Exhaust Emissions and Fuel Economy of a Diesel-Powered Citroen Sedan

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Background

The Environmental Protection Agency is interested in the feasibility of using the Diesel engine as a powerplant for light-duty vehicles. When compared to the Otto cycle engine, the Diesel engine generally exhibits lower fuel consumption and lower exhaust emissions. On the other hand, the Diesel engine typically has a lower power-to-weight ratio, is noisier, and has objectionable exhaust odors.

Generally, when a new Diesel-powered vehicle is developed, the EPA is interested in obtaining a prototype version of the vehicle for an evaluation of exhaust emissions and fuel economy. Such evaluations may be brief, consisting of characterization of fuel economy and HC, CO and NOx emissions. At other times, more extensive tests may be carried out to quantify odor, smoke and particulate emissions.

The Citroen Company of France is intending to enter a Diesel-powered car in the U.S market. Before attempting new vehicle certification, Citroen requested a test program at the EPA Ann Arbor, Michigan, laboratory to establish correlation between the Citroen laboratory and the EPA laboratory.

This report summarizes the exhaust emissions and fuel economy measured during the correlation program at the EPA laboratory. The conclusions from the EPA evaluation test can be considered to be quantitatively valid for the specific test vehicle used, however, it is reasonable to extrapolate the results from the EPA test to other similar vehicles in a directional or qualitative manner, i.e., to suggest that similar results are likely to be achieved on similar vehicles.

Test Vehicle Description

The vehicle supplied for the test program is a 1976 Citroen Pallas CX sedan. The engine is a four-cylinder Diesel with a prechamber type of combustion chamber. The engine is mounted transversely, and drives the front wheels through a four-speed manual transmission.

The vehicle was tested at an inertia weight of 3500 lbs. A compilation of pertinent vehicle statistics is given on the Vehicle Information sheet at the end of this report.

Test Program

Exhaust emission and fuel economy tests were conducted in accordance with the 1975 Federal Test Procedure ('75 FTP) for light-duty Diesel

vehicles (Federal Register, June 30, 1975, Vol. 40 No. 126, Part III). Testing included the '75 FTP, the EPA Highway Fuel Economy Test (HFET), measurement of steady state emissions, and acceleration time from 0-60 mph.

Test Results

Exhaust emissions and fuel economy of the Citroen Diesel are summarized in the following tables.

'75 FTP
Mass emissions in grams per mile (grams per kilometer)

	HC	CO	NOx	Fuel Economy (Fuel Consumption)
Average of 2 tests	0.40 (0.25)	1.8 (1.1)	1.54 (0.96)	24.9 miles/gal. (9.5 liters/100km)

HFET
Mass emissions in grams per mile (grams per kilometer)

	HC	CO	NOx	Fuel Economy (Fuel Consumption)
Average of 2 tests	0.16 (0.10)	0.7 (0.5)	1.46 (0.91)	32.1 miles/gal. (7.4 liters/100km)

Combining the '75 FTP and HFET using weighting factors of .45 and .55 respectively (and averaging harmonically), yields a combined fuel economy of 27.7 miles/gal.

Figure 1 shows the combined city/highway fuel economy of the Citroen Diesel relative to EPA Certification data for 1976 model vehicles. Diesel-powered passenger cars were not included in the calculation of the sales-weighted fuel economy. The combined city/highway fuel economy of the Peugeot 504 and Mercedes 240D are indicated as separate data points. The Peugeot and Mercedes are the only Diesel-powered vehicles in the 3500 lb. inertia class certified for 1976.

Tables I-III following the text of this report contain individual test data for the '75 FTP, HFET and steady state tests.

The acceleration time from 0-60 mph (average of 4 runs) is 26.0 seconds. For comparison, the acceleration time from 0-60 mph for a Mercedes 240D is approximately 23 seconds.

Conclusions

1. The Citroen Diesel demonstrated exhaust emissions below the levels required by the 1977 Federal emission standards. The emissions of the Citroen are similar to those of other Diesel-powered passenger cars tested by EPA. It should be noted that the Citroen had accumulated only 130 miles at the conclusion of the test program. Further testing would be required to verify that the exhaust emissions do not exceed allowable levels as mileage is accumulated. Federal regulations require that new vehicles meet applicable emission standards for 50,000 miles.

2. The fuel economy of the Citroen Diesel is average for Diesel-powered passenger cars in the 3500 lb. weight class. The fuel economy is superior to vehicles powered by spark-ignition engines, of the same weight class.

