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Technical Report

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

by
Glenn D. Thompson

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

Abstract

The question of the representativeness of the requested dynamometer power absorption for the Ford Fiesta was first raised during the summer of 1977. At that time, it was observed that the dynamometer power absorption requested for fuel economy measurements, 5.4 horsepower, was about 35 percent lower than the value predicted by the dynamometer power absorption versus weight table of the Federal Register.

This report compares the road and dynamometer data collected by EPA to determine the appropriate dynamometer adjustment for the Ford Fiesta to similar data submitted by Ford Motor Company in support of the alternate dynamometer adjustment requested for this vehicle.

The EPA tests concluded that a dynamometer power absorption of 7.3 horsepower is appropriate to simulate the road experience of the Ford Fiesta. The discrepancy of 1.8 horsepower between the dynamometer power absorption results obtained by EPA and those requested by Ford for fuel economy measurements is a result of significantly different road coastdown times obtained from the two test vehicles. The differences in ambient conditions during the test periods may be the source of some of the observed coastdown time differences. However, it is concluded that there remains a dynamometer absorption discrepancy of at least one horsepower which cannot be explained by the differences in the ambient condtions.

The EPA results are considered more typical of the average road load experienced by this vehicle because:

1. The EPA tests were conducted on a production vehicle.

2. The ambient conditions at the time of the EPA tests more nearly represent the average national ambient conditions.

3. Requests for alternate dynamometer power absorption from other manufacturers are in better agreement with the EPA results than those submitted by Ford.

The EPA exhaust emission tests were performed using a dynamometer adjustment of 7.5 horsepower, requested by Ford prior to their final request of 5.4 horsepower. This earlier request is in good agreement with the EPA test results, therefore, it is concluded that no discrepancies exist in the exhaust emission measurements.

The final Ford request for a dynamometer adjustment of 5.4 horsepower was used for fuel economy measurements. It is concluded that the highway fuel economy measurements were approximately three mpg greater, and the composite fuel economy was approximately one mpg greater than would have been obtained at the dynamometer adjustment obtained from the EPA road measurements.

Purpose

This report compares the road and dynamometer data collected by EPA to determine the appropriate dynamometer adjustment for the Ford Fiesta to similar data submitted by Ford Motor Company in support of the alternate dynamometer adjustment requested for this vehicle.

Background

The question of the representativeness of the requested dynamometer power absorption for the Ford Fiesta was first raised during the summer of 1977. At that time, it was observed that the dynamometer power absorption requested for this vehicle, 5.4 horsepower, was about 35 percent lower than the value predicted by the dynamometer power absorption versus weight table of the Federal Register. Also, the requested dynamometer power absorption was significantly lower than the alternate dynamometer power absorptions requested for similar small, front wheel drive vehicles such as the VW Rabbit, the Honda Civic, and the Chrysler Omni Horizon.

Discussion

The data originally suibmitted by Ford in support of their requested alternate dynamometer adjustment are given in Table 1.

Table 1

Ford Results for a Prototype Fiesta

Average Corrected Road Coastdown Times (sec)	Dynamometer Power Absorption (horsepower)
11.61	5.4

The description of the test vehicle and the plot of the vehicle-dynamometer coastdown times versus the dynamometer power absorptions, provided by Ford are given in Appendix A.

In October, 1977, the 1978 model year vehicles became available in the rental car fleet. EPA subsequently rented a Ford Fiesta 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 test.

A. The Road Measurements

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 break-in. The vehicle system was then allowed to equilibrate to ambient temperature overnight. 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 skid pad. 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, 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 verus 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.

Addtional 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 linearily dependent on the vehicle velocity.

The a_0 term 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 term represents the aerodynamic drag, an air density correction was applied to this term to correct to the the standard ambient conditions givn in the EPA Recommended Practice. The corrected coefficients which were obtained are:

$$a_0^* = 0.3476 \text{ mi/hr-sec}$$
$$a_2^* = 0.0002478 \text{ hr/mi-sec} \qquad (2)$$

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 differences 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:

$$\Delta T = 9.86 \text{ Seconds} \qquad (3)$$

B. The Dynamometer Measurements

The dynamometer phase of the Fiesta road load determination was performed at the EPA MVEL. The test procedure used was the EPA Recommended Practice for Vehicle-Dynamometer Coastdowns. The vehicle was first warmed up by driving over two EPA highway fuel economy cycles and then coastdown times were measured using a digital electronic stopwatch. The measurements were conducted on each of the four light-duty certification dynamometers which were available at the time of the test program. The resulting test data are presented in Table 1 of Appendix B and a plot of the values is also presented in this Appendix. The results of the EPA test program are summarized in Table 2.

