Emissions from a Mercedes-Benz Diesel Car Equipped with a Turbocharger

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Technology Assessment and Evaluation Branch
Emission Control Technology Division
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Background

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 systems 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 projects 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 tests 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.

Test Vehicle Description

A West Coast company, Turbocharger, Inc., is marketing a turbocharging kit for 1970-1973 Mercedes 220Ds'. Since little emissions data are available for turbocharged light-duty Diesel engines, arrangements were made for EPA testing of a 1971 Mercedes 220D before and after installation of the turbocharger kit.

The turbocharger supplied with the kit, model # 377B40 modified, is manufactured by Rayjay. It has a 3" tip to tip diameter turbine wheel and rated speed capability is 70,000 rpm peak (safety tested for 130,000 rpm). The basic package contains the turbocharger and plumbing necessary for the installation. Many of the stock parts which must be removed to make room for the turbocharger are modified for use with the kit.

In the present design of the kit, the governor modifications suggested result in elimination of the fuel cutoff at high engine speed, so there is nothing to prevent the engine from exceeding its maximum rated speed. When driving the vehicle, the engine is easy to overspeed when accelerating hard in first and second gear. A means of controlling maximum engine speed is to be introduced in future kits.

The kit is designed to supply up to 10 psi boost. The specific kit tested would actually supply 13 psi boost.

A more detailed description of the test vehicle appears on the following page.

Test Program

The vehicle was tested in accordance with the 1975 Federal Test Procedure (Federal Register, August 7, 1973, vol. 38 No. 151, Part III). Testing also included the Federal Highway Driving Cycle and measurement of acceleration times. All tests were run before and after installation of the turbocharger. Hydrocarbon emissions were measured with a Beckman model 402 heated flame ionization detector in accordance with established EPA procedures for Diesel exhaust. The same test fuel was used for all tests and meets EPA specifications for Diesel fuel (Federal Register, August 7, 1973).

Test Results

1975 FTP results are given in Tables I and II. Emissions over the 1975 FTP are broken down into individual bag data in Table III.

The effect of the turbocharger kit on emissions was negligible. Hydrocarbon emissions increased by 13%, but carbon monoxide and oxide of nitrogen emissions were unchanged. Fuel economy over the 1975 FTP and Highway Driving Cycle was also unchanged.

The acceleration of the vehicle improved considerably after installation of the turbocharger. Acceleration time from 0 to 60 mph was reduced from 29.8 seconds to 21.9 seconds.

Driveability of the vehicle was very good, with no perceptible lag on acceleration. A manifold pressure gauge installed on the vehicle indicated rapid increases during transient, part load to full load, operation. The turbocharger did not cause any noticeable increase in the noise level of the vehicle, either inside or outside. No visible smoke was observed during the acceleration tests.

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1971 Mercedes-Benz 220D
Emission control system - None

Engine

type	4-cylinder in-line,ohv,4-cycle Diesel
bore x stroke	3.43 in. x 3.64 in. (87.1mm x 92.5mm)
displacement	134 CID (2200 cc)
compression ratio	21.0:1
maximum power @ rpm	60 bhp @ 4000 wo/turbocharger
fuel metering	Bosch Fuel Injection
fuel requirement	No. 2 Diesel

Drive Train

transmission type	4 speed manual
final drive ratio	3.92:1

Chassis

type	Front engine, rear wheel drive, unit body
tire size	175R x 14
curb weight	not measured
inertia weight	3500 lbs.
passenger capacity	5
odometer	88,000 miles

Emission Control System

basic type	None
durability accumulated on system	88,000 miles on basic engine, low mileage on turbocharger

Conclusions

1) The turbocharger kit improved the performance of the test vehicle without significantly affecting either emissions or fuel economy. This conclusion is valid only for the change in fuel injection characteristics that were associated with this particular test car. Attempts to fully utilize the excess air capacity provided by the turbocharger could result in transient smoke problems and/or emission increases.

2) The turbocharger kit did not increase the mechanical noise from the engine. Very little insulation was used with the kit, so the lack of noise is inherent in the use of this model turbocharger with the 220D engine.

3) The effect of the turbocharger on engine durability has not been established at this time.

TABLE I

Mercedes 220D
Mass Emissions in
Grams per Mile

1975 Federal Test Procedure

Baseline Test #	HC	CO	CO_2	NOx	Weighted Fuel Economy miles per gallon
16-5953	0.82	2.47	394.	1.61	25.4
15-5979	0.92	2.85	418.	--	24.0
Average	0.87	2.66	406.	1.61	24.7
Turbocharged					
16-6124	1.0	2.66	400.	1.69	25.0
15-6139	0.96	2.67	420.	1.62	23.9
Average	0.98	2.67	410.	1.66	24.5
% change from baseline	+13%	0	+1%	+3%	-1%

Highway Driving Cycle Emissions and Fuel Economy

Baseline Test #	HC	CO	CO_2	NOx	MPG
16-5953	0.68	2.45	295.	1.60	33.8
Turbocharged					
16-6124	0.79	2.37	306.	1.62	32.7
15-6139	---	2.25	295.	1.56	33.9
Average	0.79	2.31	301.	1.59	33.3

TABLE II

Mercedes 220D
Mass Emissions in
Grams per Kilometre

1975 Federal Test Procedure

Baseline Test #	HC	CO	CO_2	NOx	Fuel Weighted Consumption litres/100 km
16-5953	0.51	1.52	245.	1.0	9.2
15-5979	0.57	1.77	260.	---	9.8
Average	0.54	1.65	253.	1.0	9.5
Turbocharged					
16-6124	0.62	1.65	249.	1.05	9.4
15-6139	0.60	1.66	261.	1.01	9.8
Average	0.61	1.66	255.	1.03	9.6
% change from baseline	+13%	0	+1%	+3%	+1%

Highway Driving Cycle Emissions and Fuel Consumption

Baseline Test #	HC	CO	CO_2	NOx	litres/100 km
16-5953	0.42	1.52	184.	0.99	7.0
Turbocharged					
16-6124	0.49	1.47	190.	1.01	7.2
15-6139	--	1.40	183.	0.97	6.9
Average	0.49	1.44	187.	0.99	7.1

TABLE III Mass Emissions in Grams per Mile

Test #	Bag 1 Cold Transient					Bag 2 Stabilized					Bag 3 Hot Transient					
	HC	CO	CO_2	NOx	MPG	HC	CO	CO_2	NOx	MPG	HC	CO	CO_2	NOx	MPG	
16-5953	0.75	2.46	415.	1.69	24.2	0.86	2.52	398.	1.59	25.2	0.80	2.37	371.	1.59	27.0	
15-5979	1.09	3.49	474.	--	21.1	0.90	2.77	416.	--	24.1	0.84	2.51	379.	--	26.4	
Average	0.92	2.98	445.	1.69	22.7	0.88	2.65	407.	1.59	24.7	0.82	2.44	375.	1.59	26.7	
16-6124	0.98	2.91	438.	1.82	22.9	1.04	2.76	406.	1.64	24.7	0.95	2.30	360.	1.67	27.8	
15-6139	0.97	2.66	434.	1.68	23.1	1.03	2.84	434.	1.62	23.1	0.83	2.37	381.	1.59	26.3	
Average	0.98	2.79	436.	1.75	23.0	1.04	2.80	420.	1.63	23.9	0.89	2.34	371.	1.63	27.1	