MOTOR VEHICLE POLLUTION IN AUSTRALIA

Supplementary Report No. 1

LPG In-Service Vehicle Emissions Study

prepared by the
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for

Environment Australia
&
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EXECUTIVE SUMMARY

INTRODUCTION

With the increasing interest in alternative fuels and the growth in the LPG dual fuel automotive market, the LPG In-service Vehicle Emissions Study (LPG Study) was undertaken to obtain emissions data from a sample of LPG vehicles, as an adjunct to the National In-service Vehicle Emission (NISE) study. For logistical reasons only petrol fuelled vehicles were tested under the NISE Study.

The NISE Study was completed by the Federal Office of Road Safety (FORS) in 1996. Its principal objectives were to evaluate the emission characteristics of Australia's passenger vehicle fleet and to investigate to what extent pollution control systems deteriorated over time. The results of the NISE Study were published in May 1996 as the *Motor Vehicle Pollution in Australia* Report, which is available from the Federal Office of Road Safety.

The information on the emissions performance of LPG fuelled vehicles provided by the LPG Study is timely, given the introduction from 1997 of tighter emission standards for petrol engined vehicles under Australian Design Rule 37/01. A review of ADR37/01 is also underway which, in part, aims to bring LPG fuelled vehicles supplied by original equipment manufacturers within its scope, thus applying the same emissions standards to both petrol and LPG fuelled cars.

Based on fuel usage figures supplied by the Australian Liquefied Petroleum Gas Association there are approximately 400,000 vehicles of all types operating on LPG fuel in Australia. The number of actual registered vehicles running on LPG is unclear, however it is estimated that approximately 3% of the total car fleet are dual-fuelled (petrol/LPG) vehicles. These vehicles mainly comprise taxis, company fleet vehicles and private vehicles.

OBJECTIVES OF STUDY

The LPG Study was commissioned by Environment Australia to:

1. assess the magnitude and characteristics of emissions from the in-service LPG vehicle fleet;

2. assess the potential for reductions in emissions through tuning;

3. compare those emission levels with similar vehicles operating on petrol; and,

4. evaluate the same short emission tests as conducted in the NISE Study for possible inclusion in an inspection/maintenance program.

METHOD

The LPG study used the same test and vehicle processing protocols as the NISE Study.

Note: Cars tested in the LPG Study fall into two distinct groups that are generally treated separately when analysing test data:

(a) Vehicles manufactured after January 1986 were built to comply with Australian Design Rule ADR 37 and designed to run on unleaded petrol. They generally have computer-controlled engine management systems, fuel injection, and are fitted with catalytic converters.

(b) Cars made between 1974 and 1986 were designed to meet the less stringent ADR 27 and run on leaded petrol, do not have catalytic converters and generally have carburettors rather than fuel injection systems.

A sample of 36 vehicles representative of the in-service LPG fleet were selected comprising 13 taxis, 10 fleet vehicles and 13 private vehicles. The private vehicles were broken up into two subsets of seven vehicles manufactured before 1986 and six manufactured after 1986. A further subset of vehicles was also subjected to evaporative emission tests.

Most of the LPG vehicles tested used the more sophisticated "closed loop" technology, in which the fuel delivery is continuously adjusted via a electronic feedback mechanism from the exhaust system. Some vehicles, mostly from the private fleet, used the older "open loop" technology, where there is no feedback and the air/fuel ratio is manually set at a fixed value.

Tests ranged from the complex and time consuming ADR certification test protocol (to which vehicle manufacturers have to comply to supply vehicles to the Australian market), to the simplest checks which can be done with minimal equipment at a repair shop. Each vehicle was tested both in its "as received" condition and then again after tuning and minor repairs had been carried out. A 60/40 blend of propane/butane was used as the test fuel. This is representative of that available in the Sydney and Melbourne metropolitan areas.

The tuning of vehicles was carried out as would be performed in a typical LPG repairer workshop to optimise the vehicle for operation on LPG. The vehicle's air filter, spark plugs, points (if applicable) and oil were routinely replaced however the focus was on repairing faults rather than replacing components.

KEY FINDINGS

The key findings of the LPG Study are listed below.

Emissions from LPG Vehicles

The emissions measured in the LPG Study were the four emissions regulated by the ADRs for petrol engined vehicles. These are exhaust emissions of carbon monoxide (CO), hydrocarbons (HC) and oxides of nitrogen (NOx), and evaporative hydrocarbon emissions.

1. The majority of the LPG vehicles tested were able to meet the relevant ADR exhaust emission limits for which the vehicles were designed.

2. Company fleet vehicles, on average, were the lowest emitters of CO and HC, whilst private vehicles were the highest emitters. Average NOx emissions were similar in all categories.

3. “Gross emitting” vehicles (those emitting many times above ADR limits) existed across all categories.

