Evaluation of the NCAC Dual Catalyst Pinto

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Technology Assessment and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Environmental Protection Agency

Background

The National Clean Air Coalition (NCAC), a non-profit environmental organization, contacted the Environmental Protection Agency about a prototype emission control system they had developed and had operating on a 1974 Ford Pinto. The system was aimed at emission levels of .41 grams per mile hydrocarbons (HC), 3.4 grams per mile carbon monoxide (CO), and .4 grams per mile oxides of nitrogen (NOx). Confirmatory testing at the EPA laboratory was requested, and the Emission Control Technology Division agreed to conduct an evaluation test program as part of its continual technology assessment function.

The Environmental Protection Agency receives information about many systems which appear to offer potential for emission reduction or fuel economy improvement compared to conventional engines and vehicles. EPA's Emission Control Technology Division is interested in evaluating all such systems, because of the obvious benefits to the Nation from the identification of systems that can reduce emissions, improve economy, or both. EPA invites developers of such systems to provide to the EPA complete technical data on the system's principle of operation, together with available test data on the system. In those cases in which review by EPA technical staff suggests that the data available show promise, attempts are made to schedule tests at the EPA Emissions Laboratory at Ann Arbor, Michigan. The results of all such test programs are set forth in a series of Technology Assessment and Evaluation Reports, of which this report is one.

The conclusions drawn from the EPA evaluation tests are necessarily of limited applicability. A complete evaluation of the effectiveness of an emission control system in achieving performance improvements on the many different types of vehicles that are in actual use requires a much larger sample of test vehicles than is economically feasible in the evaluation test projects conducted by EPA. For promising systems it is necessary that more extensive test programs be carried out.

The conclusions from the EPA evaluation test can be considered to be quantitatively valid only for the specific test car used, however, it is reasonable to extrapolate the results from the EPA test to other types of vehicles in a directional or qualitative manner, i.e., to suggest that similar results are likely to be achieved on other types of vehicles.

System Description

The vehicle tested was a 1974 Ford Pinto with a four-cylinder 122 CID (2000 cc) engine and four-speed manual transmission. Curb

weight of the vehicle as tested was 2580 lbs. A complete vehicle description is given in the vehicle description table on the following page.

Exhaust emissions are controlled by a dual catalyst system in which a Gould GEM 67 NOx reduction catalyst is followed by a Matthey-Bishop oxidation catalyst. Air is injected ahead of each catalyst and also, on cold starts, at the exhaust ports for 120 seconds. The Gould catalyst used was not the latest Gould Getter catalyst which employs an oxygen removal catalyst ahead of, and in the same canister as, the NOx reduction catalyst. (The purpose of the small oxidation catalyst in the "Getter" system is to prevent any oxygen "spikes"-momentary increases in oxygen concentration-from entering the NOx catalyst. This insures a proper reduction atmosphere for the NOx catalyst and lengthens durability.) The reduction catalyst, in both cases, is a base metal composition (containing nickel) on a metallic substrate.

The air pump was not a standard item on the vehicle, but was installed by the developer with this system. The standard exhaust gas recirculation unit was disconnected and none was used on the system. A modified Holley carburetor was installed and calibrated to deliver a raw (in the exhaust manifold without air injection) CO concentration of 2-2½ percent throughout the entire operating range. This is a richer mixture than the standard carburetor gave and is necessary in order to maintain an abundance of carbon monoxide at the entrance to the NOx reduction catalyst. The distributor timing curve was modified, the basic timing was increased from 6° to 10° BTDC, and full vacuum advance was utilized.

Test Procedure

Exhaust emissions tests were conducted according to the 1975 Federal Test Procedure ('75 FTP), described in the Federal Register of November 15, 1972. An additional test on the EPA Highway Cycle was run. All tests were conducted using an inertia weight of 2750 lbs (1248 kg) with a road load setting of 9.9 horsepower (7.39 kW) at 50 miles per hour (80.5 km/hr).

The vehicle was driven to the EPA laboratory from Buffalo, New York, and no calibration changes were made to the vehicle either when it arrived or before any of the tests. Two '75 FTP's and one EPA Highway Cycle were run on the vehicle.

At the request of NCAC personnel, the engineer who drove the vehicle to the EPA laboratory, who was familiar with the test procedures, drove the vehicle during the first '75 FTP. Also at the request of NCAC, the fuel used during the test program was Amoco Super Premium, a high octane lead-free gasoline. The vehicle had been run exclusively on this

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1974 Pinto
Emission control system - Dual catalyst

Engine

type	4 stroke Otto cycle, OHC, 4 cyl, in-line
bore x stroke	3.57 x 3.03 in./90.7 x 77 mm
displacement	122 CID/2000 cc
compression ratio	8.2:1
maximum power @ rpm	not available
fuel metering	Holley modified carburetor
fuel requirement	91 RON unleaded

Drive Train

transmission type	4 speed manual
final drive ratio	3.40

Chassis

type	unitized construction, front engine, rear wheel drive, 2 door coupe
tire size	A 78-13
curb weight	2580 lbs/1171 Kg
inertia weight	2750 lbs/1248 Kg
passenger capacity	4

Emission Control System

basic type	reduction catalyst, oxidation catalyst
oxidation catalyst location	exhaust system, under floor
make	Matthey-Bishop
reduction catalyst location	exhaust system, near firewall
make	Gould GEM 67
EGR type	None
air injection	stock Ford, geared lower than normal
additional features	
durability accumulated on system	about 7000 miles except for oxidation catalyst about 2500 miles

fuel and since it has a different density from Indolene Clear, a standard test fuel used at the EPA laboratory, EPA was asked not to change fuels. Changing to Indolene would have required a recalibration of the special carburetor to assure the same air-fuel ratio. The higher density and higher carbon fraction of hydrocarbons were accounted for in calculating fuel economy and hydrocarbon emissions from the vehicle.

