

Emission Results from a Prototype
Audi Fox

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

Background

The Environmental Protection Agency receives information about many devices for which emission reduction or fuel economy improvement claims are made. In some cases, both claims are made for a single device. In most cases, these devices are being recommended or promoted for retrofit to existing vehicles although some represent advanced systems for meeting future standards.

The EPA is interested in evaluating the validity of the claims for all such devices, because of the obvious benefits to the Nation of identifying devices that live up to their claims. For that reason the EPA invites proponents of such devices to provide to the EPA complete technical data on the device's principle of operation, together with test data on the device made by independent laboratories. In those cases in which review by EPA technical staff suggests that the data submitted holds promise of confirming the claims made for the device, confirmatory tests of the device are scheduled at the EPA Emissions Laboratory at Ann Arbor, Michigan. The results of all such confirmatory 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 confirmatory tests are necessarily of limited applicability. A complete evaluation of the effectiveness of an emission control system in achieving its claimed 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 confirmatory test projects conducted by EPA. ^{1/} For promising devices it is necessary that more extensive test programs be carried out.

The conclusions from the EPA confirmatory tests can be considered to be quantitatively valid only for the specific type of vehicle used in the EPA confirmatory test program. Although it is reasonable to extrapolate the results from the EPA confirmatory 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, tests of the device on such other vehicles would be required to reliably quantify results on other types of vehicles.

In summary, a device that lives up to its claims in the EPA confirmatory test must be further tested according to protocols described in footnote ^{1/}, to quantify its beneficial effects on a broad range of vehicles. A device which when tested by EPA does not meet the claimed results would not appear to be a worthwhile candidate for such further testing from the standpoint of the likelihood of ultimately validating the claims made. However, a definitive quantitative evaluation of its effectiveness on a broad range of vehicle types would equally require further tests in accordance with footnote ^{1/}.

^{1/} See Federal Register 38 FR 11334, 3/27/74, for a description of the test protocols proposed for definitive evaluations of the effectiveness of retrofit devices.

The Emission Control Technology Division of the Office of Mobile Source Air Pollution Control was contacted by representatives of Audi NSU Auto Union AG about testing a prototype Audi vehicle. Consistent with ECTD's continuing interest in the evaluation of advanced automotive emission control technology, a test program was conducted by the Technology Assessment and Evaluation Branch.

Vehicle Description

The vehicle tested was a catalyst-equipped Audi Fox prototype, with a 4-cylinder 97 cubic inch engine and 4-speed manual transmission. The car is described in detail in the Vehicle Description table on the following page.

The emission control system consists of a three-way catalytic exhaust reactor. This single catalytic unit is used for the control of hydrocarbons, carbon monoxide and nitrogen oxide emissions. The catalyst on this prototype Audi had experienced less than 100 miles (160 Km) of use.

To achieve control of all three pollutants at once in the same reactor requires close control of the engine air-fuel ratio at a point very near to stoichiometric. This degree of control is achieved using the signal from an oxygen sensor in the exhaust stream to control a Bosch K-Jetronic continuous-type fuel injection system in a closed loop system.

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. Additional tests included the '72 FTP and the EPA Highway Cycle. All tests were conducted using an inertia weight of 2500 lbs. (1133 kg) with a road load setting of 7.0 horsepower (5.22 kw) at 50 miles per hour (80.5 km/hr). This road load is lower than the 9.4 hp specified in the Federal Register for vehicles in the 2500-lb inertia weight class. The specified road load is to be used unless a manufacturer chooses to determine road load by measuring absolute manifold pressure on the road at 50 mph and duplicating that pressure on the chassis dynamometer. This has been done by Audi, who found that their road load was only 7 hp at 50 mph, due in part perhaps to lower air resistance for the Audi vehicle than "typical" vehicles on which the standard horsepower settings were based.

