Investigation of the Effects of the Installation of an Oxidation Catalyst on a Diesel Powered Vehicle

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Technology Assessment and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Environmenal Protection Agency

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Background

The number of Diesel powered automobiles and light-duty trucks sold in the United States has significantly increased in the past few years with the increased interest in fuel economy. Both domestic and foreign automobile manufacturers have announced plans to expand the availability of Diesels both in the number of models and the number of total units built. This increased importance of Diesels has caused a significant amount of discussion as to the ability of the manufacturers to meet the recently announced EPA Diesel Emission Standards.

Since there was little or no experience with the effects of installing an oxidation catalyst in a Diesel powered vehicle, the EPA decided to investigate this configuration for its effects on both regulated and unregulated pollutants. Due to the relatively low hydrocarbon and carbon monoxide emissions typical of Diesel exhaust, the initial question was whether the catalyst would attain a sufficient temperature to allow it to function as intended. After establishing that the catalyst would function, its effect on emissions, both gaseous and particulate, on fuel economy, and on vehicle performance were to be investigated.

The conclusions drawn from this EPA evaluation test can be considered to be qualitatively and quantitatively valid only for the specific vehicle and catalysts used. However, it is reasonable to extrapolate the results from the EPA test to other types of Diesel powered vehicles in a qualitative manner, i.e., to suggest that similar results are likely to be achieved on other Diesel engines using similar oxidation catalysts.

Summary of Findings

1. Both catalysts* used in the investigation achieved light-off (50% or greater conversion efficiency) shortly after the start of the cold-start Federal Test Procedure. For the FTP, both catalysts yielded HC and CO values which were substantially reduced from the baseline condition while NOx emissions remained unchanged. Compared to the stock configuration, particulate emissions were unchanged for the Ford catalyst and showed a substantial increase for the Engelhard catalyst.

2. For the HFET, both catalysts showed a significant reduction of CO emissions and no change in NOx emissions from the baseline. The Ford catalyst showed substantial reductions of HC while the Englehard showed some increase of HC emissions compared to the baseline.

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*Ford production catalyst normally used with Ford 250 CID gasoline powered vehicles. Engelhard research catalyst with catalyst loading and materials chosen for use with Diesel passenger vehicles.

3. In stock configuration the vehicle was able to follow the FTP and HFET driving cycles. However, with the catalysts installed, the vehicle had difficulty achieving the higher acceleration rates of the driving cycles at speeds above 30 mph. Typically the vehicle was four MPH slower than the desired speed.

4. With a catalyst, the vehicle's accelerator pedal response was very poor. It was extremely difficult, therefore, to properly modulate the vehicle's speed and accurately following the driving cycle.

5. The fifty mile per hour steady state tests showed that the two catalysts substantially reduced CO emissions while there was little change in NOx emissions from the baseline. The Ford catalyst reduced the HC emissions while the Engelhard catalyst had no effect on HC emissions compared to the baseline.

6. Propane injection was attempted on the Englehard catalyst to determine whether a richer mixture would result in higher catalyst temperatures and, therefore, lower overall emissions. Attempts to raise the catalyst temperature by "feeding" propane into the exhaust manifold were fruitless. At high loads there was no increase in catalyst temperature or conversion efficiency. At low loads the catalyst temperature decreased and conversion efficiency decreased.

7. The diesel particulates were bioassayed for mutagenitic properties. The results of these tests were inconclusive.

Test Vehicle

The test vehicle was a 1975 Mercedes Benz 300D equipped with an automatic transmission. This vehicle has been used extensively for emissions testing and has a history of stable emissions. The vehicle was fitted with a catalyst sized to have approximately the same volume as that for an equivalent powered gasoline vehicle.

The Englehard catalyst was tested first. This catalyst had a monolith substrate with approximately three times the loading of a conventional gasoline catalyst and was similar to others Englehard had used for testing on Diesels. The "Ford" catalyst was a production catalyst normally installed in medium displacement Ford gasoline powered vehicles. Specifications of these catalysts are given on the test vehicle description in the following page.

