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Emissions From Two LPG Powered Vehicles

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Michael A. Caggiano
Division of Motor Vehicle Pollution Control
National Air Pollution Control Administration
Department of Health, Education, and Welfare

Subject: Results of evaluations on vehicles run on LP-Gas

An evaluation of the emissions from two vehicles, equipped to run on LP-Gas, has been completed. The two vehicles were:

a) A 1968 Buick Skylark, 350 CID automatic transmission and the Impco "300 A" LP-Gas carburetor. This vehicle was supplied by George Leck of Cities Service Oil Company.

b) a 1969 Ford Galaxie, 351 CID automatic transmission, and Algas MX500 LP-Gas carburetor. This vehicle was also equipped to run on gasoline. The National LP-Gas Association provided this car.

The evaluation consisted of:

a) Simultaneous collection and measurement of exhaust by the 1970 Federal Procedure and Constant Volume Sampling (CVS) Procedure (nine 8-mode cycles). Both cold and hot start tests were run.

b) Measurement of oxides of nitrogen content of the sample bag from CVS using the Saltzman technique.

c) Reactivity measurement of exhaust using subtractive column analysis of CVS sample bag.

d) Qualitative assessment of vehicle driveability by several staff personnel.

A summary of results is included in the attached tables.

The results of the emissions measurements indicate that there is, as expected, a substantial reduction in carbon monoxide emissions, when compared to a similar gasoline fueled engine. The Ford showed a significant reduction in hydrocarbon emissions when switching from LP-Gas to gasoline. No such comparison was possible with the Buick. Included in Table I are some data from two NAPCA surveillance vehicles with similar engines to the ones run on propane. The hydrocarbon levels obtained with LP-Gas vehicles are not impressive when compared to the surveillance vehicle hydrocarbon levels.

Based on the subtractive column data, the hydrocarbons emitted from a propane fueled engine are less reactive due to the lower olefin and aromatic content of the exhaust.

The oxides of nitrogen (NO_X) output is higher with propane as the fuel, perhaps as much as 50 percent higher.

While using the subtractive columns we noticed that it took much longer for the column removing the olefins to reach equilibrium than the cycle timer allowed. This suggests that it would be wise to use a recorder with the FID and to manually control the time spent in each cycle.

When comparing the CVS data with the data from the 1970 procedure for the two cars, the Buick is better than the Ford by 1970 Procedures but the same or slightly worse by CVS. This could be due to the two speed automatic in the Buick or simply that the Buick has higher emissions than the Ford in the modes not measured by the 1970 Procedure.

The dilution and reactivity factors used in the 1970 procedure calculations are those used by the State of California, i.e. for propane;

$$\text{Correction Factor} = \frac{13}{\%\ CO_2 + (0.5)\%\ CO + (1.8 \times 6)\ HC}$$

$$\text{reactivity factor} = 0.75$$

The staff generally agreed that the driveability of both cars was good. In cold "drive-away" these cars are probably superior to current vehicles. Power loss, was insignificant. We had an opportunity to cold start the Buick Skylark at ambient temperatures below 20° F. In these cold starts the Buick started at least as well as gasoline fueled vehicles.

In summary, based on these vehicles and the tests performed, LP-Gas fueled engines when compared to similar gasoline fueled engines are:

HC	CO	NO_X	Reactivity
perhaps better	much better	worse	better

It should be stressed that time and manpower limitations did not permit determining that these engines were in the optimum state of tune for LP-Gas. Therefore, this data cannot be interpreted as the best that can be expected from an LP-Gas fueled vehicle. It is indicative of the kind of emissions obtained from a simple conversion from gasoline to LP-Gas as the motor fuel.

TABLE I

Summary of Results

Vehicle	Test	CVS Procedure			1970 Federal Procedure			
		HC (FID)	CO	NO_x	HC	CO	HC	CO
		grams/mile			PPM	%	grams/mile	
Buick	Cold Start	3.56	5.41	9.5	171*	.154	2.17	3.66
"	" "	3.34	4.22	8.4				
"	Hot Start	3.08	4.15	7.4	164*	.175	2.09	4.16
"	" "	2.95	5.26	7.5				
Ford	Cold Start	3.12	6.40	---				
"	" "	3.09	8.32	8.6	225*	.243	2.85	5.80
"	Hot Start	2.91	8.17	---				
"	" "	2.70	5.97	8.4				
"	" "	2.69	6.76	9.4	221*	.274	2.80	6.52
"	30-Cruise	2.31	2.02	9.3				
"	40-Cruise	2.09	1.48	7.5				
Ford - using gasoline								
	Cold Start	7.36	37.77	5.2	309	.95	3.91	22.67
	1969 Surveillance Fleet Vehicles							
Buick - Skylark - 350 CID								
	Cold Start				110	.81	1.39	19.20
	Hot Start	1.92	29.60	4.0	102	.85	1.30	20.16
Ford - Fairlane - 351 CID (3500 pound Inertia)								
	Cold Start				251	.52	2.90	11.30

* Corrected using California dilution and reactivity factors.

TABLE II

Exhaust Hydrocarbon Composition
by Subtractive Column Analysis

Vehicle	Test	Parafins & Benzene	Olefins	Aromatics
		% of Total Hydrocarbons		
LP-Gas Buick	Cold Start	74.5	25.5	0
" "	Hot Start	73.0	24.7	2.3
Standard 1969 Buick	Hot Start	30	47.5	22.5
LP-Gas Ford	Cold Start	72	22	6
" "	" "	59	29	12
" "	Hot Start	67	27	6
" "	" "	57	26.6	16
" "	30-Cruise	63.5	22	14.5
" "	40-Cruise	51.6	30	18.4
on Gasoline Ford	Cold Start	40	36.4	23.6