An Evaluation of a 1975 Prototype Chrysler Passenger Car

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Background

One of the most promising 1975 prototype vehicles reported to EPA during the Suspension Hearings of April 1972, was a Chrysler Corporation passenger car equipped with twin Engelhard catalytic converters. Based on the emission data from this vehicle, Chrysler was predicted to be able to comply with the 1975 Federal Emission Standards. After the completion of the 50,000 mile durability testing, Chrysler representatives agreed to loan this vehicle, designated car 333, to EPA for an evaluation in our Ann Arbor laboratory.

Vehicle Tested

Car 333 is an extensively modified 1971 Plymouth Fury equipped with a 360 CID V-8 engine and an automatic transmission. The heart of the emission control system used on the vehicle is a pair of Engelhard catalytic converters. These monolithic platinum converters were installed in each side of the exhaust system about as far back as the front seat. Additional modifications included exhaust gas recirculation (EGR) and air injection.

At the beginning of our series of tests on the vehicle the odometer registered 58,500 miles. One of the two catalysts had been on the vehicle since the beginning of mileage accumulation. The other catalyst was a replacement for one of the vehicle's original converters which had been removed for laboratory analysis. The replacement catalyst was another Engelhard unit with several thousand miles accumulated on it at the time of EPA testing.

Test Program

A series of tests were run on car 333 to determine what the emission levels from such a system would be in a variety of different vehicles. Chassis dynamometer loadings were varied to simulate passenger car weights, with two passengers, of 3000, 4500 and 5500 pounds. Replicate tests at each of these inertia weights were run. At 4500 pounds two different configurations were tested. First the vehicle was run without any adjustments and then it was run with the dashboard EGR switch in the "off" position.

Using a special "medium duty" dynamometer the vehicle was evaluated at elevated horsepower and inertia weight settings. During a recent procedures development program the horsepower requirements of medium duty (6000 GVW to 14,000 GVW) vehicles were determined. At 6000 pounds test weight the dynamometer was set at 31.5 horsepower at 50 mph. 6000 pound test weight passenger cars are tested with only 14.4 hp at 50 mph. The increase in road load horsepower in the medium duty testing reflects the increase in frontal area of lightly loaded truck-type vehicles compared to passenger cars of equivalent weights. At 7000 pounds test weight the 50 mph horsepower was set at 41.9.

Fuel consumption over the Federal urban driving cycle was determined during each test using both carbon balance and weighing techniques.

The 1975 Federal Test Procedure was used throughout the testing. A description of the Federal procedure is attached as Appendix I.

In addition to the chassis dynamometer testing, an "over the road" comparison between car #333 and a 1972 Plymouth Fury rental car was made.

Test Results

A summary of the test results appears in Tables I, II, and III. Table I consists of data accumulated when the vehicle was tested as if it was a passenger car of three different weights. Besides the standard test weight of 4500 pounds, the vehicle was tested at 3000 pounds and 5500 pounds. As shown graphically in Figure I, there was a pronounced effect on NOx emissions when different vehicle weights were simulated. An 86% increase in NOx emissions occured when the test weight was changed from 3000 pounds to 5500 pounds. Hydrocarbon and carbon monoxide emissions also tended to increase as test weight increased but the trend was less pronounced.

The 4500 pound tests were the first run by EPA on this vehicle. Prior to EPA testing the car operated on unleaded fuels other than "indolene clear" test fuel for over 2000 miles. With the first EPA test (number 12-2356) a step change in fuel type was made. It is possible that this step change in fuel type caused the lack of stability during these first tests.

Also presented in Table I are data accumulated at 4500 pounds with the vehicle's dashboard EGR switch in the "off" position. It is not known if this switch completely eliminated EGR or only reduced the EGR rate. Shutting off this EGR switch caused a significant increase in NOx emissions and significant decreased in HC and CO emission. The effect on fuel consumption was insignificant.