Test Procedure

The vehicle was tested in four basic configurations. 1) The Engelhard catalyst was installed in the engine compartment near to the exhaust manifold outlet. This installation required some sharp bends in the exhaust pipe. 2) The same configuration was tested with exhaust tubing

Test Vehicle Description
Chassis model year/make - 1975 Mercedes 300D
VIN - 11511412019885

Engine

Type	I5, 4 cycle, Diesel pre-chamber, OHV
Bore x Stroke	3.58 in. x 3.64 in. (91.0 mm x 92.5 mm)
Displacement	183 CID (3000 cc)
Compression Ratio	21:1
Maximum power at RPM	77 hp/57 kW at 4000 rpm
Fuel Metering	High Pressure, In-Line pump
Fuel Requirement	Diesel Fuel No. 2

Drive Train

Transmission Type	4 Speed Automatic
Final Drive Ratio	

Chassis

Type	4 Door Sedan, Front Engine, Rear Drive
Tire Size	Michelin XZX 175 SR 14 Tread 2 Plies Steel + 2 Plies Rayon Sidewall 2 Plies Rayon
Inertia Weight	4000 pound
Passenger capacity	5

Emission Control System

Basic Type	Engine Modification
Additional Features	Catalyst (see Catalyst Description Below)
Durability Accumulated on System	300 Miles on Engelhard catalyst 150 Miles on Ford catalyst

CATALYST DESCRIPTION

Ford Catalyst

General Type	Oxidation
Total Volume (cu. in.)	95 $\pm$ 6% (92 Clamshell/89/Stuffed (alt)
Substrate Type	Monolithic
Active Material	67% Platinum, 33% Palladium
Loading (grams/cubic foot)	25
Surface Area (BET) (m^2/cc)	7.5 minimum

Englehard Catalyst

General Type	Oxidation
Total Volume	77
Substrate Type	Monolithic corning 200 cells/in^2
Active Material	100% platinum
Loading (grams/cubic ft.)	78

replacing the catalyst to determine the effects of the catalyst and the effects of the exhaust pipe geometry. 3) and 4) Both the Ford and the Engelhard catalyst were then placed beneath the vehicle such that changes to the stock exhaust system geometry were minimized. Thermocouples were installed in the catalysts to measure catalyst inlet and outlet temperatures.

The exhaust manifold back pressure was measured at 50 mph to determine the effect of each configuration on the exhaust back pressure. Also, the exhaust manifold was insulated in an effort to raise the temperature of the exhaust gases entering the catalyst.

A modal analyzer was used to determine the catalyst efficiency at each mode of the FTP and at intervals in the fifty mile per hour steady state tests prior to any emissions or particulate testing. For modal analysis, continuous raw exhaust emissions were taken simultaneously both before and after the catalyst. During the first test configuration, the Engelhard catalyst installed in the engine compartment, propane was injected at the exhaust manifold to assist in catalyst light-off.

The testing of each configuration consisted basically of multiple cycles of the Federal Test Procedure (FTP), the Highway Fuel Economy Test (HFET), and a fifty mile per hour steady state procedure. Particulates were measured from the 4-bag FTP tests. Ames analysis was performed to determine whether the resultant particulates were mutagenic and, therefore, possibly carcinogenic.

The Ames test is a biochemical assay that uses a tester strain of Salmonella bacteria that is a histidine deficient strain. As such, since it cannot produce its own histidine to survive, the strain must mutate to survive. For the Ames test, the tester strain is placed in a Petri dish without histidine and with the chemical being tested. If the chemical mutates the bacteria (thus correcting the genetic defect), the Salmonella returns to normal, produces histidine, and is able to survive. By counting the number of colonies of bacteria that have "reverted", an indication of the mutagenic potential of the chemical can be obtained. If the chemical does not mutate the bacteria, it dies for lack of histidine. These mutagenic effects have been correlated with known carcinogens with some success.

The standard light-duty diesel test procedure was modified by incorporating an 18 inch particulate tunnel in the sampling system. The tunnel was flowed at 500 SCFM to keep the dilute exhaust temperature below 125°F at the sample zone. At this point a small sample is drawn thru a 47 mm filter. By accurately weighing this filter and measuring the flow volume through the filter, total particulate mass can be calculated. The HFID sample is also taken at this sample zone. These procedures have now been issued as a formal test procedure in the proposed "Particulate Regulation for Light-Duty Diesel Vehicles", Federal Register, February 1, 1979.

For bioassay a large particulate sample is required. Therefore, a much larger filter (8 x 10 inches) was incorporated down stream of the particulate sample zone. The dilute exhaust was drawn through this filter and then returned to the tunnel. These samples were sent to a laboratory for chemical extraction of the particulates and bioassay.

The changes outlined in the preceding two paragraphs do not affect the vehicle's gaseous emissions.

