observed between the Ford and EPA test conditions was the tire inflation pressures.

The Ford road tests were conducted at tire inflation pressures of 30 and 32 psi, front to rear respectively, while the EPA tests were conducted with inflation pressures of 26 and 28 psi. This difference in tire pressure would theoretically be expected to cause a change of about 0.8 horsepower in the vehicle road power and a reduction of about 0.8 seconds in the road coastdown time.

TRC personnel had been instructed to conduct the road tests at the normal tire inflation pressures recommended by the manufacturer; therefore the basis for the test pressure difference was investigated. TRC personnel reported that the vehicle was prepared by the local Ford dealer who had inflated the tires to approximate 26-28 psi. In addition, the consumer safety information contained in the vehicle glove box was based on the tire inflation pressure of 26-28 psi.

The vehicle owner's manual did not specifically recommend any tire inflation pressures but referred the reader to the decal on the jamb of the passenger door. This decal recommended tire inflation pressures of

26-28 psi for the best vehicle ride and 30-32 for maximum fuel economy.

Since either inflation pressure might be considered as recommended by the manufacturer, a brief telephone survey of local Ford dealers was conducted to ascertain which inflation pressure might be considered normal for the vehicle, at least as originally delivered to the customer. All dealers responded that the vehicles were normally prepared for the consumer with tire inflation pressures of 26-28 psi or lower. It was therefore concluded that tire inflation pressures of 30-32 psi are not typical for this vehicle even at the time of dealer preparation. Consequently, the high tire inflation pressures cannot be considered typical for the normal use of this vehicle.

In addition, the EPA recommended practice for road load determination currently chooses standard ambient conditions of 68°F. The Ford procedure for road load determination chooses 74°F as the standard conditions. This difference in standard conditions would increase the vehicle road load approimately 2 percent and therefore decrease the corrected coastdown time by about 0.3 seconds.

The average U.S. annual temperature is about 60°F, even lower than the EPA standard temperature (1). Consequently, test results corrected to 68°F are certainly more representative of typical owner use than results corrected to 74°F.

These two effects, temperature and tire pressure, nearly explain the observed differences between the two test results. The remaining differences must be attributed to test and vehicle variability. Since the EPA test conditions were much closer to typical consumer vehicle use, the EPA results are judged to be more representative of the in-use experience of the vehicle. Consequently, the dynamometer adjustment of 12.3 horsepower is considered representative of typical vehicle experience.

B. The Emission and Fuel Economy Effects of the Dynamometer Adjustment

In December 1977, the Certification Division conducted exhaust emissions and fuel economy measurements as a function of dynamometer power absorption. The vehicle used was a Ford LTD. The data from the Certification Division tests are given in Appendix D. Regression analyses of these data conclude that the vehicle fuel economy significantly decreases with increasing dynamometer power absorption, the NOx emissions increase with increasing dynamometer power absorption, and the HC and CO emissions tend to decrease with increasing power absorption. The regressions statistics indicate there is little confidence that the

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(1) U.S. Bureau of the Census, Statistical Abstract of the United States: 1975 (96th edition) Washington, D.C. 1975.

slopes of the HC and CO regression lines are different from zero. Therefore, the statistically significant effects are the increase in NOx emissions and the degradation of the vehicle fuel economy with increasing dynamometer power absorption. The fuel economy and NOx missions data, together with the regression lines are plotted in Figures 1 and 2.

The plots of the data demonstrate the strong dependence of the vehicle fuel economy on the dynamometer power absorption. The statistical confidence in the effects of the dynamometer power absorption on the vehicle fuel economy was, as expected, very high. The confidence in the prediction of the effects on NOx emissions was, however, somewhat weaker. The statistical uncertainty in the effects on NOx emissions was primarily caused by the, possibly outlier, datum from the test at the lowest dynamometer power absorption.

The regression lines can be used to predict the effect on NOx emissions and fuel economy if the vehicle had been tested at the higher, more representative, dynamometer power absorptions. The deficiency in the dynamometer adjustment for the vehicle during the applicable emissions tests was, therefore, 9.5 horsepower versus 12.3 for vehicles without air conditioning and 10.5 versus 13.5 horsepower for air conditioned vehicles. The predicted increase in NOx emissions would be approximately 0.07 gm/mi for both of the two cases.

Including the predicted NOx increase of 0.07 gm/mi most of the certification vehicles tested to represent the LTD engine families would still have met the NOx standard. There was, however, one which would have exceeded the 2.0 gm/mi standard but would have been certified because of round-off tolerances (2). It should be noted that this analysis strongly depends on the slope of the NOx versus dynamometer power absorption regression, shown in Figure 2. If, for example, the datum at the lowest dynamometer power absorption were judged to be an outlier and deleted, the slope of the regression would increase and failure of these vehicles with high NOx emissions would probably be predicted. Considering this sensitivity of the regression and the normal test variability, the success or failure of this particular vehicle, if tested at a representative dynamometer power absorption, cannot be accurately predicted.

The same discrepancy in the dynamometer power absorption would result in a predicted decrease in fuel economy of about 0.26 mi/gallon for the urban cycle. The highway fuel economy would be expected to decrease approximately 0.6 mi/gallon, or about 3 percent for vehicles both with and without air conditioning. Based on current sales predictions, such a decrease in the fuel economy of this vehicle would be expected to lower the Ford Corporate Average Fuel Economy for 1978 (3).

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(2) C. Larson, discussion, February 1977.

