Department of Environment

ENVIRONOTE

No 3

Petrol passenger vehicle emissions testing and maintenance investigation program

AN INITIATIVE OF THE PERTH AIR QUALITY MANAGEMENT PLAN

Introduction

Motor vehicles are the single largest contributor to the pollutant load into the Perth airshed. Therefore achieving a reduction in their impact on air quality is essential to achieving clean air. The *Perth Air Quality Management Plan* (AQMP) is a 30-year plan to ensure that clean air is achieved and maintained throughout the Perth metropolitan region. It seeks to do this by reducing the emissions of air pollutants that are currently causing occasional episodes of unacceptable air quality and by preventing the development of future problems. The AQMP *Implementation Strategy* identifies the reduction of vehicle emissions as essential to the success of the AQMP.

In recognition of this, a program investigating the performance of mid-aged (manufactured between 1986 -1996) petrol passenger vehicles in Perth was undertaken in 2005. The major objectives of the *Petrol Passenger Vehicle Emissions Testing and Maintenance Investigation Program* (PPV Program) were to measure emissions from this sector of the passenger vehicle fleet and to assess the effectiveness of repairs and vehicle maintenance on the emissions of poor performing vehicles. The results from this program will assist future policy development.

Vehicle emissions

Vehicles contribute over 80% of the carbon monoxide (CO) pollution into Perth's airshed and around half of the oxides of nitrogen (NOx). From 1975, all new cars in Australia were required to be fitted with basic anti-pollution equipment. Since January 1986 all new cars have been built with catalytic converters and have been designed to run on unleaded petrol. To further regulate vehicle emissions, Australian Design Rules (ADRs) have been developed that set the emission limits vehicles are designed to meet when new. However, with the total number of kilometres travelled by passenger vehicles in Perth set to increase, a decrease in the emissions of individual vehicles due to these measures will not be sufficient to decrease the total pollution output.

Modern vehicles rely heavily on "active" systems to control pollution levels (catalytic converters, on-board computers and sensors, etc). A national study found that these systems become less efficient as the total kilometres travelled by the vehicle increases and that these vehicles tended to deteriorate faster than older pre-catalytic converter vehicles. Furthermore, this study presented that mid-aged vehicles significantly contributed to the total vehicle fleet emissions. This vehicle category stood out because of their relatively high average emissions, their continued heavy usage and their high numbers due to Australia's low fleet turnover rate. In comparison, newer vehicles may on average travel more kilometres per year, but generally have lower average emissions. Also, older vehicles tend to have higher average emissions, but are operated less frequently, contributing to a declining proportion of the total vehicle fleet emissions.

For these reasons the PPV Program targeted mid-aged vehicles for testing. Within this age group, vehicles were selected to represent the actual in-field distribution of makes and models registered in Perth, with large Australian made family vehicles the most popular.

The vehicle testing program

The PPV Program measured exhaust and evaporative emissions. "Exhaust emissions" are by-products of the fuel combustion process, whilst "evaporative emissions" are vapours of fuel released from the vehicle into the atmosphere without being burnt. Evaporative emissions are a major issue in Perth as they significantly contribute to the formation of photochemical smog during summer.

Vehicles were tested in the condition they were received, excluding some minor repairs carried out when faults were likely to affect the sampling of emissions. The vehicles were obtained from a number of sources including private owners, company fleets, dealers and rental companies. Each vehicle tested was assigned a unique vehicle identification code comprised of the size of the vehicle (small, medium, large) and the year it was manufactured (eg – Vehicle "Small 1987"). To differentiate between vehicles of the same size and year of manufacture, letters were used after the year (eg – Vehicle "Small 1991(a)"). The pollutants measured in the PPV Program were total hydrocarbons (THC), CO, carbon dioxide (CO_2) and NOx. ADR limits were applied as the pass/fail threshold for the measured levels of these pollutants.

Exhaust emissions were measured for 50 vehicles. The 25 poorest performing vehicles underwent replacement of the catalytic converter and/or a tune-up. Automotive service centres undertook all repairs carried out on vehicles chosen for retesting. The vehicles were then re-tested to determine the effect of the repairs on exhaust emissions.

Twenty of the 50 vehicles were also selected for evaporative emissions testing. The nine worst performing vehicles had their fuel tank filler cap replaced and/or repairs to the filler neck and vapour lines to determine the effect on evaporative emissions.