Results

The original goal of this test program had been to install a catalyst on the vehicle, to operate the vehicle in any manner necessary to achieve catalyst light off (50% or greater conversion efficiency), and to obtain samples for bioassay tests. However since the catalysts were able to light off rather easily in transient driving cycles, a more complete test program was practicable.

In the various test configurations the vehicle was tested for gaseous and particulate emissions. The test procedures used were the FTP, Highway Fuel Economy Test and 50 mph steady state. For this testing an 18 inch particulate tunnel was employed. The individual test results are given at the end of this report. These results are summarized in the following table:

Table I

Mercedes Benz Diesel
FTP Emissions
Grams Per Mile

	HC (HFID)	CO	CO_2	NOx	MPG	Particulates
Typical Baseline	.23	.86	441	2.01	23.0	.47
Engelhard Catalyst (Engine Compartment)	.14	.10	423	1.93	24.0	.59
Engelhard Catalyst (Underneath vehicle)	.14	.18	424	1.97	24.0	.57
With Bypass for Engelhard (in engine compartment)	.18	.80	413	1.94	24.5	.43
Ford Catalyst	.10	.49	404	1.96	25.1	.44

For the FTP, both catalysts yielded HC and CO values which were substantially reduced from the already low baseline condition while NOx emissions remained unchanged. The Engelhard catalyst was especially effective in reducing CO emissions. Particulate emissions were unchanged for the Ford catalyst and showed a substantial increase for the Engelhard catalyst. However, this particulate level was still lower than that emitted by most full sized diesel passenger vehicles available in the U.S. There was no appreciable difference in the emission results for the Engelhard catalyst in either location.

Table II

Mercedes Benz Diesel
HFET Emissions
Gram Per Mile

	HC (HFID)	CO	CO_2	NOx	MPG	Particulates
Typical Baseline	.15	.54	332	1.86	30.5	.32
Engelhard Catalyst (Engine Compartment)	.13	.03	361	1.83	28.1	1.02
Engelhard Catalyst (Underneath vehicle)	.08	.05	365	1.88	27.9	.78
Bypass for Engelhard Catalyst	.08	.50	354	1.90	28.8	.38
Ford Catalyst	.03	.07	342	1.82	29.8	.51

For the HFET, both catalysts showed a significant reduction in CO, no change in NOx emissions from the baseline and a slight decrease in fuel economy. The Ford catalyst showed substantial reductions of HC while the Engelhard showed some increase in HC emissions when compared to the baseline. Particulate emission rates were increased substantially, especially for the Engelhard catalyst.

The reason for this higher particulate emission rate for the Engelhard catalyst is not known. Sulfate mass was not measured, but could possibly be the reason if the Engelhard catalyst had a higher sulfate conversion efficiency than the Ford catalyst.

Table III

Merdedes Benz Diesel
50 mph Steady State Emissions
Grams Per Mile

	HC (HFID)	CO	CO_2	NOx	MPG	Particulates
Typical Baseline	.08	.54	330	1.70	30.5	.35
Engelhard Catalyst (Engine Compartment)	.10	.04	342	1.70	29.7	.89
Engelhard Catalyst (Underneath vehicle)	.06	.03	320	1.70	31.8	.69
Bypass for Englehard Catalyst	.08	.47	344	1.90	29.5	.37
Ford Catalyst	.04	.11	333	1.78	30.5	-

The fifty mile per hour steady state tests showed that the two catalysts substantially reduced CO emissions while there was little change in NOx emissions from the baseline. The Ford catalyst reduced HC emissions while the Engelhard catalyst had no substantial effect on HC emissions compared to the baseline. Particulate emissions were unchanged for the Ford catalyst and showed a substantial increase for the Engelhard catalyst.

In stock configuration this vehicle was able to follow the FTP and HFET driving cycles. However, with the catalysts installed, the vehicle had difficulty achieving the higher acceleration rates of these driving cycles at speeds above 30 mph. Typically the vehicle would be four mph slower than the desired speed. Also, with a catalyst, the vehicle's throttle response was very poor. Therefore, it was extremely difficult to properly modulate the vehicle speed to accurately follow the driving cycle. These deficiences were probably caused by the increase in back pressure caused by the modifications and resultant reduction in available power (see Tables V and VI).

The principle objective of this study was to obtain particulate samples of a catalyst vehicle for bioassay. Samples were successfully obtained. The results of these tests are inconclusive. Appendix A consists of copies of two letters discussing the results of the bioassay (Ames) tests.