(3) J.D. Murrell, discussion, February 1977.

Vehicle Fuel Economy
versus
Dynamometer Power Absorption

TEST VEHICLE: Ford LTD 8A1-351W-F-64
INERTIA WEIGHT CATEGORY: 5000 pounds

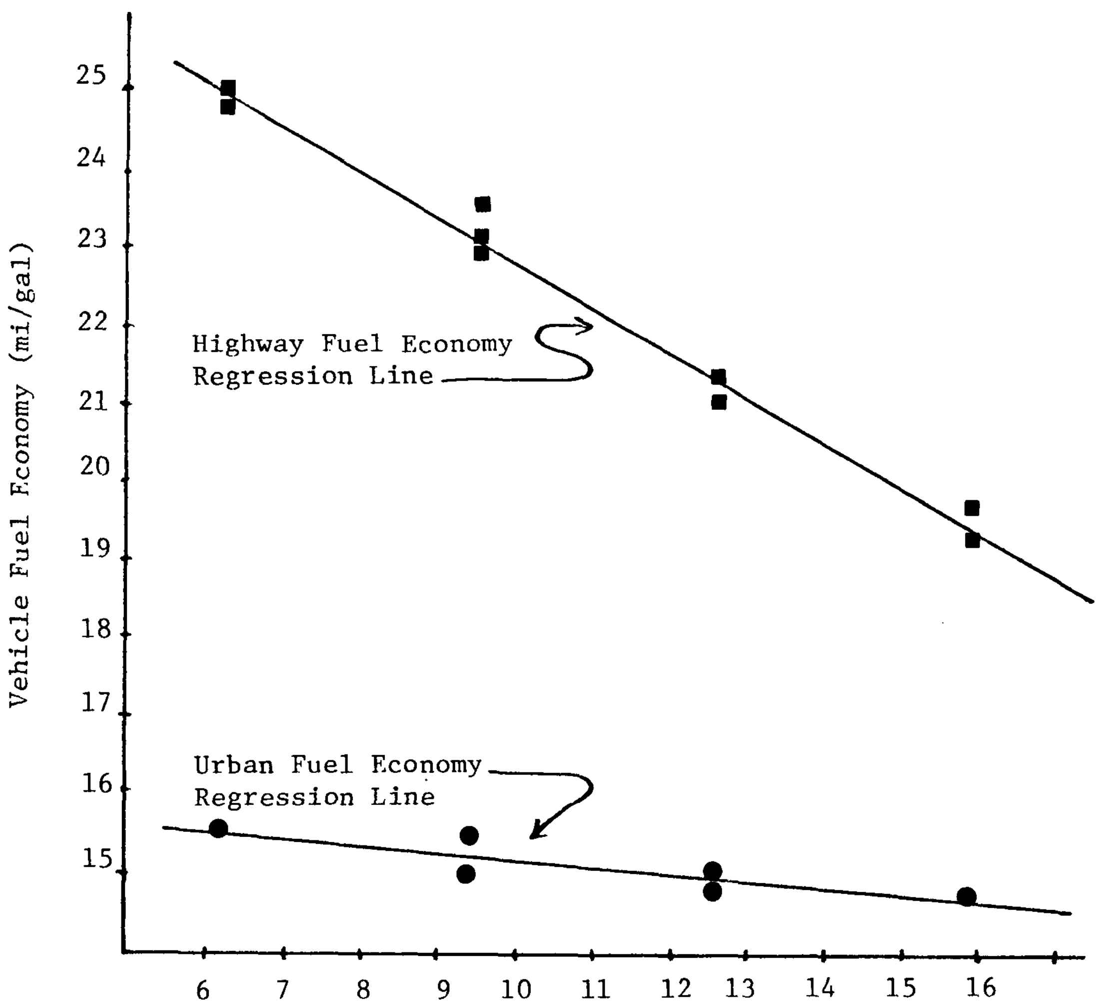


Figure 1

Nitrogen Oxide Emissions
versus
Dynamometer Power Absorption

TEST VEHICLE: Ford LTD 8A1-351W-F-64
INERTIA WEIGHT CATEGORY: 5000 pounds

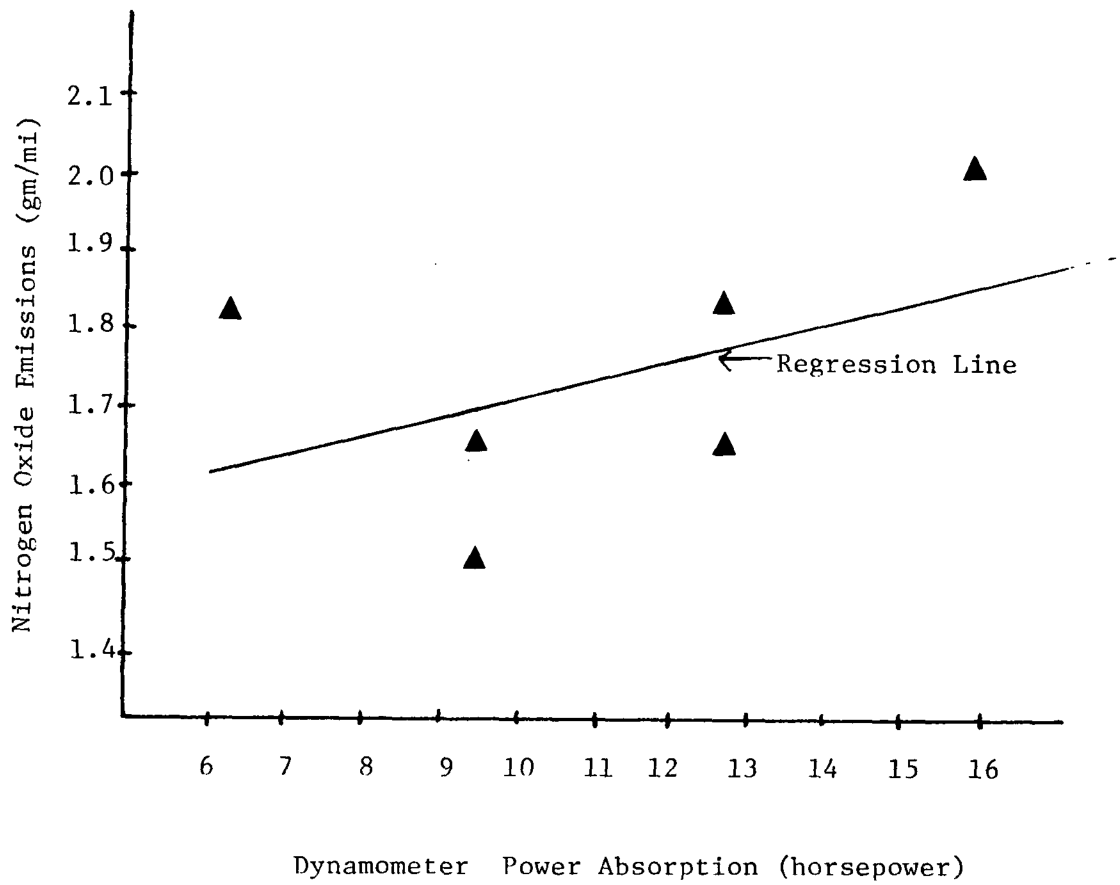


Figure 2

V. Conclusions

It is concluded that the EPA tests of the Ford LTD were unrepresentative because:

1. The road data submitted by Ford is unrepresentative of anticipated consumer use of the vehicle because of the tire pressures used during the dealer preparation of the vehicle for consumer use.

2. At least one of the certification test vehicles submitted to EPA had a rear axle load unrepresentative of production LTDs tested. This unrepresentativeness of the vehicle had an additional effect of reducing the power required from the engine during certification tests.

It is further concluded that the unrepresentative nature of these tests resulted in reduction of the NOx emissions measurements for these vehicles. Most of the vehicles tested to represent the LTD would still be expected to meet the exhaust emission standards if these vehicles were tested at the higher, more representative dynamometer power absorption. One test vehicle was, however, sufficiently close to the 2.0 gm/mi NOx standard that the success or failure of this particular vehicle cannot be accurately predicted.

The unrepresentative nature of the EPA fuel economy tests resulted in a significant increase in the vehicle fuel economy for the Ford LTD. This increase could affect the 1978 Ford Corporate Average Fuel Economy.

APPENDIX A

EPA Report of August 1977

Abstract

Concern about the EPA fuel economy measurements has focused greater attention on the dynamometer and the dynamometer adjustment. Specifically the alternate procedures for determining the dynamometer adjustment to simulate the vehicle road experience affords an opportunity for both greater precision and possible abuse. Because of the possibility for abuse it was decided to occasionally check the coast down times of the certification test vehicle on the dynamometer, with the dynamometer adjusted to the requested power setting, versus the road coast down times reported for the vehicle by the manufacturer. While this procedure assumes the