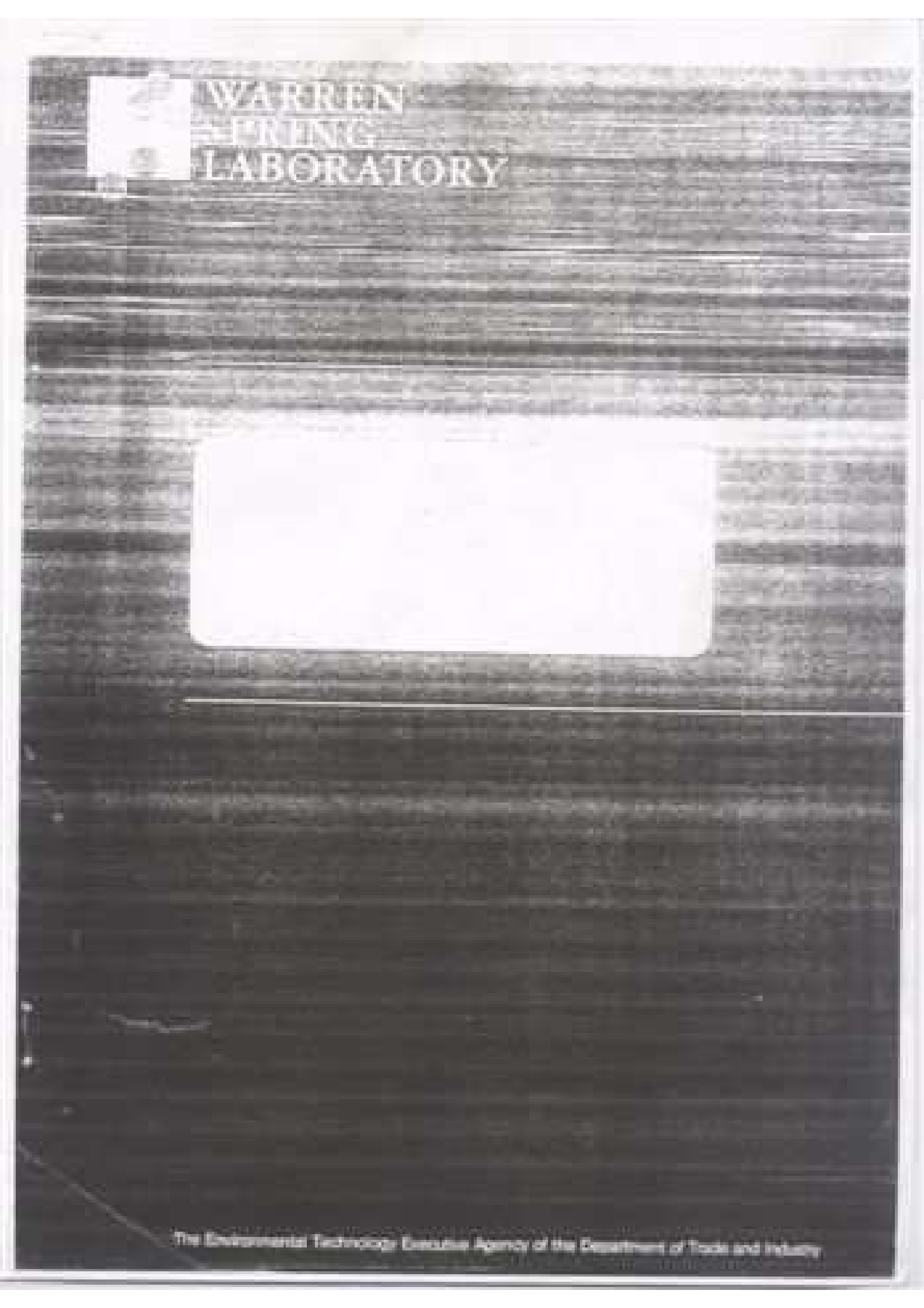

WARREN SPRING LABORATORY
The Environmental Technology Executive Agency of the Department of Trade and Industry

1 The Effect on Exhaust Emissions and Power Output of Fitting a FUEL CAT Fuel Treatment Device to a FORD ESCORT Diesel Car

1. INTRODUCTION

This report describes a programme of work carried out at the Warren Spring Laboratory for Power Makers Limited. A Ford Escort diesel estate car was used to measure the differences in exhaust emissions and power output which were effected by fitting a FUEL CAT fuel treatment device.