Prior to the standard emission tests, the vehicle was checked with an exhaust modal analyzer to determine if the catalysts were functioning and to evaluate the effectiveness of propane injection in assisting the catalyst to light-off. The vehicle exhaust was sampled continuously both before and after the catalyst with two continuous analyzers. These analyzers are controlled by a process computer to continuously calculate mass emissions and catalyst conversion efficiency.

Catalyst light-off (50% or greater conversion efficiency) occurred at the relatively low temperature of 400°F. There was no appreciable temperature rise across the catalyst. This was probably due to the relatively low HC and CO concentrations in the Diesel's exhaust.

Attempts to raise the catalyst temperature by "feeding" propane into the exhaust manifold were fruitless. At 50 mph, there was no change in HC conversion rate and temperatures across the catalyst did not increase. At 40 mph, catalyst temperatures continually decreased and conversion efficiency decreased.

The foregoing results are summarized below:

Table IV

Engelhard Catalyst

		HC		CO	
Test Type	Avg. Temp. F°	% Efficiency	Time of Occurance	% Efficiency	Time of Occurance
Cold LA-4		20%	300 sec.	40%	330 sec.
Hot LA-4	450-500	70%	115 sec.	100%	30 sec.
50 MPH	600	80%		100%	
Idle	400-450	80%		100%	
50 MPH Propane	480	90%		100%	
40 MPH	200	---		----	

Ford Catalyst

		HC		CO	
Test Type	Avg. Temp. F°	% Efficiency	Time of Occurance	% Efficiency	Time of Occurance
Cold LA-4	----	60-40%	330 sec.	90%	125 sec.

Prior to the start of testing several checks were made to determine typical pressure losses through the Engelhard catalyst. These tests were performed by flowing air through the catalyst at known rates and measuring the pressure drop across the catalyst. The results are summarized in the table below:

Table V

Catalyst	Flow Rate SCFM	Pressure Drop in H_2O
Engelhard	116	.46
	193	.93

Pressure drop characteristics across the Ford catalyst were not determined.

The airflow/pressure drop data suggested that there should be minor increases in exhaust system back pressure caused by the catalyst. Tests on the vehicle showed, however, that there was a substantial back pressure penalty. The results of the back pressure tests performed at 50 mph are summarized in the following table:

Table VI

Baseline	6.9 in H_2O
Engelhard catalyst in engine compartment	35 in H_2O
With bypass for Engelhard	22 in H_2O
Ford catalyst	18.7 in H_2O

These results showed that the cobbled engine compartment installation significantly increased engine back pressure (catalyst and catalyst bypass). These configurations also resulted in the greatest deviations in the vehicle's capability to follow the driving trace.

At the conclusion of testing, the catalysts were removed and inspected. Neither catalyst showed any visual signs of plugging due to deposits. Both catalysts had maintained their respective efficiencies throughout this short test program.

Conclusions

Catalysts can be effective in reducing Diesel HC and CO emissions. However, the long term durability of these systems was not determined.

Catalysts can adversely affect Diesel particulate emissions and reduce vehicle performance if incorrectly sized and/or installed without adequate system design.

The chemical nature and biological activity of the Diesel particulates from a catalyst vehicle was not determined. The test results available from this test were too limited to draw any conclusions.

Mercedes Benz Diesel Catalyst
FTP Results gm/mi

Date	Test No.	HC(HFID)	CO	CO2	NOx	MPG	Particulate
		Engelhard Catalyst Installed in Engine Compartment					
6-14	79-2620	.12	.06	431	1.93	23.6	0.59
6-15	79-2624	.15	.13	421	1.93	24.1	0.62
6-16	79-2633	.14	.10	416	1.92	24.4	0.56
		Bypass for Engelhard Catalyst (Engine Compartment Configuration)					
6-20	79-3052	.26	.81	414	1.95	24.5	0.42
6-21	79-3069	.10	.78	412	1.93	24.6	0.44
		Ford Catalyst					
6-28	79-3088	.11	.45	412	2.08	24.6	0.45
6-29	79-3473	.09	.53	397	1.83	25.6	0.42
		Engelhard Catalyst Installed Underneath Vehicle					
6-30	79-3575	.14	.19	411	1.87	24.7	0.57
7-29	79-4388	.14	.17	437	2.06	23.3	
		Typical Baseline Emissions					
		.23	.86	441	2.01	23.0	.47