validity of the submitted road coast down data, it does provide an easy and convenient check that the dynamometer experience of the test vehicle is similar to the reported road experience. It insures that vehicle components such as tires and drive train lubricants are effectively the same on the EPA test vehicle as on the vehicle which was road tested by the manufacturer.

The Ford LDT was selected for such a "quick check" since the alternate dynamometer adjustment requested by the manufacturer, 9.5 horsepower, was considered unusually low. This vehicle is being certified in both the 4500 and 5000 pound inertia weight classes. The requested alternate power adjustment is 3.9 horsepower below the 13.4 horsepower specified for a 5000 pound vehicle in the current Federal Register table and 3.2 horsepower below the 12.7 horsepower specification for a 4500 pound inertia weight vehicle. This large difference seemed particularly questionable since there is no obvious reason, such as exceptional aerodynamics, to expect this large discrepancy for a conventional front engine, rear axle drive vehicle.

The investigation concludes that when the certification vehicle is operated on the dynamometer, the requested dynamometer adjustment of 9.5 horsepower at 50 mph, does not result in an accurate dynamometer simulation of the reported road experience of the vehicle tested by Ford.

Background:

Concern about the EPA fuel economy measurements has focused greater attention on the dynamometer and the dynamometer adjustment. Specifically the alternate procedures for determining the dynamometer adjustment to simulate the vehicle road experience affords an opportunity for both greater precision and possible abuse. Because of the possibility for abuse it was decided to occasionally check the coast down times of the certification test vehicle on the dynamometer, with the dynamometer adjusted to the requested power setting, versus the road coast down times reported for the vehicle by the manufacturer. While this procedure assumes the validity of the submitted road coast down data, it does provide an easy and convenient check that the dynamometer experience of the test vehicle is similar to the reported road experience. It insures that vehicle components such as tires and drive train lubricants are effectively the same on the EPA test vehicle as on the vehicle which was road tested by the manufacturer.