Since it is possible to determine emissions and carbon balance fuel consumption values for a 1972 Federal Test Procedure (FTP) from analysis of the first two bags of a 1975 FTP, a comparison of fuel consumption data from car #333 with data from 1973 model year certification vehicles was made. Running with full EGR and less than one-half the NOx level required for 1973-75 the 1975 prototype got 4% better fuel economy than the average of all 1973 certification vehicles of the same weight. The Chrysler 1975 prototype demonstrated a 6% improvement over its 1973 counterpart, the 360 CID Plymouth.

1972 FTP
(All data in miles per gallon)

Vehicle	MPG
Average of all 1973 certification vehicles tested at 4500 I.	10.13
Average of 360 Plymouth 1973 certification cars (4500 I)	9.92
Average of last three car #333 at 4500 I with full EGR	10.5

Table II presents data on the "medium duty vehicle" simulation. The hydrocarbon levels do not appear to be significantly different than the levels achieved during the lgiht duty (passenger car) testing. The HC levels are, however, somewhat questionable due to the higher background levels present in our medium duty testing area. HC measurement was difficult in bags two and three due to the higher dilution rates obtained with the large medium duty CVS unit. Carbon monoxide levels were somewhat higher than those obtained during the light duty testing but a high degree of control was maintained. The catalyst temperature gauge installed on the vehicle indicated that there was no danger of overtemperature during LA4 driving cycle operation. The vehicle had no difficulty in keeping up with the speed vs. time trace at either 6000 or 7000 pounds test weight.

NOx emissions measured during medium duty operation were significantly higher than NOx measured during light duty testing. Tests were run at 6000 pounds with and without the EGR switch turned on. The data indicates that the EGR system was just as effective during the medium duty simulation as during the passenger car testing. The EGR accounted for a 50% NOx decrease in both cases.

Table III presents the data recorded during 60 mph cruise operation at the standard test weight of 4500 pounds. HC, CO, and NOx emissions were very low and the fuel economy was excellent.

When the driveability and performance of car #333 was compared to a 1972 Plymouth Fury rental car (360 CID engine) no significant differences were noticed. Neither vehicle had any adverse driveability characteristics. The acceleration performance of both vehicles was almost identical. Zero to sixty mile per hour acceleration times were about 11.5 seconds for both cars.

Conclusions

1. After EGR rate was reduced, Chrysler prototype #333 demonstrated the ability to achieve the emission levels required for model year 1975 with high mileage on one catalyst and low mileage on the other catalyst.

2. Reducing EGR rate caused significant increased in NOx emissions and significant reductions in HC and CO emissions.

3. NOx emissions were a function of vehicle test weight. An 83% increase in weight (from 3000# to 5500#), caused an 86% increase in NOx emissions.

4. HC and CO emissions did not change significantly as test weight was varied.

5. The fuel economy of prototype #333 was better than the fuel economy of the average 1973 certification vehicle of the same weight.

6. The fuel consumption measured at different inertia weights did not change drastically. This is probably due to more efficient power to weight ratios at the higher loadings.

7. Reducing the EGR rate did not cause significant changes in fuel economy. This testing indicates that EGR systems can be designed to reduce NOx emissions without adversely affecting fuel consumption. The EGR system on car #333 was a proportional system.

8. Exhaust emissions and fuel economy at 60 mph cruise condition were both very good. Unlike many 1973 models and other advanced prototypes tested, the Chrysler 1975 prototype did not have provisions for switching off emission control systems when conditions specific to the LA4 (Federal) driving cycle are not

encountered. At 60 mph cruise the NOx emissions from car #333 were much lower than several 1976 prototypes previously tested because NOx control was maintained. Catalyst temperatures at 60 mph cruise were lower than during portions of the LA4 cycle. There apparently is no need to bypass the catalyst system just because expressway speeds are encountered. Fuel economy at 60 mph cruise calculated to be over 18 miles per gallon.

9. Overall acceleration performance and driveability of car #333 was as good as the 1972 production counterpart.

10. Data from the "medium duty" simulation indicates that the catalytic converters could maintain a high level of control under much higher loading conditions than normally found in passenger car operation. NOx levels were significantly higher during the medium duty simulation but the EGR system was still quite effective.