2. TEST PROGRAMME

To measure the effect of the device a production on - road vehicle was used as a test vehicle. The vehicle was taken directly from service and tested to obtain a set of "baseline" results. At the end of these tests the FUEL CAT device was fitted according to the manufacturers instructions and the tests were repeated. These were labelled the "+ Device" condition. The vehicle was then returned to normal service to accumulate mileage. The drivers of the vehicle during this period were not aware that the vehicle was under test and were not issued with any special operating instructions. After 2000 miles and again after 3500 miles the vehicle was temporarily withdrawn from service and the tests repeated on each occasion.

2.1 Test Vehicle

The test vehicle used was a 1.8 litre, normally aspirated, Ford Escort estate car first registered in 1991. It has been owned from new by WSL and it is known that the engine has not been modified from makers specification. At the start of the test period the vehicle had covered ***** recorded miles.

2.2 Test Cycles

The vehicles was subject to two types of tests both carried out on a chassis dynamometer (rolling road).

2.2.1 Power Tests

For these tests the vehicle was driven on the dynamometer with the throttle held wide open. The vehicle speed was then controlled by altering the dynamometer loading. For the first, baseline, tests speed, power absorbed and dynamometer setting were recorded for each of six conditions. In subsequent tests the six previously recorded dynamometer settings were repeated and the resulting road speed and power output recorded.

2.2.2 Steady State Emission Tests

Steady state emission tests were carried out at seven road speeds, 60 - 120 Kph in steps of 10 Kph. The dynamometer loading was set to reproduce the normal road loading of the vehicle. Speed control was effected by depressing the throttle pedal using a mechanical "foot".

Emissions were measured using a Constant Volume Sampler (CVS) in the manner prescribed in the current EEC legislation (91/441/EEC). Each test at one speed was of 6 minutes duration, this being the time required to collect sufficient particulate sample to meet the EEC criteria.

1. A consistent increase in the power output was recorded over the speed range 70 - 120 Kph.

2. The increase in power output was greatest at the two ends of the speed range and least in mid - range.

3. Carbon Monoxide emissions were reduced significantly after the device was fitted. The reduction has increased as the vehicle has accumulated mileage.

4. Particulates emissions reduced as mileage was accumulated with the device fitted.

5. These results apply only to the vehicle tested and possibly those of similar technology.

6. The test vehicle was a low emitter of CO and particulates. Some significant reductions of these pollutants, in percentage terms, were measured in the tests reported here. It is not known if the same reductions would apply to a high emitting vehicle.

Figure 1 - Improvement in Power Output with Road Speed

3 RESULTS

3.1 Power Tests

The results of the power tests are given in Tables 1 and 2 below. Table 1 records the effect of the device on the road speed and Table 2 gives the corresponding effects on power output. The nominal target speeds for these tests were 70,80,90,100,110 and 120 Kph.

Table 1 Effect of Device on Road Speed

Test Condition	Road Speed Kph					
Baseline	70.6	80.5	90.8	100.7	109.9	120.5
+ Device	74.6	83.7	93.2	102.1	111.2	122.4
+ 2000 miles	74.3	83.2	91.1	101.5	110.4	121.4
+ 3500 miles	74.5	83.1	90.9	101.9	111.4	122.4
Difference %[1]						
+ Device	+5.7	+4.0	+2.9	+1.4	+1.2	+1.5
+ 2000 miles	+5.2	+3.4	+0.4	+0.8	+0.8	+2.5
+ 3500 miles	+5.5	+3.0	+0.5	+1.2	+1.4	+2.4