Discussion:

The Ford LTD was selected for such a "quick check" since the alternate dynamometer adjustment requested by the manufacturer, 9.5 horsepower, was considered unusually low. This vehicle is being certified in both the 4500 and 5000 pound inertia weight classes. The requested alternate power adjustment is 3.9 horsepower below the 13.4 horsepower specified for a 5000 pound vehicle in the current Federal Register table and 3.2 horsepower below the 12.7 horsepower specification for a 4500 pound inertia weight vehicle. This large difference seemed particularly questionable since there is no obvious reason, such as exceptional aerodynamics, to expect this large a discrepancy for a conventional front engine, rear axle drive vehicle.

EPA tested two 1975 Ford LTD's in the recent road load project. The results of these measurements, 11.6 horsepower for one vehicle and 12.6 horsepower for the other vehicle, are in better agreement with the current Federal Register table than with the Ford requests (1). The mean of the two EPA results, 12.2 horsepower would be the best EPA estimate of the appropriate dynamometer adjustment for this vehicle based on the road load project measurements. The frontal area based equation which is proposed for the 1979 model year also yields dynamometer adjustments which are nearer the current table than are the Ford requested dynamometer adjustments. Using frontal area data submitted by Ford for the 1975 vehicles, the proposed equation predicts a dynamometer adjustment of 12.4 horsepower for these vehicles (2).

Because of the apparent discrepancies between the EPA measurements and predictions, and the requested dynamometer adjustment, a certification vehicle, vehicle number 8A1-351W-F-64, was selected for this quick check. Ford personnel were invited to observe these tests. The tests were conducted on dynamometer number 4, the same dynamometer which was used for the recent certification running change tests on this vehicle.

For these tests the vehicle was prepared in the same manner it would be treated for certifications testing. The fuel tank was filled to approximately 40% capacity as indicated by the vehicle fuel gauge. The vehicle was then placed on the dynamometer and the restraining cable explicitly checked by the dynamometer operator to insure the cable tension was typical of normal EPA dynamometer testing. At this time the tire inflation pressures were also checked and adjusted to 45 psi. The dynamometer inertia weight simulation was however adjusted for 5000 pounds since this was the inertia weight simulation used by Ford to develop the requested dynamometer adjustment.

The EPA vehicle and dynamometer warmup procedure requires the vehicle be driven for 30 minutes at approximately 50 mph. The Ford personnel present requested that the Ford warm-up procedure be used in these tests. This procedure calls for the vehicle to be repeatedly accelerated to 70 mph, then allowed to coast, with the transmission engaged, down to 40 mph. Previous EPA tests have not shown a significant difference between the dynamometer power absorber settings which result from either of these warm-up methods. Therefore, the Ford request was granted, and the gradual acceleration-deceleration warm-up pattern was repeated for 30 minutes.

Coast downs, from 55 mph to 45 mph were then performed for five nominal horsepower settings. The total dynamometer absorbed power, the indicated dynamometer absorbed power and the coast down times are given in Table 1.

Table 1

Dynamometer No. 4, IW = 5000 pounds, 8/19/77

Total Dynamometer Power at 50 mph (horsepower)	Indicated Dynamometer Power at 50 mph (horsepower)	Coast Down Time Interval (sec)
9.2	6.5	22.9
9.3	6.6	22.7
10.2	7.4	20.8
10.2	7.4	21.0
10.2	7.4	21.4
11.4	8.6	19.9
11.3	8.5	20.0
12.2	9.4	19.1
12.2	9.4	18.5
13.0	10.2	17.6
13.0	10.2	17.7

The coast down times are plotted versus the total dynamometer power at 50 mph in Figure 1. An equation of the form:

$$Hp = a + bt + ct^2 \qquad (1)$$

was fitted to the total dynamometer power and coast down time data by the method of least squares. The resulting coefficients of the line were:

$$a = 38.1 \text{ hp}$$
$$b = -1.92 \text{ hp/sec}$$
$$c = 0.0289 \text{ hp/sec}^2$$

This line is also plotted in Figure 1.

Ford reported the target dynamometer coast down time to be 18.58 seconds. This target dynamometer coast down time was calculated by correcting the road coast down times to the time appropriate for a standard set of ambient conditions. In addition corrections were made to adjust for the difference in the inertia weight of the vehicle as road tested, and the dynamometer simulated inertia weight category of 5000 pounds. A vertical line corresponding to 18.58 seconds is shown on Figure 1. This line intersects the curve at 12.3 horsepower which is 2.8 horsepower higher than the dynamometer adjustment requested by Ford. This difference between the EPA and Ford results is considered significant.

Immediately following the coastdown tests the vehicle was weighed, including the test driver, on the EPA scales. The total vehicle weight, and each axle load were:

front axle load	2520 pounds
rear axle load	1910 pounds
total vehicle weight	4420 pounds

Throughout the tests the observing Ford personnel were insistent that the test vehicle should be ballasted so that the rear axle load was equivalent to the rear axle load of the vehicle Ford dynamometer tested. The rear axle load and total weight reported for the Ford vehicle were:

rear axle load	2156 pounds
total vehicle weight	4834 pounds

The vehicle road tested by Ford was approximately 400 pounds heavier than the EPA certification vehicle. The rear axle load on the Ford road vehicle was also greater than the rear axle load on the certification vehicle. In addition, the ratio of the load on the rear axle to the total vehicle weight was greater on the Ford road vehicle than it was on the vehicle supplied for certification.