TABLE I

1975 Federal Test Procedure
(all data in grams per mile)

3000# Inertia w/EGR

Test Number	HC	CO	NOx	MPG
12-2368	.38	5.47	.88	11.1
12-2373	.39	4.22	1.05	10.9
AVERAGE	.39	4.85	.97	11.0

4500# Inertia w/EGR

Test Number	HC	CO	NOx	MPG
12-2356	.69	8.14	1.72	10.6
12-2361	.65	7.44	1.52	10.3
12-2362	.50	6.35	1.47	10.5
12-2393	.44	5.10	1.34	9.9
12-2401	.56	4.60	1.34	10.4
12-2409	.44	3.93	1.43	10.9
12-2413	.43	4.24	1.32	11.5
AVERAGE	.53	5.69	1.45	10.6
AVERAGE of Last Three	.48	4.26	1.36	10.9

4500# Inertia wo/EGR

Test Number	HC	CO	NOx	MPG
12-2399	.31	3.76	2.51	10.8
12-2404	.33	2.80	2.92	11.2
AVERAGE	.32	3.28	2.72	11.0

5500# Inertia w/EGR

Test Number	HC	CO	NOx	MPG
12-2379	.49	6.07	1.81	9.8
12-2383	.51	5.71	1.78	10.0
AVERAGE	.50	5.89	1.80	9.9

TABLE II

1975 Federal Test Procedure
(all data in grams per mile)

Medium Duty Vehicle Simulation

6000# Inertia w/EGR

Test Number	HC	CO	NOx	MPG
12-2417	.20	4.99	3.52	8.52
12-2419	.34	5.89	3.39	8.63
AVERAGE	.27	5.44	3.46	8.57

6000# Inertia wo/EGR

Test Number	HC	CO	NOx	MPG
16-0009	.39	5.77	7.08	8.7

7000# Inertia w/EGR

Test Number	HC	CO	NOx	MPG
18-0495	.39	6.74	4.86	7.4
18-0499	.21	8.32	4.50	8.1
AVERAGE	.30	7.53	4.68	7.8