Vehicle exhaust emissions results

Eighteen of the 50 vehicles tested were found to exceed one or more of the ADR emission limits. The most common pollutant limit exceeded was CO, followed by THC and NOx. The most frequent faults seen in vehicles that exceeded the limits were degradation of the catalytic converter, exhaust oxygen sensor failure and a rich air-fuel ratio mixture. Several faults were identified that were make/model specific. The failure rate for popular Australian built makes was comparatively high.

Once vehicle repairs and maintenance were completed, four of the 18 vehicles that failed the first emissions test passed upon re-test. Three of those still in excess of the emissions limit were light commercial vehicles and were not expected to achieve the target because 1) they were not built to ADR37; and 2) they were tested at "half laden mass" so as to represent their likely in-field duty cycle. Consequently, it could be argued that the effectiveness of the corrective action was 27% (four out of 15 vehicles). Of the total 25 vehicles that had rectifications undertaken, 10 passed the re-test (40%).

Of the 15 ADR37 compliant vehicles that were retested, three had the catalytic converter replaced, nine had a tune-up and three had both the catalytic converter replaced and a tune-up.

Two of the three ADR37 compliant vehicles that failed the initial emissions testing (67%) passed on retest after undergoing replacement of the catalytic converter. Only one ADR37 compliant vehicle of the nine that failed the initial test (11%) passed on re-test after undergoing a tune-up. Replacement of the catalytic converter and a tune-up was effective in reducing exhaust emissions of one of the three ADR37 compliant vehicles (33%) sufficiently to produce a pass in the re-test.

The low rate of reduction in exhaust emissions after a tune-up only may be somewhat attributed to repairs that were undertaken to improve the operation of the engine, not necessarily to reduce pollutant emissions. In particular, adjustment of idle CO emissions was seen to have negative effects elsewhere in the drive cycle. In some cases the tune-up was detrimental to the emissions performance of the vehicle. This was illustrated by a particular vehicle that passed the initial emissions test but failed on re-test after undergoing a tune-up.

Results for the entire test fleet indicate that replacement of the catalytic converter and/or a tune-up were effective in reducing exhaust emissions by 18-30% (range depending upon the pollutant and whether non-ADR37 vehicles are included), of which 12-22% was achieved by the changing of the catalytic converter, either in combination with a tune-up or alone.

Figures 1, 2 and 3 below show CO exhaust emissions before and after change of the catalytic converter, a tune-up and both change of the catalytic converter and a tune-up, respectively.