Dynamometer No. 4

IW = 5000 pounds

8/18/77

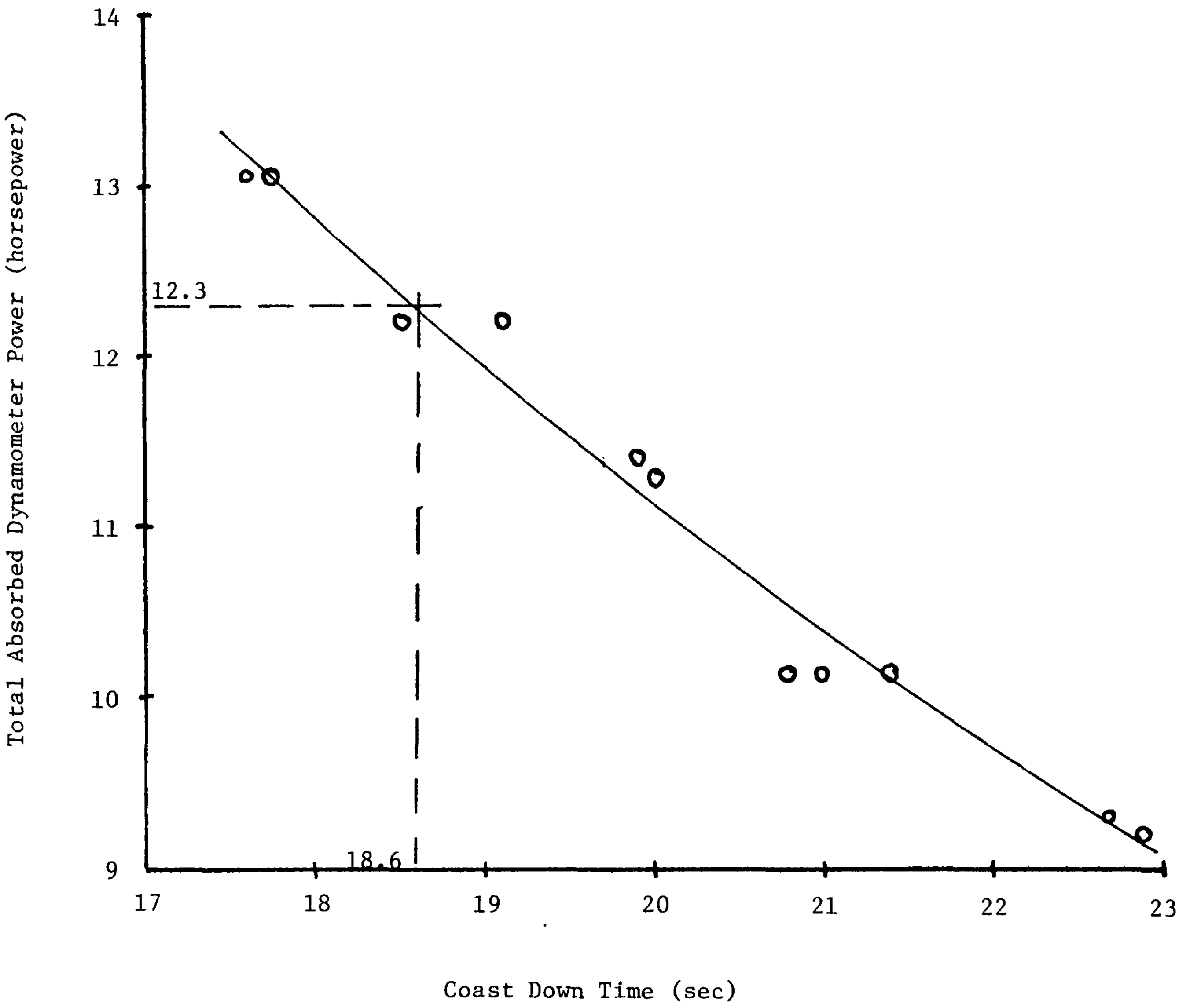


Figure 1

Mr. D.W. Berens of Ford stated that the vehicles Ford had road tested had been carefully prepared to reflect the aerodynamic and weight characteristics of the standard or base vehicles presented in the Ford Part I application. Mr. Berens also stated that the vehicle road tested by Ford was equipped with the same displacement engine as the certification vehicle, however the transmissions and rear axles might be different.

Mr. Clayton LaPointe of Ford was adamant that it was inappropriate to perform dynamometer tests on the Ford certification vehicle without ballasting the vehicle. Mr. LaPointe felt it was unrealistic to expect the dynamometer simulation of the unballasted vehicle to reflect the road experience of the Ford coastdown vehicle. Mr. LaPointe estimated the difference in tire power dissipation between the ballasted and unballasted configuration could be approximately one horsepower at 50 mph.

The results of these tests certainly support Mr. LaPointe's contention that the dynamometer experience of the unballasted vehicle is an unrealistic representation of the road experience of the vehicle road tested by Ford. However, if the road vehicle is representative of the intended 1978 product, was a non-representative vehicle supplied by Ford for exhaust emission certification and fuel economy testing?

To insure the accuracy of EPA exhaust emission and fuel economy tests the dynamometer experience of the vehicle during these measurements must accurately simulate the road experience of the intended production vehicle. If it is necessary to adjust the rear axle load to correctly simulate the road experience, this should also be done during the certification testing.