Table 2

EPA Production Vehicle Results

Corrected Road Coastdown Time (sec)	Average Dynamometer Power Absorption (horsepower)
9.9	7.3

There is a significant discrepancy between the results reported by Ford and those obtained by EPA. The corrected coastdown times differed by approximately 1.8 seconds and the resulting dynamometer adjustments differed by 1.9 horsepower. A review of the data indicate that the difference between the road coastdown times is the source of the dynamometer power absorption discrepancy. For example, assuming a dynamometer target coastdown time of 11.6 seconds, the EPA dynamometer data yield a dynamometer power absorption of 5.2 horsepower, which is in good agreement with the Ford request of 5.4 horsepower. Both the Ford and EPA data sets are

plotted in the figure of Appendix B, demonstrating the good agreement of the dynamometer data.

Reviewing the test vehicle descriptions does not indicate any obvious probable cause for the large difference between the road coastdown times. The vehicle tires were the same type, size, and produced by the same manufacturer for each vehicle. Also, the test weights were approximately equivalent. The test conditions, and the chosen standard conditions were however, somewhat different. The primary difference was the test temperature, 61°F for the EPA tests versus 82°F for the Ford tests, and the standard condition temperature, 68°F for EPA versus 74°F for Ford. The temperature differences can account for some of the differences in the corrected coastdown times, but not nearly the observed difference. The difference in the standard ambient conditions would change the corrected coastdown times by only a few tenths of a second. Even if no temperature corrections were used, the worst possible case, the difference in the actual test conditons of approximately twenty degrees would be exptected to change the road coastdown times by less than 0.6 seconds. This still leaves over one second, or more than one horsepower which cannot be explained by temperature differences.

During the EPA tests the wind velocity was slightly higher, 9 mph versus 5 mph reported during the Ford tests. This could account for some decrease in the EPA coastdown times, but since both the EPA and Ford results are corrected to zero head-tail wind conditions, any residual wind effects should be small.

It was hypothesized that the observed coastdown time differences might have been induced by abnormal non-driving wheel brake drag during the EPA road tests. The brake drag of the non-driving wheels was investigated when the EPA test vehicle was at the EPA MVEL. At this time no significant drag of either non-driving wheel brake was observed.

The observed differences in the vehicle coastdown times appear to be the result of some vehicle or vehicle component differences between the two test vehicles. The EPA test vehicle was a rental production vehicle prepared prior to the tests by a Ford dealer. In addition, the ambient test conditions during the EPA tests were much nearer the national average weather conditions than the 82^{o} temperatures observed during the Ford road load measurements. Consequently, the EPA measurements are believed to be more typical of the average road load experienced by this vehicle in consumer service.

An additional reason to believe the EPA results are more appropriate for this vehicle is comparison of the EPA results versus the alternate dynamometer power absorption requests from other manufacturers. Table 3 presents the EPA results and the Ford results versus the requests from other manufacturers of similar small front wheel drive vehicles.

Table 3

Average Requested Dynamometer Power Absorption
for 1978 Model Year Vehicles

Vehicle (equipped with radial tires)	Dynamometer Power Absorption (horsepower)
Honda Civic	7.8
VW Rabbit	7.3
Chrysler Omni-Horizon	6.9
Renault Le Car	7.5
Ford Fiesta (EPA results)*	7.3
Ford Fiesta (Ford results)	5.4

*Data, except this entry were supplied by the EPA Certification Division, 1977.

C. Analysis of Emission and Fuel Economy Effects of the Requested Alternate Dynamometer Power Absorption

In the process of investigating the possible effects of the requested dynamometer adjustment on vehicle emissions and fuel economy it was discovered that Ford Motor Company originally requested a dynamometer adjustment of 7.5 horsepower for this vehicle. The request was later revised to the lower value of 5.4 horsepower. The emissions tests for the vehicle were performed at the higher, original dynamometer power absorption request. Since this request is in very good agreement with the EPA measurements of 7.3 horsepower, the certification tests were conducted with dynamometer power absorption appropriate for the vehicle. Therefore, no degradation of the exhaust emission test results would be expected if these tests were conducted at the EPA determined dynamometer adjustments.