4. Of the seven vehicles which underwent evaporative emission tests, only one result was under the ADR limit. Those vehicles which failed the test emitted from three to more than thirty times the limit. Both the LPG and petrol fuel systems on a vehicle can contribute to evaporative emissions in a dual fuelled vehicle. A speciation test conducted on one vehicle with high evaporative HC emissions revealed that most of these emissions from this vehicle were derived from the petrol fuel system.

5. Taxis and company fleet vehicles had an LPG fuel consumption rate of approximately 18 L/100 km, whilst private vehicles operated at approximately 20 L/100 km.

Comparison with the Petrol Fleet (NISE Study results)

Similar make and model vehicles (Holden Commodores and Ford Falcons) from the NISE study have been used when comparing the two fuel types. The difference in sample size between the two fleets (36 LPG vehicles, 129 Petrol vehicles) should be considered when comparisons are made between the two fuel types. The key findings in this comparison were:

1. The average evaporative emissions from LPG vehicles were more than twice those of similar petrol vehicles from the NISE study.

2. The older (pre 1986) vehicles emitted slightly lower emissions of CO, HC and NOx than NISE study petrol vehicles of similar make and model.

3. Newer (post 1986) vehicles also emitted less HC emissions, but slightly higher CO and NOx, than NISE study petrol vehicles of similar make and model.

Effects of Tuning and Maintenance on Emission Levels

1. Tuning of both older (pre-1986) and newer (post-1986) vehicles with open loop systems had a significant effect on reducing CO and HC emissions, while NOx emissions increased (significantly for older and marginally for newer vehicles) after tuning.

2. Whilst vehicles with open loop systems benefited substantially from tuning, tuning had a minimal impact on CO, HC and NOx emissions from vehicles with closed loop systems.

3. The pre-tune HC and CO emission levels on vehicles with closed loop systems are significantly lower than vehicles with open loop systems.

4. Tuning did not have a significant effect on reducing evaporative emissions, which on occasion were slightly higher after tuning.

5. The average cost for tuning and minor maintenance regime undertaken in the Study was $260, compared to $220 for similar vehicles in the NISE Study.

6. The fuel consumption of these vehicles was reduced by an average of twelve percent after tuning.

Short Emission Test Performance

A long-standing goal for governments seeking to reduce vehicle pollution has been to develop a short test that reliably identifies high polluting vehicles. To address this all vehicles in the NISE study were tested using a number of short tests both prior to and after tuning.

The vehicles in the LPG Study were subjected to the same short tests. The tests were:

IM-240 - Modified IM240 (Inspection & Maintenance) Test Procedure

This test is based on the first four minutes of the ADR37/00 certification test cycle and covers about 2km total distance. Emission results are converted to grams per kilometre for HC, CO and NOx.

ASM - Acceleration Simulation Mode Test Procedure (ASM2525)

The vehicle is driven on a chassis dynamometer at a speed of 40km/h. Concentrations of raw exhaust emissions of HC, CO and NOx are measured.

SS60 - Steady State Loaded 60km/h

The vehicle is driven on a chassis dynamometer at a constant 60km/h. Emissions of HC, CO and NOx are measured.

HIGH IDLE - Steady State High Idle Test Procedure

With the engine running at a speed of 2500 rpm the concentrations of raw exhaust emissions are measured for HC and CO.

IDLE - Steady State Idle Test Procedure

With the engine running at idle speed (accelerator not depressed) the concentrations of raw exhaust emissions are measured for HC and CO.

For each vehicle tested, the results of the short tests have been compared with the ADR certification test results obtained from that vehicle. The results of these comparisons follow.

1. The IM-240 test was found to correlate best with the ADR certification test.

2. The loaded steady state SS60 and ASM25/25 tests show a better correlation with ADR certification test than the idle and high idle tests.

SUMMARY

The study produced diverse information regarding the emission characteristics and the deterioration of pollution control systems of the LPG in-service fleet. The study also highlighted deficiencies in the data available on the make up and operation of the LPG fleet. While these shortcomings did not affect this Study directly, they do limit the capacity to use the Study results to accurately estimate LPG vehicle impacts on urban air quality.

The following points summarise the emissions picture for dual fuelled (petrol/LPG) vehicles when operated on LPG:

- There were relatively small differences in exhaust emissions performance between the vehicles tested and comparable vehicles operating on petrol
- Most of the vehicles complied with the exhaust emission standards applicable to comparable petrol engined vehicles
- Most of the vehicles exceeded the evaporative emissions standards applicable to comparable petrol engined vehicles by a wide margin
- Tuning and minor maintenance improved HC and CO emissions and fuel consumption on most vehicles, but the benefits were not evenly distributed. Tuning did not improve NOx or evaporative emissions.
- The in-service tests based on the use of a dynamometer were the most effective.