Conclusions:

1) When the certification vehicle is operated on the dynamometer, the requested dynamometer adjustment of 9.5 horsepower at 50 mph, does not result in an accurate dynamometer simulation of the reported road experience of the vehicle tested by Ford.

2) The vehicle road tested by Ford was significantly different from the vehicle provided for certification testing.

Recommendations:

1) It is recommended that the vehicle discrepancy be resolved. That is, which vehicle best represents the vehicle Ford intends to sell? The road experience of the intended sales vehicle should be determined, then the dynamometer adjustment necessary to simulate the road experience of the intended sales vehicle should be used for certification and fuel economy testing. The weight and weight distribution of the certification vehicle should be adjusted, if necessary, to simulate the intended sales vehicle.

2) The requested dynamometer adjustments for other Ford vehicles should be checked.

3) The "representativeness" of all Ford certification and fuel economy vehicles should be investigated.

References

1. G.D. Thompson, EPA Technical Support Report for Regulatory Action, "Light-Duty Vehicle Road Load Determination", December 1976.

2. G.D. Thompson, EPA Technical Support Report for Regulatory Action, "Prediction of Dynamometer Power Absorption to Simulate Light-Duty Vehicle Road Load", April 1977.

APPENDIX B

EPA Dynamometer Data
from the
Ford LTD Rental Vehicle

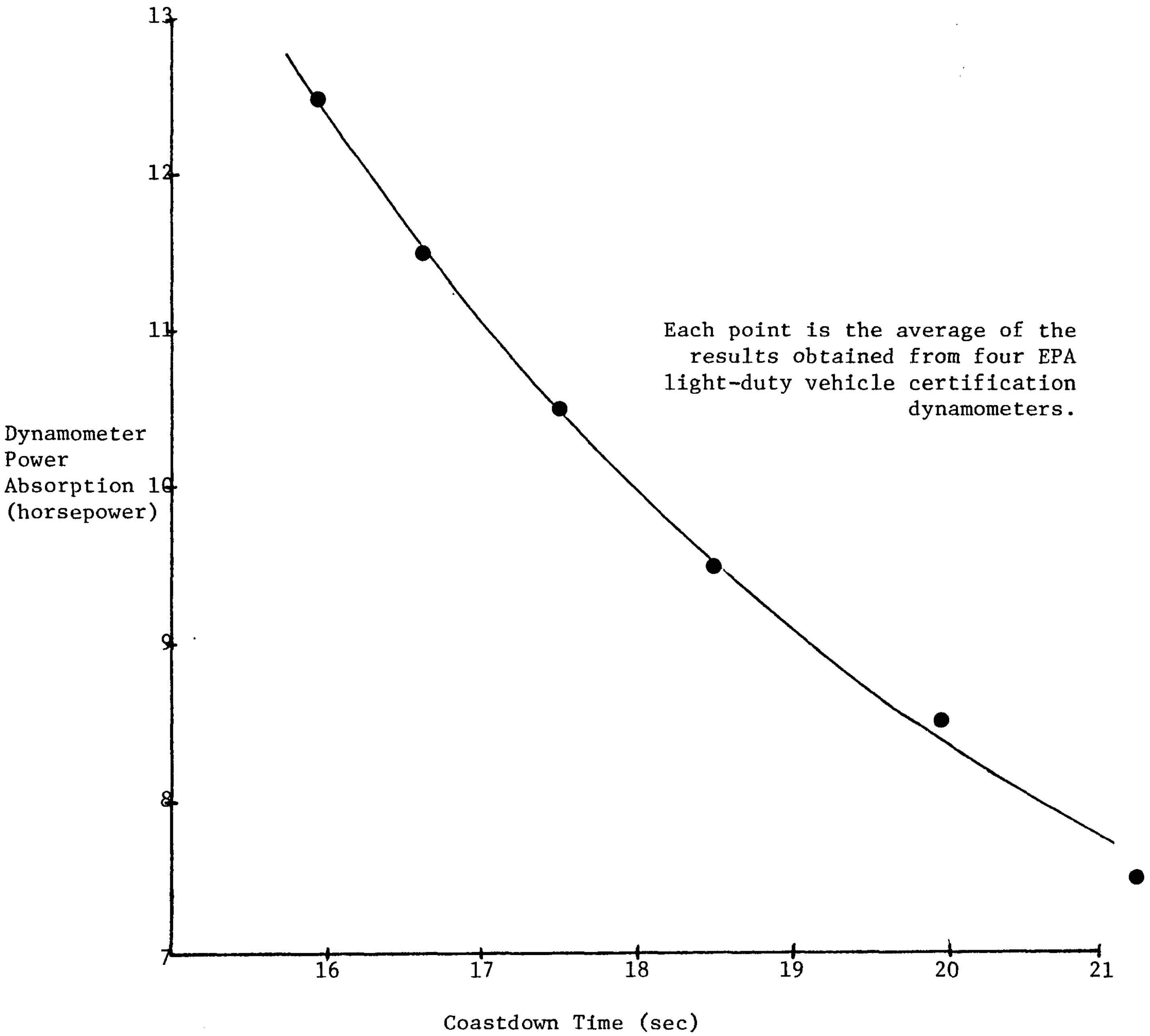
FORD LTD (TRC RENTAL VEHICLE)