Table 2 Effect of Device on Power Curves

Test Condition	Power Kw					
Baseline	14.0	17.3	20.9	22.8	24.1	21.4
+ Device	16.3	19.3	21.6	23.1	24.8	26.9
+ 2000 miles	16.1	19.0	21.1	23.2	24.6	27.4
+ 3500 miles	16.2	18.8	20.7	23.4	24.9	27.1
Difference %[1]						
+ Device	+16.4	+11.6	+5.3	+1.3	+2.9	+4.3
+ 2000 miles	+15.0	+ 9.8	+2.9	+1.8	+2.1	+6.7
+ 3500 miles	+15.7	+ 8.7	+1.0	+2.6	+3.3	+6.7
MEAN	+15.7	+10.0	+3.1	+1.9	+2.8	+5.9

[1] Difference calculated from:-

Diff.% = (Reading - Baseline)/ Baseline *100

The mean power improvement is shown plotted against nominal road speed in Figure 1 at the end of this report.

Emissions were measured using a Constant Volume Sampler (CVS) in the manner prescribed in the current EEC legislation (91/441/EEC). Each test at one speed was of 6 minutes duration, this being the time required to collect sufficient particulate sample to meet the EEC criteria.

3. RESULTS

3.1 Power Tests

The results of the power tests are given in Tables 1 and 2 below. Table 1 records the effect of the device on the road speed and Table 2 gives the corresponding effects on power output. The normal target speeds for these tests were 70, 80, 90, 100 and 120 Kph.

Table 1 Effect of Device on Road Speed

Test Condition	Road Speed Kph					
Baseline	70.6	80.5	90.6	100.7	109.9	120.3
+ Device	74.6	83.7	93.2	102.1	111.2	122.4
+ 2000 miles	74.3	83.2	91.1	101.5	110.8	123.4
+ 3500 miles	74.3	82.1	90.9	101.9	111.4	123.4
[1] Difference %						
+ Device	+5.7	+4.0	+2.9	+1.4	+1.2	+1.6
+ 2000 miles	+5.2	+3.4	+0.6	+0.8	+0.8	+2.4
+ 3500 miles	+5.5	+2.0	+0.3	+1.2	+1.4	+2.4

Table 2 Effect of Device on Power Output

Test Condition	Power Kw					
Baseline	14.0	17.3	20.5	22.8	24.1	25.4
+ Device	16.3	19.3	21.6	23.1	24.8	26.5
+ 2000 miles	16.1	19.0	21.1	23.2	24.6	27.1
+ 3500 miles	16.2	18.8	20.7	23.4	24.9	27.1
[1] Difference %						
+ Device	+16.4	+11.6	+5.3	+1.3	+2.9	+4.3
+ 2000 miles	+15.0	+9.8	+2.9	+1.8	+2.1	+6.7
+ 3500 miles	+15.7	+8.7	+1.0	+2.6	+3.3	+6.7
MEAN	+15.7	+10.0	+3.1	+1.9	+2.8	+5.9

1 Difference calculated from :-

Diff % = (Reading - Baseline) / Baseline * 100

The mean power improvement is shown plotted against nominal road speed in Figure 1 at the end of this report.

3.2 Steady State Emissions

Steady state emissions were calculated, as grammes of pollutant emitted per kilometre travelled (g/Km), for Carbon Dioxide (CO2), Carbon Monoxide (CO), Hydrocarbons (HC), Oxides of Nitrogen (NOx) and Particulates. Fuel consumption by the cars calculated using the carbon balance method and expressed as litres of fuel required to travel 100 Km (l/100Km).

3.2.1 Carbon Dioxide

The CO2 emission rates at the seven set speeds are given in Table 3 below. Differences are calculated as a proportion of the baseline emissions. The differences are shown plotted against target speed in Figure 2

Table 3 Carbon Dioxide Emissions

Road Speed Kph	60	70	80	90	100	110	120
Emissions g/Km							
Baseline	108.0	113.2	120.5	133.3	144.0	167.5	193.3
+ Device	92.1	99.9	108.8	118.0	135.8	147.8	172.6
+ 2000 miles	93.9	101.4	110.6	120.1	136.8	150.5	177.9
+ 3500 miles	99.5	106.9	120.5	133.6	144.8	166.7	194.1
Difference %							
+ Device	-14.7	-11.0	- 8.9	-12.8	- 6.0	-11.8	-10.7
+ 2000 miles	-11.0	- 9.6	- 8.2	-11.2	- 5.0	- 6.7	- 8.0
+ 3500 miles	- 7.8	- 2.9	0.0	- 1.3	+ 0.6	- 1.8	+ 0.4
MEAN	-11.8	- 7.8	- 5.7	- 8.4	- 3.5	- 6.7	- 6.1

3.2.2 Carbon Monoxide

Carbon Monoxide emissions and differences are given in Table 4. Differences are shown plotted in Figure 3.