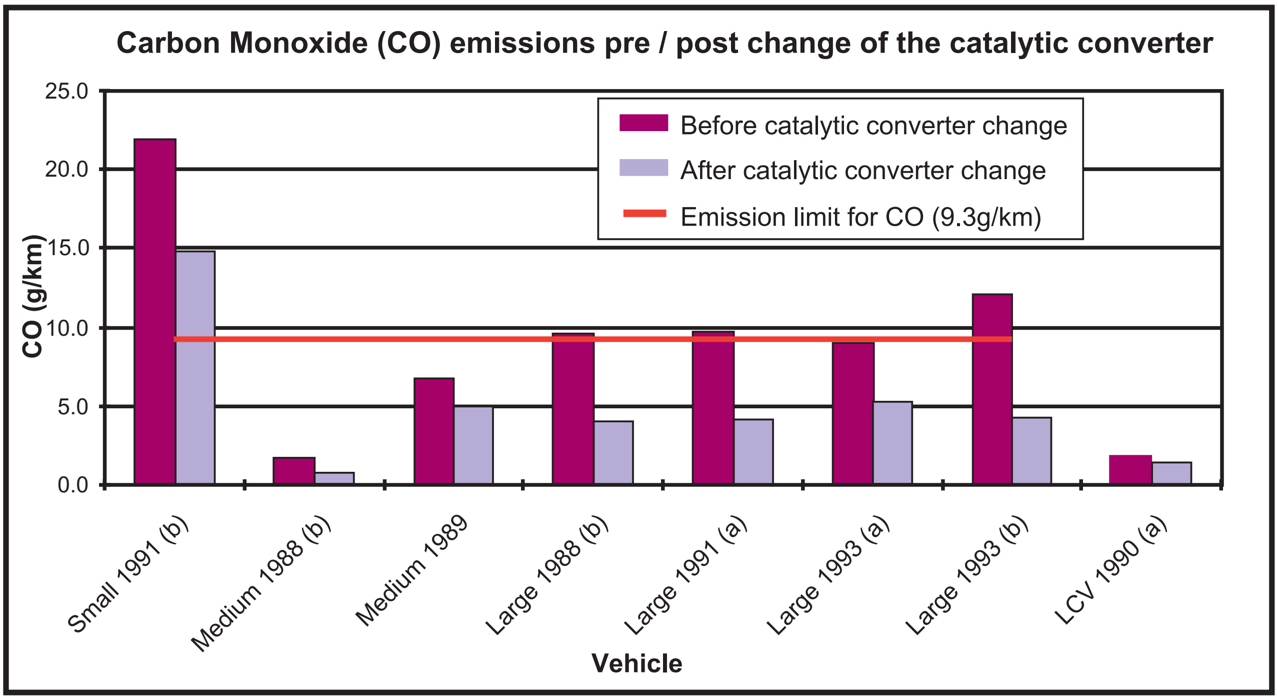

Figure 1 – Carbon Monoxide (CO) exhaust emissions before and after change of the catalytic converter