IWC = 5000 Pounds

Nominal Actual Power (Hp)	Mean Coastdown Times (sec) Dyno #1	Dyno #2	Dyno #3	Dyno #4	Average Coastdown Time for all Dynos (seconds)
13.5	15.12	15.34	14.41	15.12	15.00
12.5	15.96	16.18	15.54	16.06	15.94
11.5	16.61	16.74	16.25	16.88	16.62
10.5	17.67	17.80	16.74	17.86	17.52
9.5	18.63	18.71	18.05	18.64	18.51
8.5	19.96	20.22	19.57	20.19	19.98
7.5	21.23	21.49	20.58	21.30	21.15

Dynamometer Power Absorption
versus
Average Coastdown Time

Ford LTD (Rental Vehicle)
IWC 5000 Pounds



APPENDIX C

Ford Motor Company Data
Tests of November 1977

Test Vehicle Characteristics Supplied
by Ford for the Production LTD

Vehicle: 1978 Ford LTD - 4 Door Sedan
Vehicle No.: 313-T-025

Road Test Data:

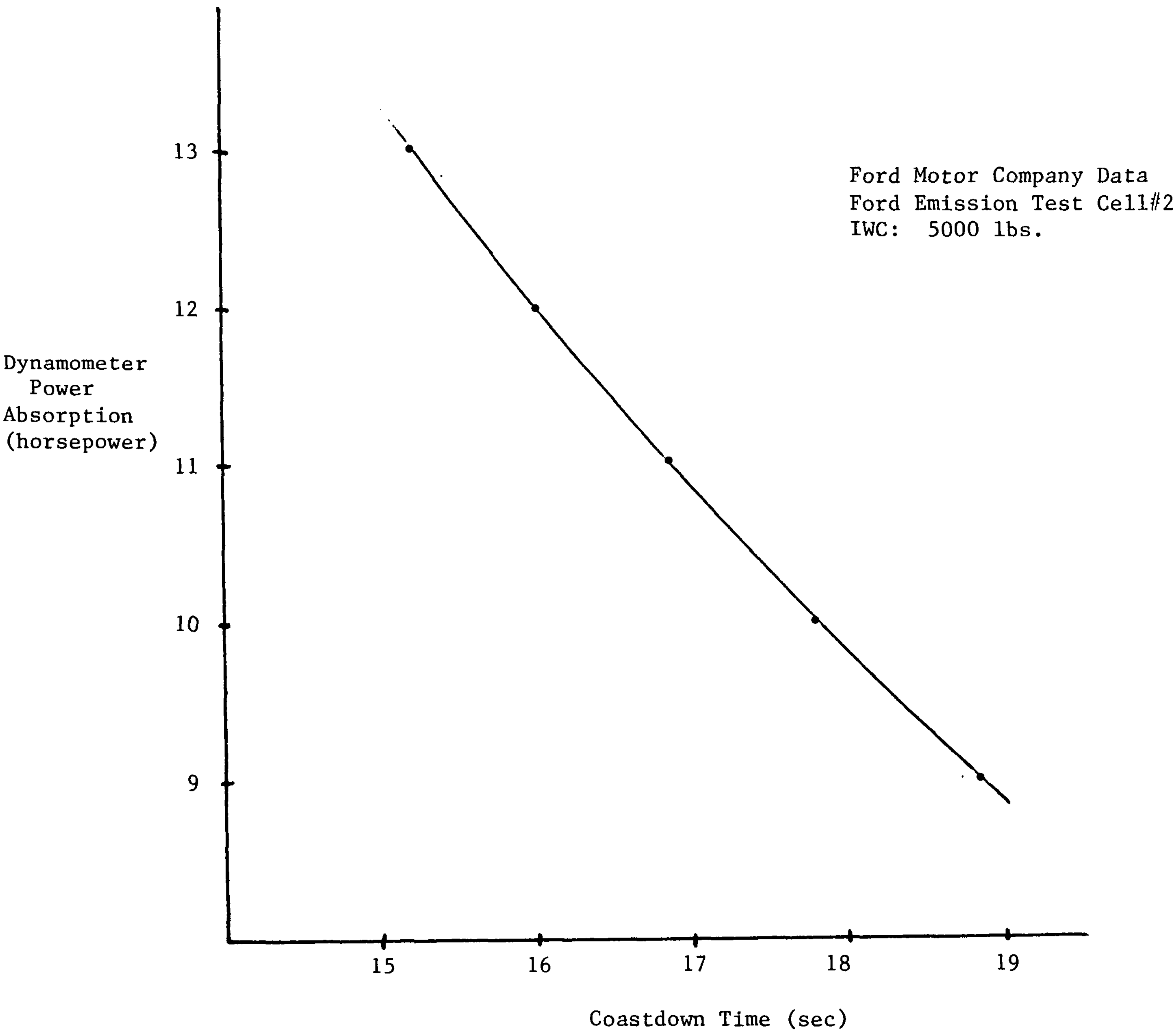
Total weight:	4770 pounds
Rear axle load:	2089 pounds
Front tire pressure:	30 psi
Rear tire pressure:	32 psi
Corrected road coastdown time:	17.42 seconds

Dynamometer Test Data:

	Test Cell 2	Test Cell 6
Total weight:	4760 lbs.	4792 lbs.
Rear axle load:	2090 lbs.	2090 lbs.
Rear tire pressure	45 psi	45 psi
Inertia weight category	5000 lbs.	5000 lbs.
Dynamometer power absorption corresponding to a coastdown time of 17.42 seconds	10.36	11.75