Table 4 Carbon Monoxide Emissions

Road Speed Kph	60	70	80	90	100	110	120
Emissions g/Km							
Baseline	0.182	0.231	0.289	0.291	0.353	0.499	0.618
+ Device	0.189	0.240	0.263	0.277	0.341	0.379	0.508
+ 2000 miles	0.174	0.189	0.200	0.206	0.293	0.407	0.453
+ 3500 miles	0.136	0.182	0.207	0.184	0.216	0.290	0.346
Difference %							
+ Device	+ 3.3	+ 3.9	- 9.0	- 4.8	- 3.9	-25.4	-17.8
+ 2000 miles	- 6.4	-13.9	-30.8	-29.2	-16.9	-17.9	-26.4
+ 3500 miles	-14.3	-21.2	-28.4	-36.8	-38.1	-41.6	-11.7
MEAN	- 3.1	-10.4	-23.4	-23.8	-20.0	-27.9	-20.0

3.2.3 Oxides of Nitrogen

Emissions and differences of Oxides of Nitrogen are given in Table 3. Differences are shown plotted in Figure 4.

Table 3 Emissions of Oxides of Nitrogen

Road Speed Kph	60	70	80	90	100	110	120
Emission g/Km							
Baseline	0.733	0.925	1.254	1.437	1.542	2.220	2.541
+ Device	0.547	0.788	1.066	1.266	1.430	1.786	2.040
+ 2000 miles	0.534	0.713	1.048	1.405	1.386	1.981	2.216
+ 3500 miles	0.639	0.780	1.196	1.348	1.517	2.034	2.356
Difference %							
+ Device	-25.4	-14.8	-15.0	-14.1	- 7.2	-19.5	-19.7
+ 2000 miles	-27.1	-22.7	-16.4	- 6.1	-10.1	-10.8	-12.8
+ 3500 miles	-12.8	-15.7	- 4.6	-10.0	- 1.6	- 8.3	- 7.2
MEAN	-21.8	-17.7	-12.0	- 7.4	- 6.3	-12.9	-13.2

3.2.4 Emissions of Particulates

Particulate emissions are given in Table 4 below. Differences are shown plotted against road speed in Figure 5.

Table 4 Particulate Emissions

Road Speed Kph	60	70	80	90	100	110	120
Emission g/Km							
Baseline	0.052	0.074	0.135	0.137	0.137	0.211	0.256
+ Device	0.054	0.084	0.112	0.124	0.144	0.158	0.212
+ 2000 miles	0.029	0.060	0.081	0.082	0.111	0.158	0.199
+ 3500 miles	0.025	0.048	0.068	0.063	0.077	0.114	0.135
Difference %							
+ Device	+ 3.8	+13.5	-20.8	- 9.4	+ 5.1	-25.1	-17.2
+ 2000 miles	-44.2	-18.9	-47.1	-40.1	-19.0	-25.1	-22.3
+ 3500 miles	-51.9	-35.1	-49.6	-54.0	-43.8	-46.0	-47.3
MEAN	-30.8	-13.5	-41.2	-34.3	-19.3	-32.1	-28.9

3.2.3 Calculated Fuel Consumption

Fuel consumption figures, calculated by the carbon balance method, are given in Table 7. Differences are shown plotted in figure 6.