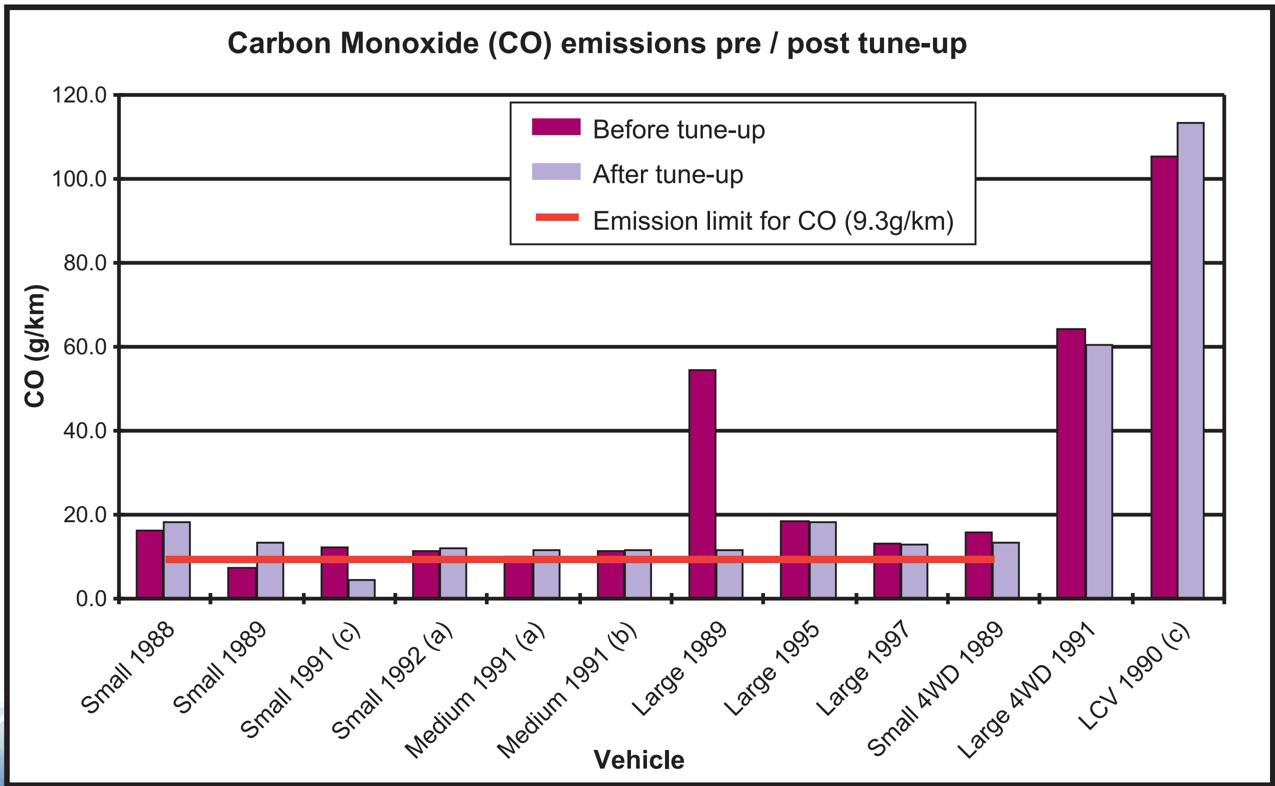

Figure 2 – Carbon Monoxide (CO) exhaust emissions before and after tune-up

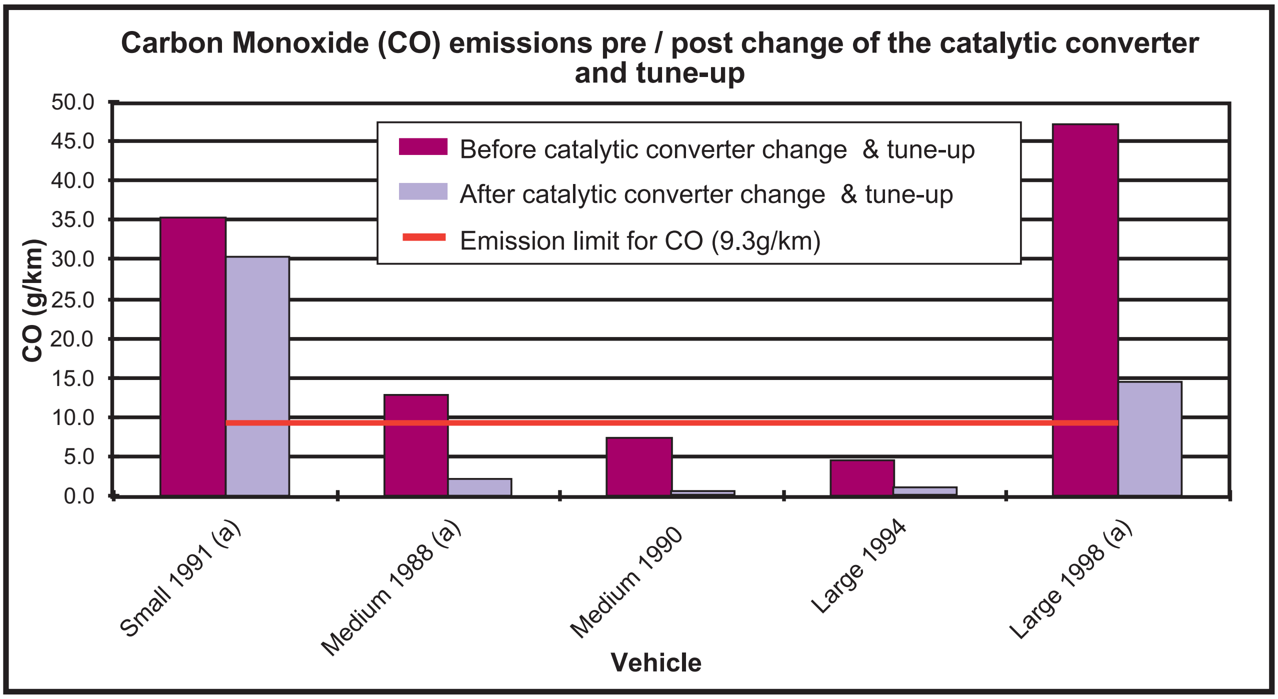

Figure 3 - Carbon Monoxide (CO) exhaust emissions before and after change of the catalytic converter and tune-up

Vehicle evaporative emissions results

Of the 20 vehicles tested, 60% reached or exceeded the ADR evaporative emissions limit. The most common fault causing failure was leakage from the fuel filler cap or filler neck. Perished fuel vapour lines were a common problem specific to one Australian built model. Of the nine vehicles sent for repair, 55% passed the re-test. Of those vehicles with fuel cap leakages, 43% were repaired by replacement of the cap. Other vehicles with fuel cap leakages had additional problems that could not be rectified by replacement of the cap only.

The results indicated that evaporative emissions are dominated by those arising from daily air temperature change and not emissions generated due to operation of the vehicle. These results are of national importance due to the lack of evaporative emissions data for vehicles in Australia. Evaporative emissions can be as important as exhaust emissions during summer in Australia, because the high outdoor temperatures lead to high levels of evaporation.

Future work

The PPV Program has demonstrated that emissions of pollutants were reduced by the replacement of catalytic converters and fuel caps, though the results were not consistent for all vehicles tested. There is a need to further assess the extent of certain observed faults and explore other methods of emissions reduction. The Commonwealth is currently progressing the second National In-Service Emissions Study (NISE 2), which will test emissions from a larger sample of vehicles. There will be a review of the results from this study in conjunction with the PPV Program to increase the size of the data set and consider the trend in emissions of newer vehicles.

For further information on the PPV Program, please refer to the complete report *"Petrol Passenger Vehicle Emissions Testing and Maintenance Investigation Program – Final Report"* published by the Department of Environment, available on our website at www.environment.wa.gov.au, or alternatively at the

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