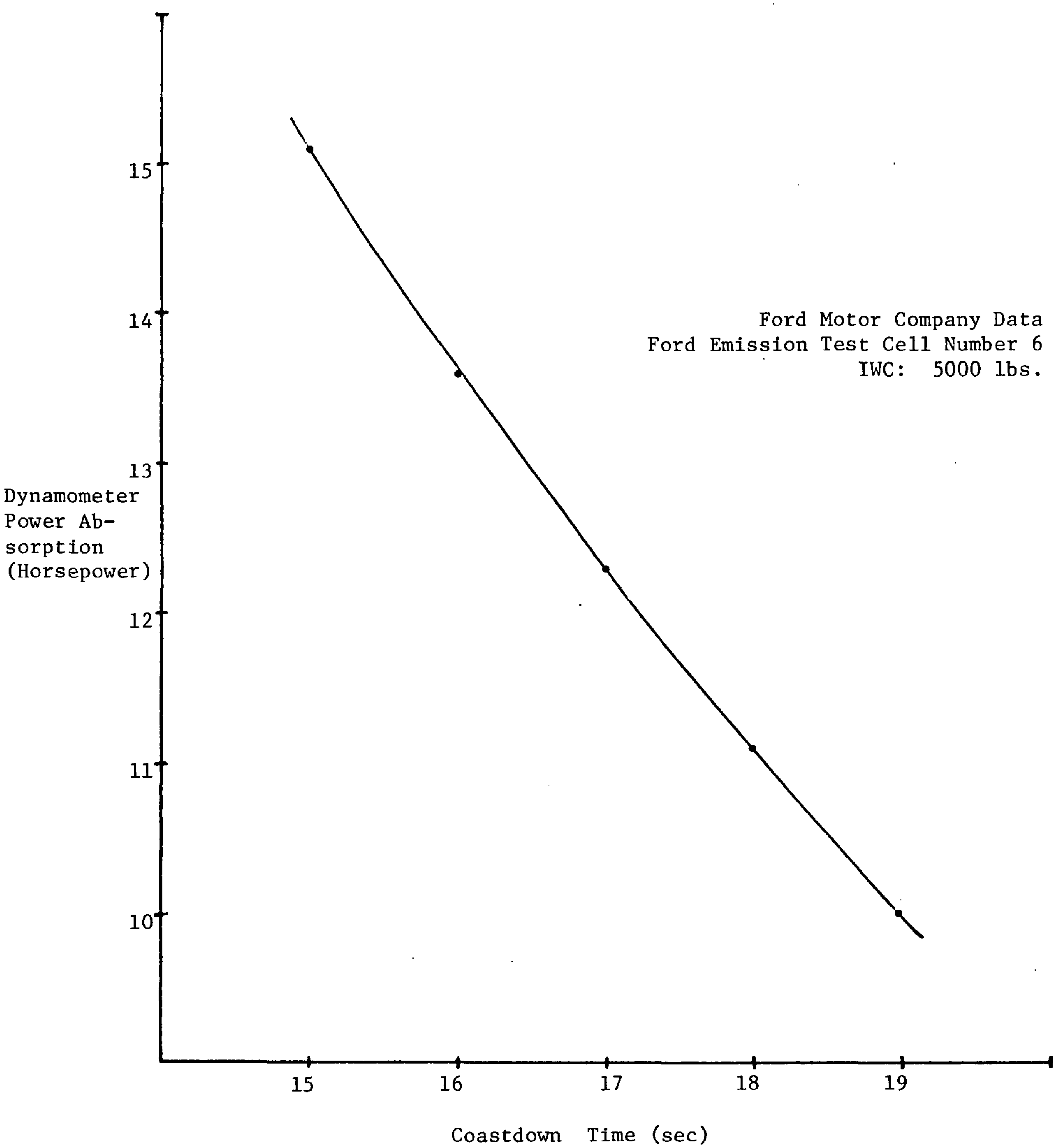
Coastdown Time
versus
Dyamometer Power Absorption

Ford LTD - November 1977



Coastdown Time
versus
Dynamometer Power Absorption

Ford LTD - November 1977



APPENDIX D

Effects of Dynamometer Power Absorption

TABLE D-1

Vehicle Emissions and Urban Fuel Economy
versus
Dynamometer Power Absorption

Dynamometer Power Absorption (Hp)	Hydrocarbons (gm/mi)	Carbon Monoxide (gm/mi)	Nitrogen Oxides (gm/mi)	Carbon Dioxide (gm/mi)	Urban Fuel Economy (mi/gal)
6.3	0.75	10.5	1.85	552	15.5
9.5	0.82	12.0	1.65	552	15.5
9.5	0.90	13.7	1.50	566	15.0
12.7	0.73	11.0	1.83	579	14.9
15.9	0.81	11.1	2.00	583	14.7

TEST VEHICLE: Ford LTD 8A1-351W-F-64
INERTIA WEIGHT CATEGORY: 5000 pounds

Table D-2

Highway Fuel Economy
versus
Dynamometer Power Absorption

Dynamometer Power Absorption (Hp)	Highway Fuel Economy (mi/gal)
6.3	24.8
6.3	25.0
9.5	23.7
9.5	23.0
9.5	23.2
12.7	21.1
12.7	21.4
12.7	21.1
15.9	19.7
15.9	19.3

TEST VEHICLE: Ford LTD 8A1-351W-F-64
INERTIA WEIGHT CATEGORY: 5000 pounds