The second dynamometer power absorption request from Ford, 5.4 horsepower, was used for the fuel economy measurements. Since fuel economy measurements were also obtained from the certification tests, a direct measurement of the fuel economy benefit which occurred because of the reduced dynamometer power absorption was obtained. Table 4 summarizes the fuel economy test results which were obtained by EPA for the Ford Fiesta.

Table 4

Average EPA Fuel Economy Results
versus
Dynamometer Power Absorption

Dynamometer Power Absorption (hp)	Average Measured Fuel Economy (mpg)		
	Urban	Highway	Composite
7.5	32.0	41.1	35.5
5.4	32.0	44.2	36.5

Data supplied by EPA Certification Division

Table 4 demonstrates the fuel economy results obtained from the Fiesta were significantly improved by the reduction in the dynamometer power absorption. Since a greater number of fuel economy measurements were conducted at the lower horsepower these results would predominate in the calculation of the Fiesta contribution to the corporate average fuel economy for Ford.

Conclusions

There is a discrepancy of 1.8 horsepower between the dynamometer power absorption results obtained by EPA and those requested by Ford for fuel economy measurements. This discrepancy is a result of significantly different road coastdown times obtained from the two test vehicles. The differences in ambient conditons during the test periods may be the source of some of the observed coastdown time differences. However, it is concluded that there remains a dynamometer power absorption discrepancy of at least one horsepower which cannot be explained by differences in the ambient conditions.

The EPA results are probably more typical of the average road load experienced by this vehicle because:

1. The EPA tests were conducted on a rented production vehicle.

2. The ambient conditions at the time of the EPA tests more nearly represent the average national ambient conditons.

3. Requests for alternate dynamometer power absorption from other manufactuers are in better agreement with the EPA results than those submitted by Ford.

The EPA exhaust emission tests were performed using a dynamometer adjustment of 7.5 horsepower, requested by Ford prior to their final request of 5.4 horsepower. This earlier request is in good agreement with the EPA test results, therefore, it is concluded that no discrepancies exist in the exhaust emission measurements.

The final Ford request for a dynamometer adjustment of 5.4 horsepower was used for fuel economy measurements. It is concluded that the highway fuel economy measurements were approximately three mpg greater, and the composite fuel economy was approximately one mpg greater than would have been obtained at the dynamometer adjustment obtained from the EPA road measurements.

APPENDIX A

Fiesta Data Submitted by Ford Motor Company

Test Vehicle Characteristics Supplied by Ford for the Fiesta

Vehicle: 1978 Ford Fiesta
Vehicle No: 564T218
Tires: 145 SR12 (Michelin)

Vehicle Road Test Data:

Total weight:	2060 pounds
Drive axle load:	1205 pounds
Front tire pressure:	26 psi
Rear tire pressure:	26 psi

Road Test Ambient Conditions:

Temperature:	82°F
Barometric pressure:	30.08 in. Hg
Wind:	5 mph

Corrected Road Coastdown Time:

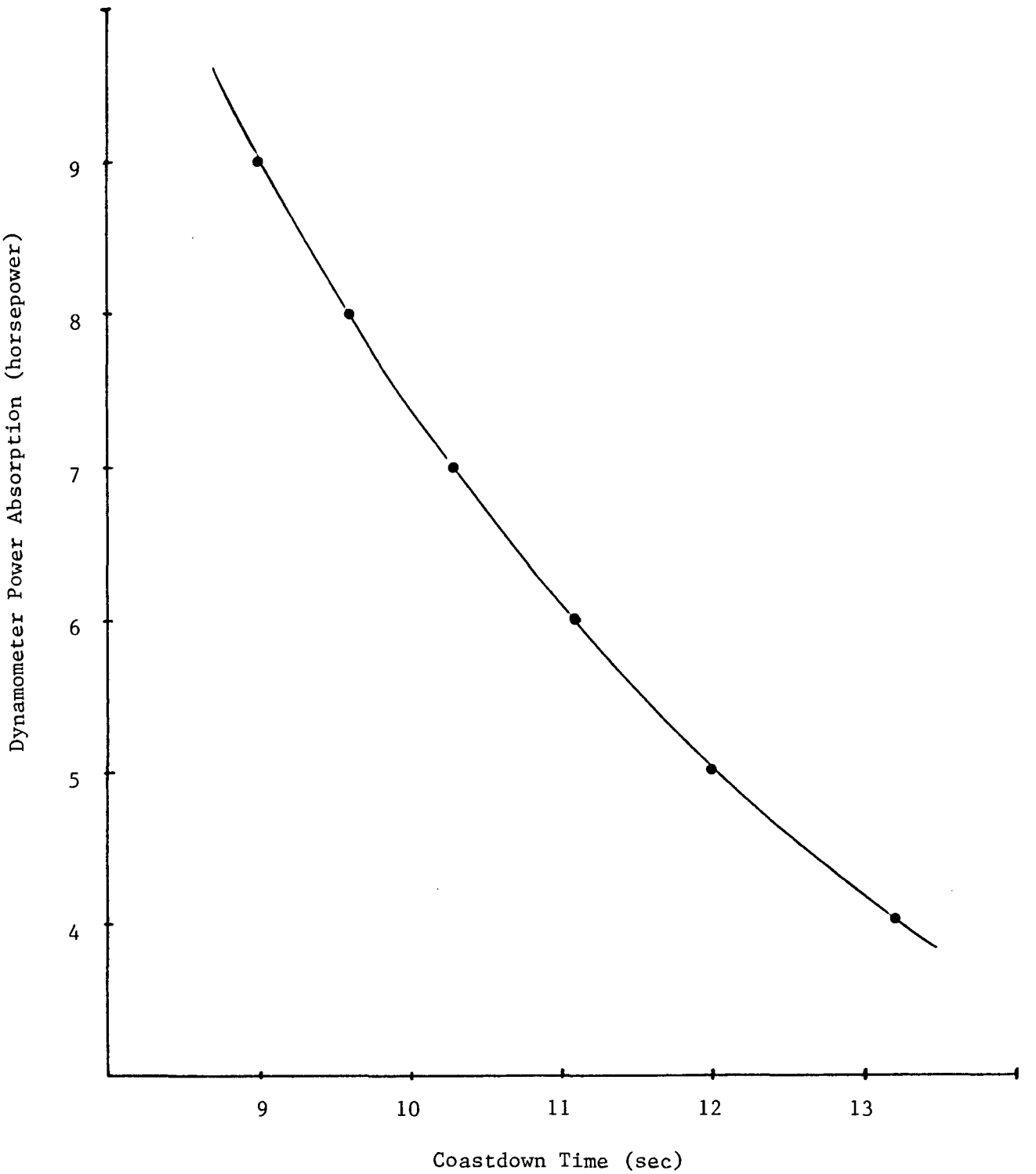
(74°F, 29.02 in. Hg, IWC = 2000 pounds) 11.61 sec.

Dynamometer Test Data:

	Test Cell 2
Total weight:	2041 pounds
Drive axle load:	1186 pounds
Rear tire pressure:	45 psi
Inertia weight category	2000 pounds
Dynamometer power absorption corresponding to a coastdown time of 11.61 seconds	5.4 horsepower

Ford Dynamometer Power Absorption
versus
Coastdown Time

Ford Fiesta
IWC = 2000 pounds



APPENDIX B

EPA Dynamometer Data from the Ford Fiesta Rental Vehicle

EPA Test Vehicle Characteristics for the Fiesta

Vehicle: 1978 Ford Fiesta
Tires: 145 SR12 (Michelin)

Vehicle Road Test Data:

Total weight:	2070 pounds
Drive axle load:	1180 pounds
Front tire pressure:	26 psi
Rear tire pressure:	26 psi

Road Test Ambient Conditions:

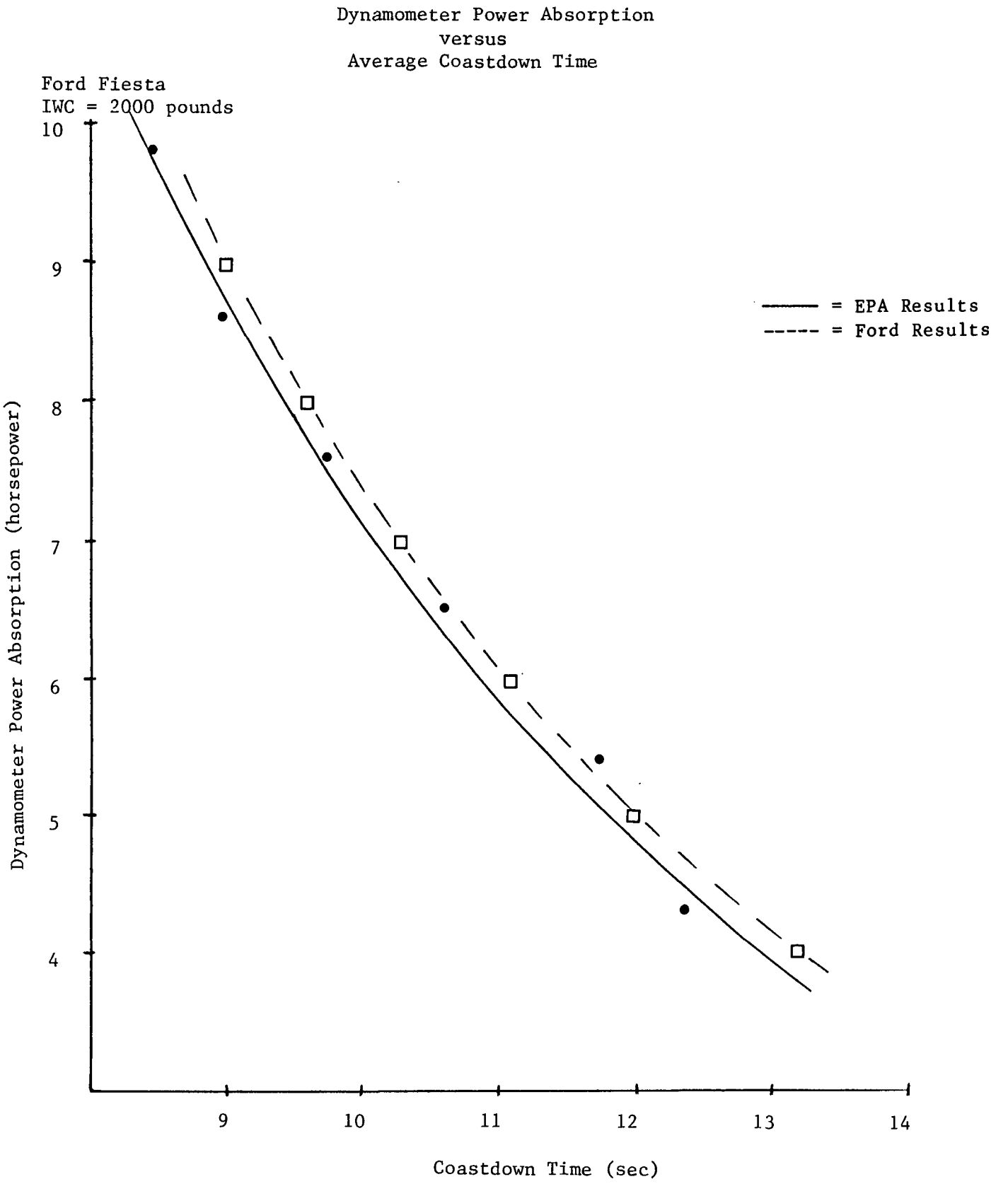
Temperature:	61°F
Barometric pressure:	29.06 in. Hg
Wind:	9 mph

Corrected Road Coastdown Time:

(68°F, 29.02 in. Hg, IWC = 2000 pounds) 9.86 sec.

Dynamometer Test Data:

Total weight:	1940 pounds
Drive axle load:	1220 pounds
Rear tire pressure:	45 psi
Inertia weight category	2000 pounds
Average Dynamometer power absorption corresponding to a coastdown time of 9.86 seconds	7.3 horsepower


Dynamometer Power Absorption
versus
Average Coastdown Time
Ford Fiesta
IWC = 2000 pounds
10
9
8
7
6
5
4
Dynamometer Power Absorption (horsepower)
9
10
11
12
13
14
Coastdown Time (sec)
——— = EPA Results
----- = Ford Results