Exhaust Emissions From Three Low-Emission Vehicles Using Catalytic Converters

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Vehicles Tested

The exhaust emission characteristics of three prototype low-emission vehicles were investigated using standard tests. All vehicles were full sized luxury type with large displacement engines. Each vehicle was equipped with an automatic transmission and air-conditioning. Vehicle #1 used a modified choke system, exhaust gas recirculation, air injection and a charcoal canister to collect unburned hydrocarbons from the exhaust during the cold portion of the test. This vehicle was equipped with a single catalytic reactor for oxidation of exhaust hydrocarbons and carbon monoxide. Vehicle #2 also had a modified choke, exhaust gas recirculation and air injection. This vehicle used two catalytic reactors, one for oxides of nitrogen reduction and one for oxidation of hydrocarbons and carbon monoxide. Special controls to reduce the amount of ammonia were also provided. Vehicle #3 used similar choke modifications and exhaust gas recirculation. This vehicle was equipped with air injection and a catalytic reactor. In order to reduce emissions during the cold portion of the test a special fuel with a modified distillation curve was provided. All vehicles were tested using tank fuel which was reported to be low octane lead free fuel.

Tests Conducted

The following tests were performed on these vehicles:

1. Standard 1970 Federal test procedure for exhaust emissions (FTP).

2. Closed, constant volume sampling technique using nine repeats of the Federal emissions test cycle (9X7).

3. Closed, constant volume sampling technique using the LA4-S4 driving schedule as developed for 1972 and later new vehicle certification (LA4).

Bag samples taken during closed cycle tests were analyzed using non-dispersive infrared analysis (IR) for carbon monoxide and carbon dioxide, flame ionization detection (FID) was used for hydrocarbon analysis. In order to compare oxides of nitrogen measurements with data taken on other vehicles, a variety of techniques were used. A modified Saltzman (Saltz) technique was used for wet chemical analysis, a chemiluminescent technique (CI), and an electrochemical (NO_X Box) technique were also used. All results are reported as NO_2 and have been corrected for humidity using the following:

$$NO_2 \text{ corr} = \frac{NO_2 \text{ measured}}{1-0.0047\ (H-75)}$$

where H is the humidity in grains of water

During some LA4 tests a determination of relative reactivity was obtained using an APCO developed subtractive column technique.

When open cycle tests are run non-dispersive infrared oxides of nitrogen data is taken.

Emission Results

All of the data taken during the test period is reported in Tables 1 through 3. Vehicle #1 showed the lowest emission values, but even this vehicle was not consistently below the 1975 emission standards of 0.46 grams per mile (gpm) hydrocarbons, 4.7 gpm carbon monoxide and the anticipated 0.4 gpm oxides of nitrogen. All three vehicles showed quite low emission values but none met the NO_x emission requirement. In Table 4 the relative reactivity of the various vehicle's exhaust is shown. The values for the fuel used are not available for conversion comparisons.

Conclusions

All three vehicles showed considerable emission reductions relative to present production vehicles. Since the vehicles were experimental prototypes with very little durability (it took two tests to determine that the charcoal canister system was inoperative during the initial tests due to a bent control arm from delivery) there was no attempt to evaluate operation off of the dynamometer. It is expected that a considerable driveability loss could be expected based on dynamometer evaluations.

Table 1

Vehicle #1 Single converter

Test Type	HC FID	CO IR	CO_2 IR	NO_x Saltz	NO_x Cl	NO_x NO_xBox	NO_x IR
LA4 CVS 4	0.5	2	583	1.0	---	0.7	---
LA4 CVS 5	0.4	3	923	0.9	---	1.0	---
FTP	0.2	4	---	---	---	---	1.0
9x7 CVS 5	1.0	4	931	1.0	1.3	1.6	---
LA4 CVS 5*	0.4	3	913	-1.0	0.7	1.2	---

*Cold storage in operation

Table 2

Vehicle #2 Dual converter

Test Type	HC FID	CO IR	CO_2 IR	NO_x Saltz	NO_x Cl	NO_x NO_xBox	NO_x IR
LA4 CVS 4	0.9	15	1115	0.5	---	0.9	---
LA4 CVS 4	1.3	23	1351	0.8	1.7	0.9	---
LA4 CVS 5	0.7	8	1135	1.0	---	1.0	---
FTP	0.1	4	----	---	---	---	0.3
9x7 CVS 5	0.7	8	1016	0.8	0.6	0.8	---

Table 3

Vehicle #3 Special fuel

Test Type	HC FID	CO IR	CO_2 IR	NO_x Saltz	NO_x Cl	NO_x NO_xBox	NO_x IR
LA4 CVS 4	0.5	2	1016	1.5	---	1.7	---
LA4 CVS 5	0.4	2	927	1.4	---	1.2	---
FTP	0.2	1	----	---	---	---	1.1
9x7 CVS 5	0.5	1	974	1.5	1.9	1.6	---

Table 4

Reactivity From Subtractive Data

	Dual Converter #2	Single Converter #1	Special Fuel #3
P + B*	74%	70%	66%
Olefins	15%	27%	29%
Aromatics	11%	3%	5%

*P + B = Parafins plus Benzene