Table 7 Fuel Consumption

Road Speed mph	60	70	80	90	100	110	120
Fuel l/100km							
Baseline	4.084	4.256	4.373	3.136	5.448	6.348	7.349
+ Device	3.493	3.793	4.171	4.685	3.158	3.616	4.559
+ 2000 miles	3.543	3.849	4.198	4.553	3.194	3.936	4.733
+ 3500 miles	3.781	4.136	4.378	5.030	5.497	6.250	7.378
Difference %							
+ Device	-14.5	-10.9	- 8.8	-13.8	- 3.7	-11.6	-10.7
+ 2000 miles	-12.9	- 9.6	- 8.2	-11.3	- 5.0	- 6.8	- 8.1
+ 3500 miles	- 7.4	- 3.8	+ 0.1	- 1.3	+ 0.9	- 1.8	+ 0.4
mean	-11.7	- 7.4	- 5.6	- 8.3	- 3.4	- 6.8	- 6.1

3.2.4 Hydrocarbon Emissions

Hydrocarbon emissions are given in Table 8 below. Diesel vehicles are not a stable source of HC emissions. A typical variance of 25% has been recorded even on a specially prepared test. This test vehicle was a low emitter of hydrocarbons and the variance between tests is likely to be great. A figure of 50% would not be unreasonable. For this reason the emissions are reported in Table 8 below but will not be commented upon further.

Table 8 Hydrocarbon Emissions

Road Speed mph	60	70	80	90	100	110	120
Emission g/km							
Baseline	0.048	0.061	0.061	0.068	0.081	0.073	0.073
+ Device	0.048	0.068	0.063	0.061	0.070	0.074	0.073
+ 2000 miles	0.058	0.058	0.057	0.054	0.053	0.064	0.062
+ 3500 miles	0.077	0.079	0.077	0.071	0.077	0.075	0.068
Difference %							
+ Device	0.0	+12.5	+ 6.6	- 7.8	+14.8	- 1.3	+ 2.7
+ 2000 miles	+18.4	+ 8.8	- 4.6	-22.3	-13.1	-16.7	-15.0
+ 3500 miles	+57.1	+19.7	+26.2	+ 7.4	+26.3	0.0	-14.1

6. CONCLUSIONS

1. A consistent increase in the power output was recorded over the speed range 70 - 120 kph.

2. The increase in power output was greatest at the two ends of the speed range and least in mid - range.

3. Carbon Dioxide emissions reduced considerably when the device was first fitted but the improvement has mostly been lost with accumulating mileage.

4. Carbon Monoxide emissions were reduced significantly after the device was fitted. The reduction has increased as the vehicle has accumulated mileage.

5. Oxides of Nitrogen were reduced when the device was fitted. The reductions decreased as mileage was accumulated.

6. Particulates emissions reduced as mileage was accumulated with the device fitted.

7. Fuel consumption has reduced in line with the CO2 emissions.

8. These results apply only to the vehicle tested and possibly those of similar technology.

9. The test vehicle was a low emitter of CO, HCs and particulates. Some significant reductions of these pollutants, in percentage terms, were measured in the tests reported here. It is not known if the same reductions would apply to a high emitting vehicle.