Mercedes Benz Diesel Catalyst
50 MPH Steady State Results gm/mi

Date	Test No.	HC(HFID)	CO	CO2	NOx	MPG	Particulate
			Engelhard Catalyst Installed in Engine Compartment				
6-14	79-2623	.11	.04	357	1.80	28.5	0.98
6-15	79-2632	.08	.03	348	1.72	29.2	0.96
6-16	79-2636	.10	.04	322	1.58	31.6	0.72
			Bypass for Engelhard Catalyst (Engine Compartment Configuration)				
6-21	79-3055	.06	.45	334	1.90	30.4	0.36
6-22	79-3072	.10	.49	354	1.90	28.7	0.36
			Ford Catalyst				
6-28	79-3472	.04	.11	333	1.78	30.5	-----
			Engelhard Catalyst Installed Underneath Vehicle				
6-30	79-3578	.06	.03	320	1.70	31.8	0.69
			Typical Baseline Emissions				
		.08	.54	330	1.65	30.5	.35

Mercedes Benz Diesel Catalyst
HFET Results gm/mi

Date	Test No.	HC(HFID)	CO	CO2	NOx	MPG	Particulate
		Engelhard Catalyst Installed in Engine Compartment					
6-14	79-2622	.199	.03	373	1.87	27.2	1.23
6-15	79-2626	.07	.03	350	1.77	29.1	0.88
6-16	79-2635	.13	.04	348	1.75	29.2	0.95
6-19	79-3051	.12	.01	374	1.92	27.2	-----
		Bypass for Engelhard Catalyst (Engine Compartment Configuration)					
6-20	79-3054	.07	.51	352	1.85	28.9	0.42
6-22	79-3071	.09	.49	355	1.94	28.6	0.34
		Ford Catalyst					
6-27	79-3086	.02	.07	334	1.72	30.5	0.36
6-28	79-3090	.03	.07	331	1.78	30.7	0.58
6-29	79-3475	.03	.08	360	1.86	28.3	0.61
		Engelhard Catalyst Installed underneath Vehicle					
6-30	79-3577	.04	.06	349	1.79	29.2	0.78
7-29	79-4389	.09	.04	373	1.92	27.3	
7-29	79-4390	.12	.04	372	1.88	27.3	
		Typical Baseline Emissions					
		.15	.54	332	1.75	30.5	.32

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: October 20, 1978

SUBJECT: Ames test results from MB 300D With and Without Catalysts

FROM: Thomas M. Baines, Engineer, CAB

TO: Charles L. Gray, Director, ECTD

THRU: Karl H. Hellman, Chief, CAB

During late June and early July, 1978, a series of samples were taken to ORD/MSERB in Research Triangle Park, N.C. These samples were from a Mercedes Benz 300D Diesel light-duty vehicle which was operated over a variety of cycles and was equipped both with and without a catalyst. MSERB was requested to extract these samples and send the extracts to the Cellular Biology Section (CBS) for Ames tests. This history is summarized in the attached 17 August, 1978 memo to you from J.H. Somers.

These samples were finally analyzed in late August and early September and the results finally communicated to us on 27 September, 1978 during a meeting with Joellen Huisingh. These results are summarized in Table 1.

In discussing these results, Joellen felt that the only statement that can be made is that the samples from the Mercedes operated both with and without a catalyst all appear to be mutagenic. It appears that the catalyst did not alter the mutagenicity of the sample. There was, however, some question about the quality of the sample. These samples were packed and transported in accordance with the instructions given to ECTD by MSERB, namely to put the filter into a manila envelope and keep it at room temperature. During the meeting, Joellen expressed concern over the stability of the samples in that they had not been handled under yellow light, stored in a nitrogen atmosphere at sub-zero temperatures (the current recommended practice).

Joellen states that it is currently not possible to compare Ames test results that have been run under different conditions at different times. With this limitation in mind it may be useful to observe that the Mercedes 300D results reported here are generally the same as (possibly a bit higher than) the results reported on the VW and Mercedes 240D in the Williamsburg paper.

I am aware that it is important that we obtain better communication of preliminary results on Ames tests with ORD in FY79. ECTD has brought this point up to various ORD people as an area to improve in FY79.

If you have any questions, please advise.

