High Temperature Durability Trial

THREE-WAY PLATINUM METALS CATALYST COMPLETES 50,000 MILES AT MAXIMUM VEHICLE SPEED

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During July 1983 the Government of the Federal Republic of Germany tabled proposals to introduce legislation effective from January 1986 that would, in practice, require three-way catalysts to be fitted to gasoline-fuelled automobiles for the control of hydrocarbon, nitrogen oxide and carbon monoxide emissions. It was stated that to facilitate this objective unleaded fuel would be made available. Although catalysts for this purpose are already in production for use in the United States of America and Japan it was suggested that they might not be entirely suitable for European applications. This was because catalysts fitted to European vehicles could be subjected to long periods of high speed driving, producing high temperature exhaust conditions which would be a very severe test of catalyst durability.

Johnson Matthey Chemicals Limited have now completed a 50,000 mile high speed durability trial with a United States specification vehicle fitted with a three-way catalyst to determine the extent to which the catalyst deactivated under such conditions. At the end of the trial the emission levels were still within the California 1983 model year limits, that is less than 0.41, 0.7 and 7.0 grams per mile of hydrocarbons, nitrogen oxides and carbon monoxide, respectively.

The test vehicle was a 1.8 litre Volkswagen Scirocco tuned to meet California 1983 model year emission limits, the fuel/air supply being controlled by an oxygen sensor feedback system (Bosch "K" jetronic). A Johnson Matthey three-way catalyst of standard production size but specifically designed for high temperature operation was fitted. The catalyst which contained platinum and rhodium in the ratio of 5:1 was deposited on a ceramic monolith support at a loading of 40 g per cubic foot. A similar imitation unit which did not contain noble metals was used to obtain baseline emissions from the vehicle.

The trial was conducted by the Motor Industry Research Association (MIRA) on their high speed durability track at Nuneaton, Warwickshire, England, between November 1983 and April 1984. The vehicle was operated at its maximum speed of 105 m.p.h. for the majority of the trial with short low speed, low temperature periods during refuelling stops. Continuous recordings were taken of the inlet and outlet temperatures to the catalyst, exit temperatures ranging between 930 and 950°C for most of the trial. This meant that catalyst mid-bed temperatures were as high as 950 to 1000°C.

As this trial was designed to test the high temperature durability of the catalyst the gasoline used contained very low levels of lead (<1 mg/l) as specified for the United States, and as a result catalyst poisoning was negligible.

Catalyst Performance

During the trial the performance of the catalyst was assessed by both the current U.S. test procedure, that is the FTP75 test (German Government proposal) and the ECE-15 test (current European test) at zero, 5,000 and 10,000 miles, and at 10,000 mile intervals thereafter. At each test point the baseline emissions of the vehicle were checked by removing the catalyst and substituting the imitation unit. In all cases sufficient catalyst and baseline tests were conducted (normally two) to ensure the results were consistent. Normal servicing procedures as laid down in the manufacturer's handbook were followed throughout the trial.

The results from the trial were extremely encouraging. Data for the FTP75 and ECE-15

Fig. 1 Emission control catalysts for use in Europe are likely to be subjected to higher exhaust temperatures than those used in the U.S.A., where maximum speed limits are in force. To establish catalyst high temperature durability, the Motor Industry Research Association has conducted high speed trials on their test track at Nuneaton, where a Volkswagen Scirocco fitted with a Johnson Matthey platinum-rhodium three-way catalyst has successfully completed 50,000 miles, mostly at a speed of 105 miles per hour

tests are summarised in Table I and Table II, respectively. During the FTP75 test the emissions exceeded the limits at some points but this was usually caused by faults in the control system and at 50,000 miles all the emissions were within the California limits, see Figure 2. Deterioration factors were calculated at 2.02 for hydrocarbons, 2.52 for nitrogen oxides and

Table I

Catalyst Performance in the FTP75 Test

Mileage	Average emissions, grams per mile			Conversion efficiency, per cent		
	HC	NO_x	CO	HC	NO_x	CO
0	0.29	0.15	3.59	82	95	78
5,000	0.17	0.20	3.19	92	92	82
10,000	0.25	0.17	3.48	85	94	79
20,000	0.23	0.31	4.39	85	88	73
30,000	0.51	0.37	5.86	73	85	68
38,000	0.50	0.48	6.20	71	80	65
50,000	0.41	0.46	5.01	73	72	69
For comparison	0.41	0.7	7.0	California 1983 model year limits		

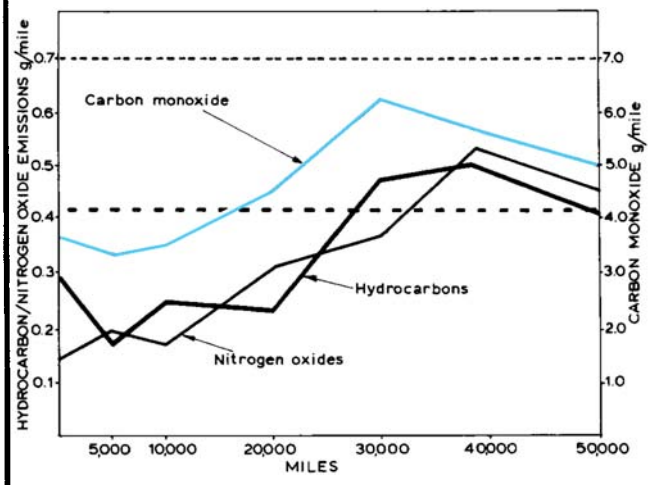

Fig. 2 Exhaust emission levels during the FTP75 test are plotted as a function of mileage, the lines being drawn through mean values of stable test points. The 1983 Californian limit for the three emissions are indicated by the appropriate broken horizontal line

1.22 for carbon monoxide; although higher than those obtained with catalysts destined for the U.S. market (normally 1.0 to 2.0) these figures are considered to be good, bearing in mind the operating conditions. Likewise catalyst conversion efficiencies were acceptable.

Emissions during the ECE-15 test were also very low. Exhaust temperatures in this test are lower than during the FTP75 cycle, and therefore it is a good measure of the activity of a severely aged catalyst. One of the most severe proposals for European vehicles has been suggested by Narjes, and would restrict hydrocarbon plus nitrogen oxide emissions to 6 grams per test, and carbon monoxide to 15 grams per test. At 50,000 miles all three emissions were within these limits.

The successful completion of this trial has demonstrated that modifications made to the technology currently used for the production of three-way catalysts have resulted in a catalyst capable of withstanding temperatures of 950 to 1000°C for very prolonged periods. It is confidently predicted that this technology, together with further improvements in catalyst design which are now being made, will enable platinum group metal autocatalysts suitable for all European driving conditions to be produced.

Table II

Catalyst Performance in the ECE-15 Test

Mileage	Average emissions, grams per test			Conversion efficiency, per cent		
	HC	NO_x	CO	HC	NO_x	CO
0	0.79	0.08	5.20	88	98	88
5,000	0.72	0.66	6.05	92	85	88
10,000	0.96	0.40	7.27	88	90	86
20,000	0.88	0.58	6.43	87	86	84
30,000	1.60	0.67	14.40	87	81	66
38,000	1.78	0.99	11.23	75	77	74
50,000	1.60	1.03	10.78	76	64	76
For comparison	6.0		15.0	Narjes proposal		