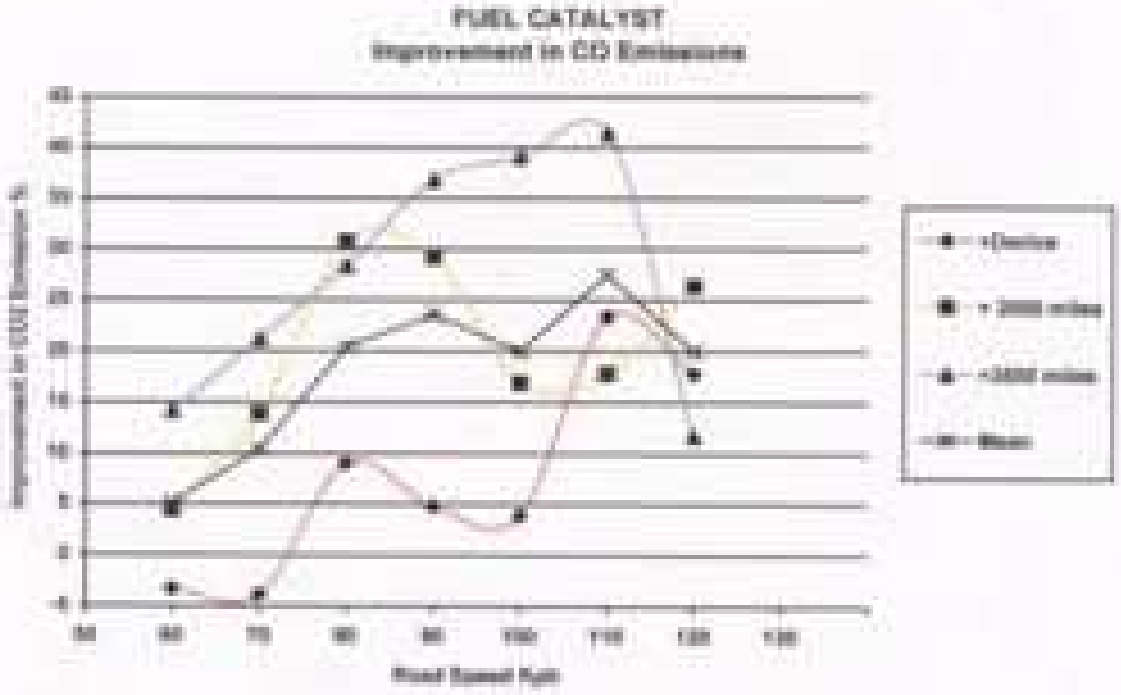


Figure 3 Improvement in Particulate Emissions with Road Speed

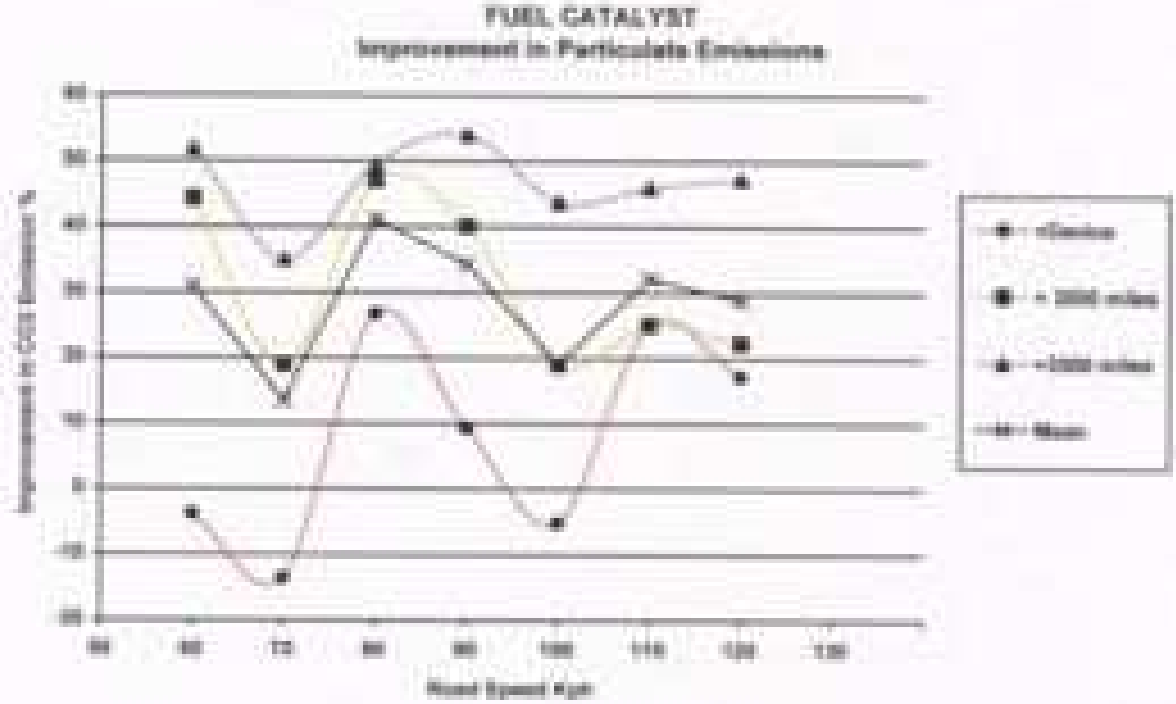


Figure 4 Improvement in Oxides