

74-17 HLG

Evaluation of the  
New York State  
Dual-Catalyst  
Vehicle

November 28, 1973

Test and Evaluation Branch  
Emission Control Technology Division  
Environmental Protection Agency

## Background

Dr. William Balgord of the New York State Department of Environmental Conservation contacted the Emission Control Technology Division to request low mileage evaluation of a dual catalyst control concept. Testing of the vehicle was arranged and conducted in June of 1973. Subsequent to this evaluation the vehicle was returned to New York State personnel for mileage accumulation. After compiling approximately 25,000 miles on the dual catalyst system, Dr. Balgord again brought the vehicle to the EPA Ann Arbor test facility for evaluation.

## System Tested

This dual-catalyst system employs Gould reduction catalysts (model Gem. 67) for control of oxides of nitrogen and Engelhard oxidation catalysts (model 2B) for control of hydrocarbon and carbon monoxide. The reduction catalysts are located forward of the oxidation catalysts in the exhaust system. To facilitate quick attainment of system operating temperature and good cold start emission control, two techniques are employed. First, the distributor timing is modulated for cold start. During starting normal ignition timing for the engine is set. Immediately upon engine start up the timing is retarded and employed for about two minutes before switching back to the normal ignition setting. To allow this timing modulation a dual point distributor system is used in conjunction with manual switching. While manual switching was employed in the prototype vehicle, production vehicles would utilize an automatic timed solenoid. The second technique involves start-up modulation of injection air. During the first two minutes of operation following cold start air is injected at the exhaust ports in front of the reduction catalysts. This injection leads to oxidation both in the exhaust manifold and in the reduction catalyst. After two minutes the exhaust port air is shut off and only normal air injection in front of the oxidation catalysts is employed. Again, on the developmental system air switching is accomplished manually but in production this manual function would also be replaced with an automatic timed solenoid.

The system as tested employed conventional carburetion calibrated to give a relatively constant carbon monoxide level of between 2 and 3 percent. Lean excursions of the

carburetor have been minimized through careful bench calibration. Since proper system performance depends on operation within this carbon monoxide band, frequent calibration based on barometric pressure (air density) is required. (One planned test at the EPA was canceled due to excessively low barometer.) In production this sensitivity could be alleviated through the use of barometric pressure compensated carburetion techniques.

The vehicle used for this system demonstration was a 1972 American Motors Matador equipped with a 304 CID eight cylinder engine and an automatic transmission. The vehicle was tested at a 3500 pound inertia weight.

#### Mileage Accumulation and Vehicle Maintenance

The dual catalyst system was operated by New York State personnel for 25,000 miles over a period of about 5 1/2 months in both city-suburban and highway situations. It is not possible to assess the equivalency of this accumulation procedure with the current certification driving schedule. Lead-free Amoco premium gasoline (as marketed in the eastern United States) was used exclusively for this mileage accumulation. New York State personnel reported that mileage accumulation will continue.

In general, maintenance on the vehicle followed that recommended by American Motors for its 1972 automobiles and did not specifically follow current certification procedures. As previously noted carburetor adjustments were frequently made to facilitate emission testing under varying barometric conditions.

#### Test Program

All testing was performed in accordance with the 1975 Federal emission test procedure as specified in the November 15, 1972, Federal Register (and appropriate subsequent modifications). Testing and vehicle operation required the use of unleaded gasoline.

A total of five emission tests were run at the EPA laboratory in Ann Arbor, Michigan. The first was conducted in June of 1973 when the catalytic system was at low mileage. Early in November of 1973 the vehicle was tested twice after approximately 25,000 miles had been accumulated on the system. During that testing starting problems attributed to poor choke and inadequate driver operation were encountered. The vehicle was returned in mid-November after a comprehensive tuneup for retest. Two additional tests were run at that time. The first of these latter two tests was voided by a CVS operation error.

Fuel economy for the second and third series of tests has been calculated using the carbon balance technique. For comparative purposes the 1972 Federal emission test procedure has also been used to calculate fuel economy.

#### Test Results

Table I illustrates the 1975 composite emission results obtained during the EPA testing. Also presented are fuel economy data calculated using the 1972 Federal emission test results and the carbon balance technique.

During tests #2 and #3 the vehicle stalled or false started several times during the cold start. This poor performance stemmed from inadequate choking and driver operation and led to relatively high hydrocarbon emissions.

Test #4 after tuneup was characterized by good starting performance. This test demonstrated emission levels near the 1976 statutory limits.

Conclusions:

1. At low system mileage the New York State dual-catalyst vehicle met the 1976 statutory levels.
2. Excluding tests which were characterized by cold starting problems, after 25,000 miles the dual-catalyst system is still operating near the 1976 statutory levels.
3. Fuel economy measured was 11% poorer than for a comparable 1973 AMC vehicle but only 3% poorer than for a comparable 1974 AMC vehicle. The test vehicle was a converted 1972 AMC vehicle, but no fuel economy data for a comparable unmodified 1972 AMC vehicle is available.

### Technical Assessment

The New York State dual-catalyst system closely parallels the type of systems reported by Gould and other manufacturers at the EPA hearings early this year. There are no significant technological differences employed by New York State except that the Gould catalyst utilized by New York State does not represent the latest generation of Gould catalysts. The vehicle did display good emission control for 25,000 miles of system operation as contrasted to the unfavorable evaluations reported earlier to EPA by manufacturers.

After meeting with New York State personnel and analyzing the data presented in this report, the EPA technical staff still considers their previous assessment of the dual-catalyst approach as valid. Relatively tight control of air-fuel ratio is required mandating the use of advanced carburetion with air density compensation. The latest test data as reported here indicates that after 25,000 miles of operation the NO<sub>x</sub> control has deteriorated and is near the statutory limit. Previous information available concerning the Gould system would suggest that rapid deterioration of NO<sub>x</sub> control after 25,000 miles would also be expected to occur for the New York State system. New York State personnel plan to continue mileage accumulation and subsequent data would be useful for verifying the deterioration rate.

While the successful demonstration of 25,000 miles of emission control at the 1976 statutory standards indicates the importance and potential of continuing research and development of the dual-catalyst approach, a single successful test does not indicate that the dual-catalyst approach is ready for implementation on new vehicle production. In his July 30, 1973, decision the Administrator concluded that "...although the Gould catalyst has shown by far the best durability results of any (reduction) catalyst to date, more work on matching the catalyst to the engine and on improved fuel metering, accompanied by extensive durability testing, will be required before it will be ready for widespread vehicle use". The data obtained through the testing of the New York State vehicle does not materially change the data base from which the Administrator drew his July 30 conclusion.

Table I  
New York State Car  
Ann Arbor EPA Testing

<u>Date</u>	<u>Test #</u>	<u>Odometer Mileage</u>	<u>HC</u>	<u>1975 FTP</u>		<u>NO<sub>x</sub></u>	<u>1972 FTP</u>
				<u>CO</u>	<u>CO<sub>2</sub></u>		<u>MPG</u>
6/6/73	1	28039	0.33	2.99	--	0.11	--
11/1/73	2	49035	1.02	3.37	746.5	0.40	11.2
11/2/73	3	49048	0.68	3.22	731.3	0.32	11.4
11/23/73	4	49175	0.37	1.67	751.4	0.47	11.2
1976 Statutory Standards			0.41	3.4	--	0.40	
Average 3500 lb 1973 vehicle			--	--	--	--	13.9
1973 AMC 3500 lb 304 CID (1 vehicle)			--	--	--	--	12.6
1974 AMC 3500 lb 304 CID (2 vehicles)			--	--	--	--	11.6