An Evaluation of the Emissions Characteristics of the Esso Well Mixed Thermal Reactor

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Background

Esso Corporation recently announced the development of an advanced emission control system for reciprocating engines. It was offered to the Environmental Protection Agency for evaluation.

Description

The vehicle tested was a 1971 Ford LTD with a special Esso thermal reactor and the necessary modifications to the vehicle for the operation of the reactor. The vehicle used a 351 cubic inch V-8 and an automatic transmission. The reactor is attached to the exhaust ports and replaces the exhaust manifold. A combination of fuel rich carburetor, exhaust gas recycle and spark retard are used to control oxides of nitrogen (NO_X) while carbon monoxide (CO) and hydrocarbons (HC) are mixed and burned in the reactor with secondary air supplied by an air pump. A special flame holder allows the system to reach operating temperature in less than 10 seconds. A complete description of the system is available in the Society of Automotive Engineers paper number 710608 presented in Montreal in June 1971.

Test Program

For the evaluation of this system, two test procedures were used. The 1972 and 1975 Federal Emission Test Procedures used for new vehicle certification were used. The 1972 test procedure uses the constant volume sampling system (CVS) to collect an exhaust sample during a 7.5 mile test conducted on a chassis dynamometer. The test is begun after the vehicle has soaked at room temperature for at least 12 hours. For 1975 tests basically the same driving cycle and sampling techniques are used but a procedure for weighting the cold portion has been added. This requires the exhaust to be sampled three times during the test and the test is increased to 11.1 miles. A complete description of the test procedures is available in the July 2, 1971, Federal Register.

The exhaust gases were measured using a flame ionization detector for HC, while CO and CO_2 were measured using infrared techniques. A chemiluminescent instrument was used for NO_X.

Results

The results from the tests calculated according to the 1972 test procedure are reported in Table 1. For reference the standards for 1972, 1973, and 1974 are also shown in this table. All results from this vehicle are well below the emission standards required for new vehicles through 1974.

The results from two of the tests where the 1975 procedure was used are reported in Table II. The standards for 1975 and 1976 are also shown in this table and the vehicle is very close to meeting the 1975 standards. Meeting the 1976 standards with this vehicle will require further NO_x reduction.

Results from other labs testing this system are shown in Table III.

Conclusions

This system will meet all standards through 1974 and shows promise for meeting the 1975 standards. In order to achieve the 1976 standards, additional controls for NO_x are required, although it may be able to meet standards in a lighter vehicle.

The results from testing this vehicle at other labs shows that consistent emission control is achieved and good correlation between laboratories is possible with low emission vehicles.

TABLE I

1972 Test Procedure

Esso Thermal Reactor
1971 Ford V-8 Automatic Transmission

(All results in grams per mile)

Test Date	HC (FID)	CO (IR)	CO_2 (IR)	NO_x (CI)
June 2, 1971	0.2	6	1019	0.6
June 23, 1971	0.1	5	1103	0.6
June 24, 1971	0.1	5	1060	0.6
1972 Standards	3.4	39	----	---
1973-74 Standards	3.4	39	----	3.0

TABLE II

1975 Test Procedure

Esso Thermal Reactor
1971 Ford V-8 Automatic Transmission

(All results in grams per mile)

Test Date	HC (FID)	CO (IR)	NO_x (CI)
June 23, 1971	0.11	4.76	0.67
June 24, 1971	0.10	3.19	0.67
1975 Standards	0.41	3.4	3.1
1976 Standards	0.41	3.4	0.4

TABLE III

Esso Data Comparisons
1972 Test Procedure

(All results in grams per mile)

Test Site	HC (FID)	CO (IR)	CO_2 (IR)	NO_x (CI)
EPA #2	0.2	5.9	1019	0.65
Ford	0.2	5.6	----	0.65
GM	0.2	5.6	----	0.68
EPA #3	0.1	4.5	1080	0.62
EPA #4	0.2	3.8	1050	0.64