3. The acceleration capabilities of the Citroen Diesel are similar to other Diesel-powered vehicles in its weight class.

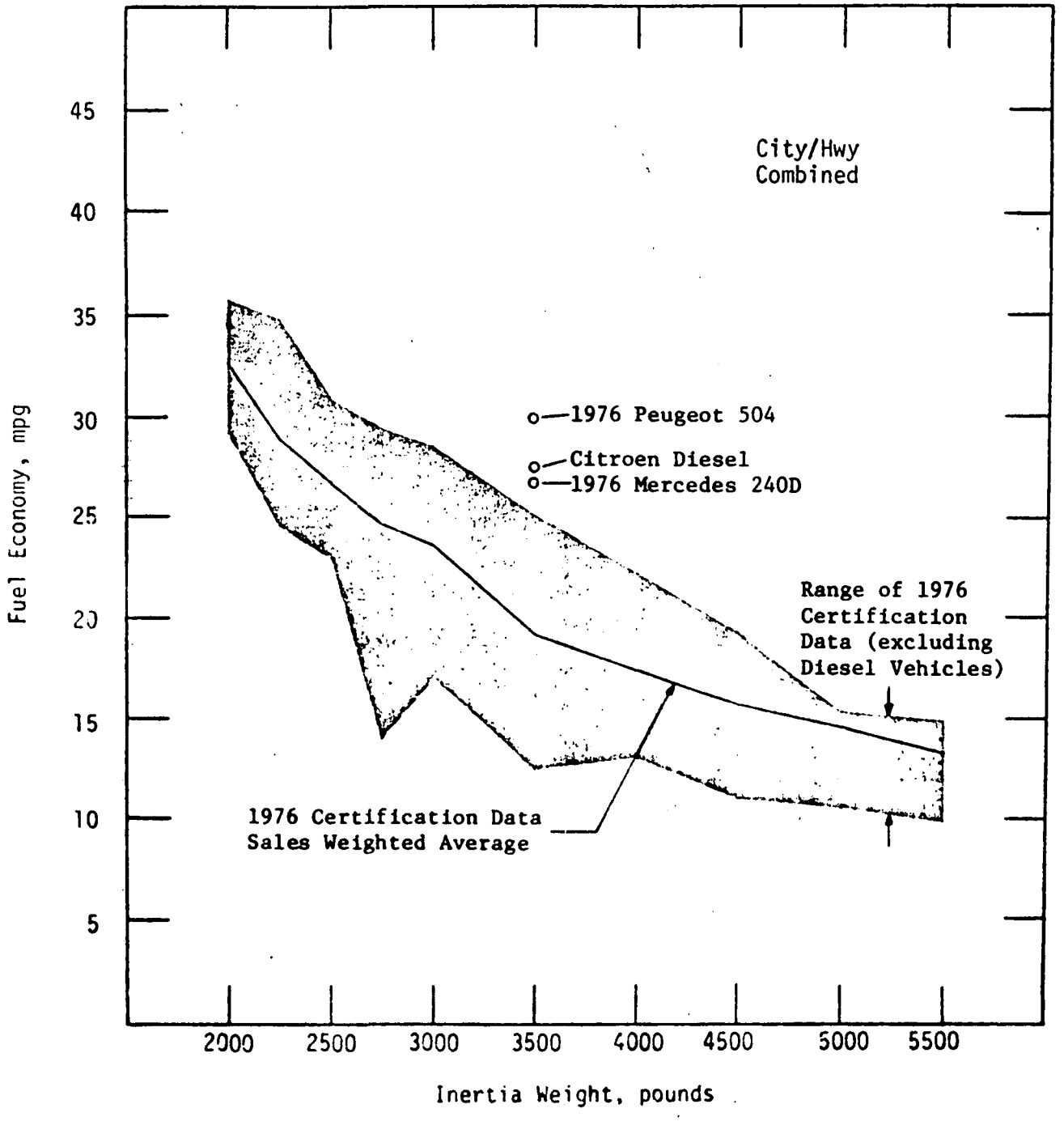

Figure 1: Fuel Economy Comparison

Table I

1975 Federal Test Procedure

mass emissions in

grams per mile

(grams per kilometer)

Test #	HC	CO	CO_2	NO_x	miles/gal (liters/100 km)
77-2837	0.40 (0.25)	1.7 (1.1)	396. (246.)	1.46 (0.91)	25.5 (9.2)
77-2845	0.39 (0.24)	1.8 (1.1)	416. (259.)	1.61 (1.00)	24.2 (9.7)
Average	0.40 (0.25)	1.8 (1.1)	406 (253.)	1.54 (0.96)	24.9 (9.5)

Table II

Highway Fuel Economy Test

mass emissions in

grams per mile

(grams per kilometer)

Test #	HC	CO	CO_2	NO_x	miles/gal (liters/100 km)
77-2839	0.16 (0.10)	0.7 (0.5)	317. (197.)	1.44 (0.90)	31.9 (7.4)
77-2841	0.16 (0.10)	0.7 (0.5)	314. (195.)	1.48 (0.92)	32.2 (7.3)
Average	0.16 (0.10)	0.7 (0.5)	316. (196.)	1.46 (0.91)	32.1 (7.4)

Table III

Steady State

Mass emissions in
grams per mile

(grams per kilometer)

	HC	CO	CO_2	NO_x	miles/gal. (liters/100km)
idle(300 secs)	0.63 gms	1.6 gms	142.gms	0.46 gms	
15 (24 kph)	0.71 (0.44)	3.7 (2.3)	475. (295.)	1.43 (0.89)	21.1 (11.1)
30 mph(48kph)	0.35 (0.22)	2.0 (1.2)	390. (242.)	1.58 (0.98)	25.9 (9.1)
45 mph(72kph)	0.23 (0.14)	1.0 (0.6)	370. (230.)	1.85 (1.15)	27.4 (8.6)
60 mph(97kph)	0.13 (0.08)	0.6 (0.4)	345. (214.)	1.56 (0.97)	29.4 (8.0)

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1976 Citroen Pallas cx
Emission control system - Engine Modifications

Engine

type . . . . . 4 stroke,Diesel Cycle, I-4,ohv
bore x stroke . . . . . 3.66 x 3.62 in./93 x 92 mm
displacement . . . . . 153 cu in./2500cc
compression ratio 22.3: 1
maximum power . . . . . 75 bhp
fuel metering . . . . . mechanical fuel injection
fuel requirement . . . . . # 2 Diesel

Drive Train

transmission type . . . . . 4 speed manual

Chassis

type . . . . . Front engine, front wheel drive
tire size . . . . . 185 R x 14
inertia weight . . . . . 3500 lbs.
passenger capacity 4

Emission Control System

basic type . . . . . .Engine modifications

durability accumulated on system . . . . . 120 mi/200 km