TABLE III

60 MPH Steady State
(all data in grams per mile)

4500# Inertia w/EGR

	HC	CO	NOx	MPG
60 mph Cruise	.07	1.40	1.01	18.7

NO_X LEVEL vs INERTIA WEIGHT

CHRYSLER '75 PROTOTYPE WITH EGR

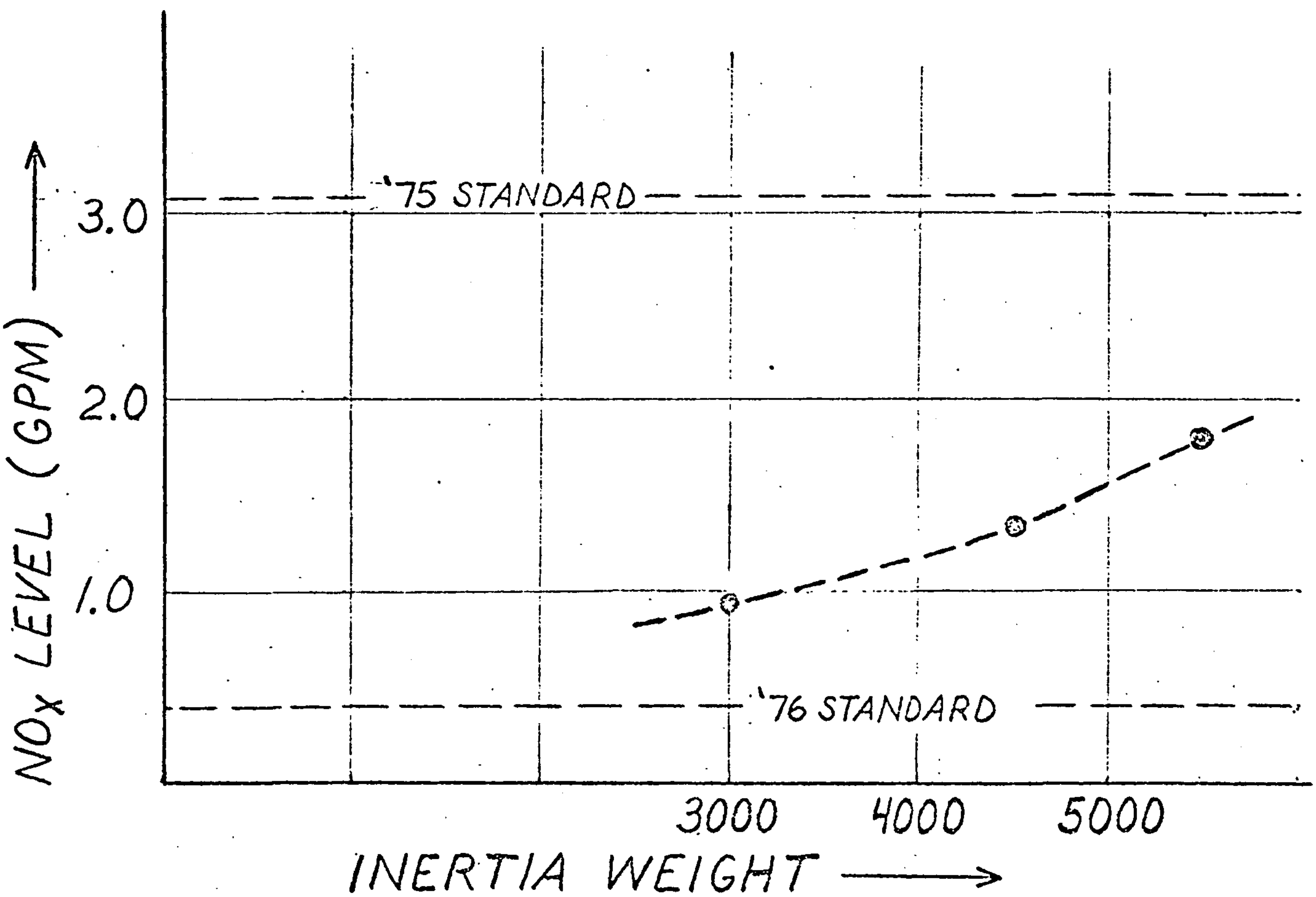

FIGURE 1.

FEDERAL EMISSION TESTING PROCEDURES FOR LIGHT DUTY VEHICLES

The Federal procedures for emission testing of light duty vehicles involves operating the vehicle on a chassis dynamometer to simulate a 7.5 mile (1972 procedure) or 11.1 mile (1975 procedure) drive through an urban area. The cycle is primarily made up of stop and go driving and includes some operation at speeds up to 57 mph. The average vehicle speed is approximately 20 mph. Both the 1972 and 1975 procedures capture the emissions generated during a "cold start" (12-hour soak @ 68°F to 86°F before start-up). The 1975 procedure also includes a "hot start" after a ten minute shut-down following the first 7.5 miles of driving.

Vehicle exhaust is drawn through a constant volume sampler (CVS) during the test. The CVS dilutes the vehicle's exhaust to a known constant volume with make up air. A continuous sample of the diluted exhaust is pumped into sample bags during the test.

Analysis of the diluted exhaust collected in the sample bags is used to determine the mass of vehicle emissions per mile of operation (grams per mile). A flame ionization detector (FID) is used to measure unburned hydrocarbon (HC) concentrations. Non-dispersive infrared (NDIR) analyzers are used to measure carbon monoxide (CO) and carbon dioxide (CO_2). A chemiluminescence (CL) analyzer is used to determine oxides of nitrogen (NOx) levels.

These procedures are used for all motor vehicles designed primarily for transportation of property and rated at 6,000 pounds GVW or less, or designed primarily for transportation of persons and having a capacity of twelve persons or less. Each new light duty vehicle sold in the United States in model years 1973 and 1974 must emit no more than 3.4 gpm HC, 39. gpm CO and 3.0 gpm NOx when using the 1972 procedure. In 1975 the standards will change to .41 gpm HC. 3.4 gpm CO and 3.1 gpm NOx using the 1975 procedure. In 1976 the standards will be .41 gpm HC, 3.4 gpm CO and .4 gpm NOx using the 1975 procedure.