of Nitrogen Emissions with Road Speed

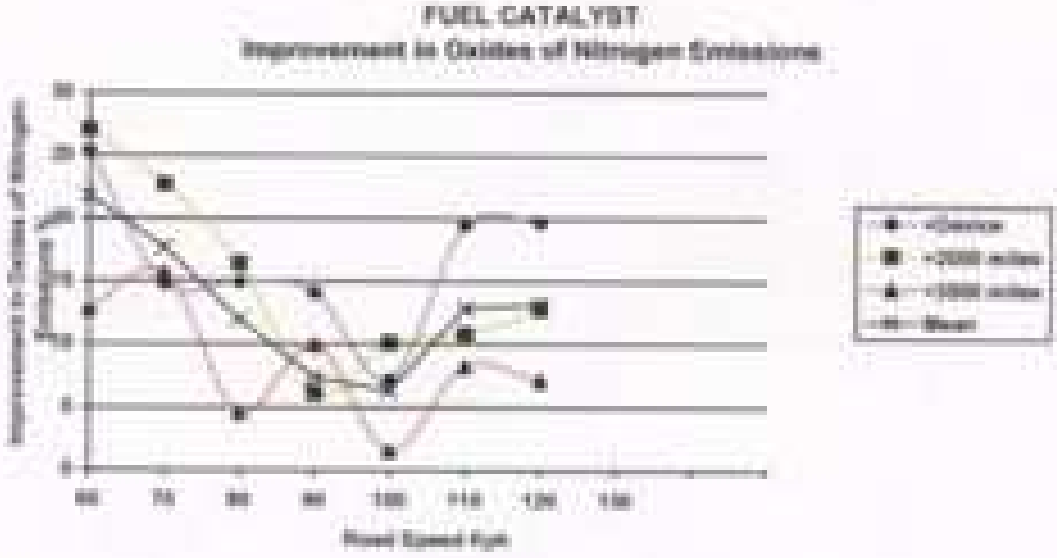


Figure 5 Improvement in Fuel Consumption with Road Speed

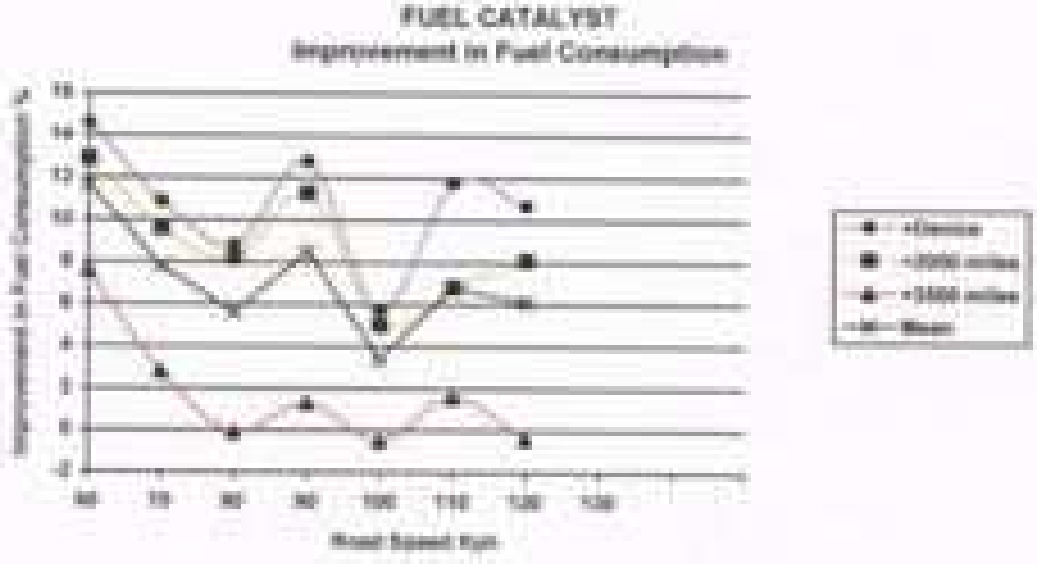