Test Results

Exhaust emissions data, summarized below, illustrate that the NCAC vehicle achieved the levels of emissions required by the 1978 Federal standards. Complete emissions data, including individual bag results, are listed in the Appendix.

'75 FTP Composite Mass Emissions
grams per mile
(grams per kilometre)

	HC	CO	NOx	Fuel Economy, miles/gallon (Fuel Consumption, litres/100 km)
NCAC vehicle avg. of 2 tests	.28 (.17)	2.20 (1.36)	.35 (.22)	20.1 (11.7)
1978 Federal emissions standards	.41 (.25)	3.4 (2.1)	.4 (.25)	

EPA Highway Cycle Mass Emissions
grams per mile
(grams per kilometre)

	HC	CO	NOx	Fuel Economy, miles/gallon (Fuel Consumption, litres/100 km)
NCAC vehicle 1 test	.10 (.06)	.04 (.02)	.17 (.11)	30.8 (7.64)

Data from Bags 1 and 2 of the '75 FTP's have been used to calculate '72 FTP mass emissions and fuel economy, for comparison with the "baseline" 1974 certification Pinto of the same type: 122 CID, manual 4-speed transmission, 2750 lbs. IW class. (The 72 FTP was the test procedure used for certification of 1972 through 1974 model year cars.)

'72 FTP Mass Emissions
grams per mile
(grams per kilometre)

	HC	CO	NOx	Fuel Economy, miles/gallon (Fuel Consumption, litres/100 km)
NCAC vehicle avg. of 2 tests	.38 (.24)	4.86 (3.02)	.52 (.32)	19.4 (12.1)
1974 Certification vehicle	2.9 (1.8)	24 (14.9)	1.8 (1.1)	22.8 (10.3)

It is seen that on the 72 FTP the NCAC vehicle demonstrated good control of pollutant emissions, at the expense of a 15 percent drop in fuel economy compared to the 1974 certification Pinto.

Vehicle driveability was very good. It started easily, did not stumble or stall, and was fairly responsive. No acceleration tests were performed, but it seemed to have comparable power to the standard Pinto and had no trouble keeping up with the driver's trace used in the '75 FTP.

Conclusions

Operating on a non-standard fuel, the NCAC Pinto, with over 7000 accumulated miles on the system (except for the oxidation catalyst, which had accumulated about 2500 miles), met the 1978 Federal emission standards with a decrease (15 percent) in fuel economy compared to a standard 1974 Pinto with the same engine and transmission.

In order to get a more rigorous comparison to other vehicles tested by EPA, the car should be calibrated to operate on the standard unleaded Indolene test fuel. Additional durability testing would also be needed to determine if the system is capable of meeting the standards at 50,000 miles, which would be necessary for certification. The NOx emissions would have to be reduced slightly to give high confidence of passing certification testing, but it is reasonable to expect this reduction with additional modifications to the basic engine. The test vehicle did not utilize any EGR which might help to give superior NOx control. Since the timing was advanced farther than manufacturer's specifications it would be desirable to check for a possible knock problem with 91 RON unleaded gasoline (the Amoco is 100 RON).

It is our technical judgement that increasing the fuel economy of the system should be the major future effort, because the NCAC vehicle compares poorly in fuel economy with other vehicles that have achieved .4 gpm NOx in tests at EPA. Examples are a dual-catalyst modification by Gould of a 1975 Vega and a 1974 Pinto fitted with a Questor base-metal catalyst system built by PPG Industries. The fuel economy of the Gould Vega (as presented in TAEB Test Report No. 75-25) was slightly better than the EPA certification value for the 1975 California Vega. The PPG-Questor Pinto, the subject of TAEB Report No. 75-20, had no loss in fuel economy when compared to the certification value for the 1974 Pinto built to meet California standards.

Appendix

Table I

'75 FTP Composite Results
Mass Emissions, grams per mile
Fuel Economy, miles per gallon

Test No.	HC	CO	CO_2	NOx	Fuel Economy
16-8966	.27	2.06	479	.37	19.7
15-8977	.28	2.33	456	.33	20.6

Table II

EPA Highway Cycle
Mass Emissions, grams per mile
Fuel Economy, miles per gallon

Test No.	HC	CO	CO_2	NOx	Fuel Economy
15-8977	.10	.04	307	.17	30.8

Table III

'75 FTP Individual Bag Results
Mass Emissions, grams per mile
Fuel Economy, miles per gallon

	Bag 1 Cold Transient					Bag 2 Hot Stabilized					Bag 3 Hot Transient				
Test Number	HC	CO	CO_2	NOx	Fuel Economy	HC	CO	CO_2	NOx	Fuel Economy	HC	CO	CO_2	NOx	Fuel Economy
16-8966	.61	9.46	459	1.00	19.9	.14	.00	497	.12	19.0	.27	.42	461	.36	20.5
15-8977	.63	10.84	484	.92	18.8	.13	.00	467	.10	20.3	.31	.35	413	.33	22.9

Table IV

'72 FTP
Mass Emissions, grams per mile
Fuel Economy, miles per gallon

Test Number	HC	CO	CO_2	NOx	Fuel Economy
16-8966	.38	4.53	478.93	.54	19.4
15-8977	.38	5.19	475.36	.49	19.5