Exhaust Emissions from an Opel Diesel Equipped with Reverse Flow Damping Valves

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Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Environmental Protection Agency

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 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 Emission 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 test can be considered to be quantitatively valid only for the specific test vehicle 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.

As part of an ongoing program to evaluate the exhaust emissions and fuel economy of light-duty Diesel-powered vehicles, the EPA agreed to test an Opel Rekord 2100D supplied by Ford Motor Company. The purpose of the test program would be to evaluate a reverse flow damping valve designed by Bosch for installation in the injector lines. The damper valve is designed to eliminate undesirable erratic injection into the combustion chamber due to stray pressure pulses in the injection lines.

Test Vehicle Description

The test vehicle is an Opel Rekord 2100D, powered by a 2100cc Diesel engine, and equipped with a four-speed manual transmission. The inertia class is 3000 lbs. A tabulation of pertinent vehicle statistics is given in the Vehicle Description on page 7.

Stray pressure pulses normally exist in the injection lines following injection of fuel into the combustion chamber. These pulses can cause the injector to "dribble" small amounts of fuel into the combustion chamber. By installing valves in the injection lines to dampen the stray pressure pulses, the dribbling of the injector is reduced or eliminated and a small decrease in emissions of unburned hydrocarbons may occur. The reverse flow damper valve is placed in the injection system between the injection line and fuel pump. One valve is used in each injection line.

Test Program

The test program was conducted in accordance with the 1975 Federal Test Procedure ('75 FTP) for light-duty Diesel vehicles (Federal Register, October 22, 1974, Vol. 39 No. 205, Part III). Testing included measurement of exhaust emissions and fuel economy according to the '75 FTP and the EPA Highway Fuel Economy Test (HFET).

The vehicle was tested in two configurations. The first configuration, the baseline, involved no changes to the manufacturer's production injection system. The second configuration was with the damper valves installed in the injection lines.

In both configurations the vehicle was tested twice according to the '75 FTP and once according to the HFET.

Test Results

Exhaust emissions and fuel economy measured during the '75 FTP are presented in the following table:

'75 FTP mass emissions in grams per mile (grams per kilometer)

	HC	CO	NOx	Fuel Economy (Fuel Consumption)
Baseline-avg. of 2 tests	0.41 (0.26)	1.5 (0.9)	1.21 (0.75)	27.6 miles/gal. (8.5 liters/100km)
Damper valves avg. of 2 tests	0.38 (0.24)	1.5 (0.9)	1.18 (0.74)	27.9 miles/gal. (8.4 liters/100km)
% Change from baseline	-7%	0	-2%	+1% (-1%)

A further breakdown of '75 FTP emissions and fuel economy is given in Tables I and II. Highway Cycle emissions and fuel economy are presented in Table III.

At the low exhaust emission levels measured from the test vehicle, it is difficult to attach importance to percent changes in emissions. For instance, the 7% reduction in HC emissions during the '75 FTP corresponds to a change in mass emissions of only 0.03 gram per mile. Based on an average of only two tests, a change of this magnitude cannot be accurately quantified. The 7% change in HC emissions can be taken to be representative of a trend toward lower HC emissions with the damper valves installed.

Conclusions

1. Installation of the damper valves resulted in a small decrease in unburned hydrocarbon emissions. Further testing is required to more accurately quantify this reduction.

2. No significant effect on fuel economy occurred during the '75 FTP and Highway Fuel Economy test.

Table I

'75 FTP mass emissions in
grams per mile
(grams per kilometer)

Test #	HC	CO	CO_2	NOx	miles/gal. (liters/100km)
Baseline					
77-1634	0.43 (0.27)	1.5 (0.9)	361. (224.)	1.19 (0.74)	28.0 (8.4)
77-1635	0.39 (0.24)	1.5 (0.9)	371. (230.)	1.22 (0.76)	27.2 (8.6)
Average	0.41 (0.26)	1.5 (0.9)	366. (228.)	1.21 (0.75)	27.6 (8.5)
Damper Valves Installed					
77-1677	0.37 (0.23)	1.5 (0.9)	356. (221.)	1.17 (0.73)	28.3 (8.3)
77-1678	0.38 (0.24)	1.4 (0.9)	369. (229.)	1.19 (0.74)	27.4 (8.6)
Average	0.38 (0.24)	1.5 (0.9)	363. (225.)	1.18 (0.74)	27.9 (8.4)
% change from baseline	-7%	0	-1%	-2%	+1% (-1%)

Table II

Individual Bag Emissions in grams per mile

	Bag 1: Cold Transient					Bag 2: Stabilized					Bag 3: Hot Transient				
Test #	HC	CO	CO	NOX	MPG	HC	CO	CO	NOx	MPG	HC	CO	CO	NOx	MPG
Baseline															
77-1634	0.44	1.6	391.	1.20	25.8	0.45	1.5	360.	1.22	28.0	0.35	1.2	340.	1.11	29.7
77-1635	0.43	1.6	402.	1.25	25.1	0.41	1.6	368.	1.25	27.4	0.33	1.2	352.	1.15	28.7
Average	0.44	1.6	397.	1.23	25.5	0.43	1.6	364.	1.24	27.7	0.34	1.2	346.	1.13	29.2
Damper Valves															
77-1677	0.40	1.5	394.	1.18	25.6	0.38	1.7	351.	1.21	28.8	0.32	1.3	337.	1.07	29.9
77-1678	0.43	1.5	399.	1.20	25.3	0.40	1.5	367.	1.23	27.5	0.32	1.2	350.	1.10	28.9
Average	0.42	1.5	397.	1.19	25.5	0.39	1.6	359.	1.22	28.2	0.32	1.3	344.	1.09	29.4
% change from baseline	-5%	-6%	0	-3%	0	-10%	0	-1%	-2%	+2%	-6%	+8%	-1%	-4%	+1%

Table III

HFET mass emissions in grams per mile (grams per kilometer)

Test #	HC	CO	CO_2	NOx	miles/gal. (liters/100km)
Baseline					
77-1639	0.22 (0.14)	0.9 (0.6)	276. (172.)	0.97 (0.60)	36.6 (6.4)
Damper Valves installed					
77-1679	0.25 (0.16)	0.9 (0.6)	271. (168.)	0.90 (0.56)	37.3 (6.3)

TEST VEHICLE DESCRIPTION

Chassis model year/make - Opel Rekord 2100D
Emission Control system - None

Engine

type	4 stroke, Diesel, I-4, ohv, indirect injection
bore x stroke	3.47 x 3.34 in./88.2 x 84.8 mm
displacement	126 cu in./2070 cc
compression ratio	22:1
maximum power @ rpm	68 bhp/50.7 kW @ 4300 rpm
fuel metering	Bosch fuel injection
fuel requirement	#2 Diesel

Drive Train

transmission type	4 speed manual

Chassis

type	front engine, rear wheel drive
tire size	165 x 14
inertia weight	3000 lb.
passenger capacity	5

Emission Control System

basic type	None
durability accumulated on system	3400 mi/5400 km