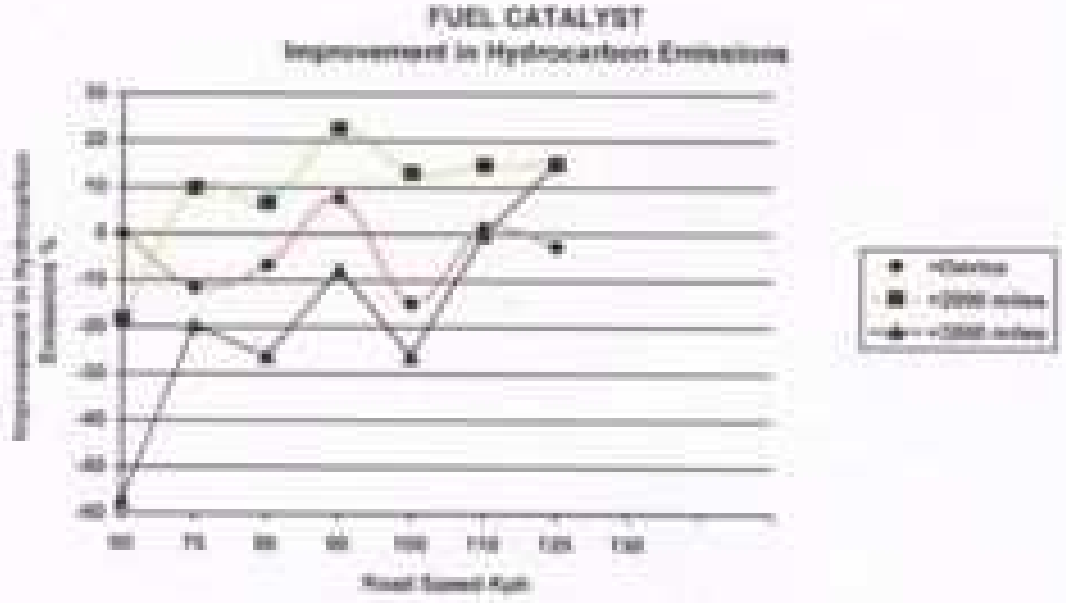
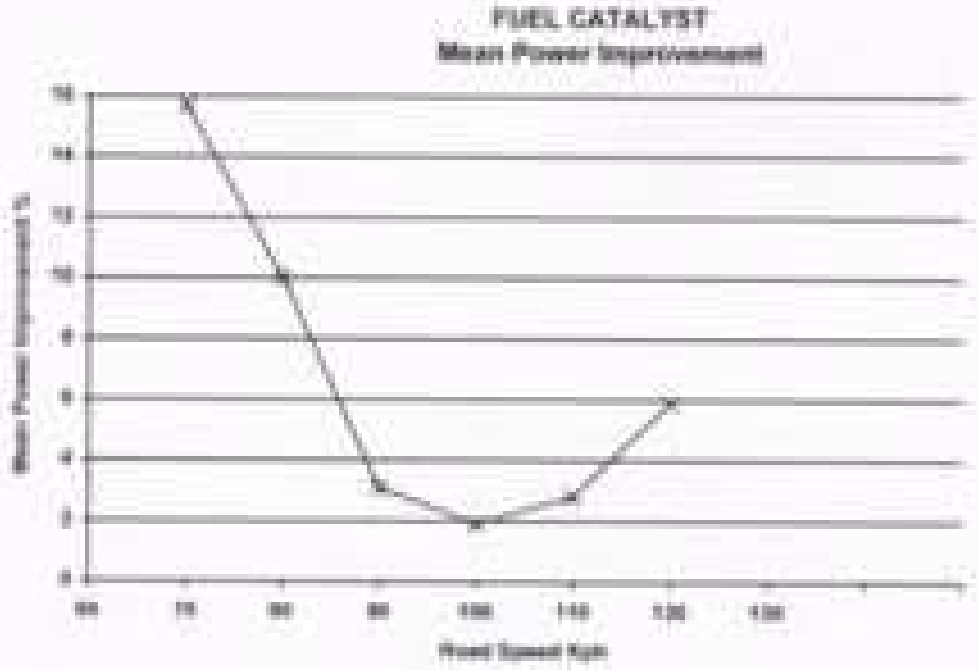


Figure 6 Improvement in Hydrocarbon Emissions with Road Speed



A COMMENT



EXECUTIVE SUMMARY