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1974 Audi Fox
Emission control system - 3-way catalyst

Engine

type	4-cycle, OHC, I4, otto cycle
bore x stroke	3.13" x 3.15" (79.5mm x 80mm)
displacement	97 CID (1580cc)
compression ratio	8.0
maximum power @ rpm	79 hp @ 5800 rpm
fuel metering	Bosch, K-Jetronic mech. fuel injection
fuel requirement	with Exh. O2 sensor
fuel requirement	91 RON unleaded

Drive Train

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transmission type . . . . . 4 speed manual
final drive ratio . . . . . 4.11
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Chassis

type	unit body construction
tire size	155.13 radials
curb weight	2100 lbs. (935 Kg)
inertia weight	2500 lbs. (1110 Kg)
passenger capacity	4

Emission Control System

basic type	3-way catalyst
substrate.	monolith
volume	75 in ³ (1220cc)
loading.	experimental state
durability accumulated on system. . . 100 mi (160 Km)	

Test Results

Exhaust emissions data, listed in Tables I and II, illustrate the ability of the test car to achieve 1977 standards at low mileage. Nitrogen oxide emissions were about twice as high as required by the 1978 standard of 0.4 grams/mile (0.25 gm/km).

Conclusions

A low mileage Audi Fox prototype equipped with fuel injection and a 3-way catalytic reactor system achieved 1977 emission levels, with NOx emissions below 1 gram per mile. The fuel economy of this low emission prototype was not significantly different from the 1974 production version of the Audi Fox.

Table I

Exhaust Emissions (grams per mile)
and Fuel Economy (miles per gallon)
from a Prototype Audi Fox
(English Units)

<u>Procedure</u>	<u>HC</u>	<u>CO</u>	<u>NOx</u>	<u>Fuel Economy</u>	
				<u>Urban</u>	<u>Highway</u>
'75 FTP	0.15	0.95	0.82	22.0	
'75 FTP	0.14	0.94	0.94	21.8	
Average	0.14	0.95	0.88	21.9	
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'77 Federal Standards	0.41	3.4	2.00		
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'72 FTP hot start	0.09	0.36	0.70	22.5	
'72 FTP hot start	0.08	0.38	0.56	22.3	
'72 FTP hot start	0.10	0.40	0.76	22.2	
Average	0.09	0.38	0.67	22.3	
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Highway Cycle	0.06	0.33	0.61		34.1
Highway Cycle	0.05	0.33	0.46		37.3
Average	0.06	0.33	0.54		35.6
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1974 Certification Values (1974 Audi Fox, 90 CID, 4-spd manual) average values from two models tested					
'75 FTP*	2.15	28.0	1.55	22.5	
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*'74 models tested by '72 FTP. These results adjusted to reflect change in test procedure.

Table II

Exhaust Emissions (grams per kilometre)
and Fuel Consumption (litres per 100 kilometre)
from a prototype Audi Fox
(Metric Units)

<u>Procedure</u>	<u>HC</u>	<u>CO</u>	<u>NOx</u>	<u>Fuel Consumption</u>	
				<u>Urban</u>	<u>Highway</u>
'75 FTP	0.093	0.59	0.51	10.7	
'75 FTP	0.086	0.59	0.58	10.8	
Average	0.090	0.59	0.55	10.8	
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'77 Federal Standards	0.255	2.11	1.24		
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'72 FTP hot start	0.054	0.22	0.43	10.5	
'72 FTP hot start	0.046	0.24	0.35	10.6	
'72 FTP hot start	0.061	0.25	0.47	10.6	
Average	0.054	0.24	0.42	10.6	
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Highway Cycle	0.040	0.33	0.61		6.9
Highway Cycle	0.033	0.33	0.46		6.3
Average	0.037	0.33	0.53		6.6
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1974 Certification Values (1974 Audi Fox, 1475 cc, 4-spd Manual) average values from two models tested					
'75 FTP*	1.34	17.4	0.96	10.5	
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*'74 models tested by '75 FTP. These results adjusted to reflect change in test procedure.