Attachments

cc: Merrill Korth
Robert Maxwell
Stanley Blacker

Table 1

Table of Ames Test Results from
Mercedes Benz 300D Diesel Vehicle Catalyst Experiments

Sample Numbers	Test Cycle	Catalyst	Specific Activity (rev./ml.) - MA**	+ MA**
1 + 12	50SS	Engelhard*+	3817	4496
6 + 13	HFET	Engelhard*+	2067	3822
9 + 10	FTP(1,2)+	Engelhard*+	1712	3973
20 + 27	HFET	No Cat	2205	3038
21 + 23	FTP(1,2,3,4)	No Cat	1267	3129
26 + 32	FTP(1,2)	Ford++	2136	3359
11	FTP(3,4)	Engelhard*+	IS*	1269
24 + 25	50SS	No Cat	362	1450
28 + 33	FTP(3,4)	Ford++	519	2147
30 + 36	50SS	Ford++	245	840

*IS = Insufficient Sample

+ Number in parenthesis indicates FTP bags during which sample was taken.

*+ Catalyst located in engine compartment, close to exhaust manifold.

++ Catalyst located in toeboard position.

** -MA = without metabolic activation

+MA = with metabolic activation

March 7, 1979

Additional Computation of Ames Test Results
From MB 300D Catalyst Study

Thomas M. Baines, Engineer, CAB

Charles L. Gray, Director, ECTD

THRU: Karl H. Hellman, Chief, CAB

The purpose of this memo is to transmit the computations that you requested. These computations are of the Ames test data from the study of the Mercedes Benz 300D operated both with and without a catalyst. You requested that in addition to the specific activity (rev./plate/ml) data reported in my 20 October, 1978 memo to you, that I compute the data in terms of revertants per plate per mile, grams particulate per mile, grams of particle bound oganics (PBO) per mile, revertents per gram of particulate sample and grams of "hot" extractable per mile. All of these data (as well as some gaseous emissions data) are given in the attached Table 1 with the exception of the "hot" extractable data. This is because 1) none of the samples were fractionated to yield such data, and 2) no light duty samples have ever been known to be fractionated to yield data which could be used to scale the data obtained in this study.

Table 1 is largely self-explanatory. However, an important points must be made. Namely, that the data can only be compared within test laboratories as the laboratories each used a different batch of the same strain of Salmonella t. bacteria. Extensive investigation in the two labs was carried out after these data were developed and it then became apparent that one batch of bacteria was significantly more sensitive than the other.

Using the data in Table 1 it can be seen that the parameter "revertents per mile (rev/mi)" ranges from 0.9×10^4 to 7.4×10^4, somewhat less than one order of magnitude. Within a given lab (NSI or CBS) the range is less, about a factor of 2 to 3.

With respect to the effect of the catalyst, the best comparisons can be made using the 50SS data from CBS with and without catalyst and the NSI data on the FTP and the HFET. These are shown in Table 2.

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Table 2

With Catalyst Compared to No Catalyst Data

Lab	Cycle	Catalyst	PBO g/mi	rev/mi[6]
CBS	50SS	Yes (Ford)	0.021	0.9×10^4
CBS	50SS	No	0.035	2.5×10^4
NSI	FTPC	Yes (Ford)	0.022	3.7×10^4
NSI	FTPC	Yes (Engel)	0.037	7.4×10^4
NSI	FTP	No	0.034	5.3×10^4
NSI	HFET	Yes (Engel)	0.026	3.7×10^4
NSI	HFET	No	0.029	4.4×10^4

In the CBS case the use of the catalyst reduced rev/mi by 64%. In the cases of the NSI data on the HFET use of the catalyst reduced rev/mi by 16%. However for the NSI data on the FTP the use of the catalyst either increased rev/mi by 45%, or reduced rev/mi by 50% depending on which catalyst (Engelhard or Ford) was used.

Because (as is pointed out in footnote 8 to Table 1) the significance of the unit rev/mi is not yet established, it is suggested that the results shown in Table 1 and Table 2 not be over interpeted. Since the Ames Test activity data has not yet even been acknowledged by ORD to be able to be used in a quantitatively comparable manner, the quantitative comparisons shown in the above table may not be supported by ORD researchers.

If you have any questions on this, please advise.

Attachment

cc: Merrill Korth
Robert Maxwell
Ralph Stahman
Stanley Blacker

CAB:BAINES:dc:2565 Plymouth Rd:X448:3/7/79

Table 1

Table of Emissions and Ames Test Results from MB 300D with and without Catalyst

Sample Numbers	Test Cycle[1]	Cat.[2]	Test Lab.[3]	Emission Rate g/mi.[4] HC[4]	CO[4]	Part.[4]	PBO[5]	S.A. (rev/ml)[6] -MA	+MA	rev/g sample[7]	rev/mi[8]
9 + 10	FTPC	Engl	NSI	0.14	0.12	0.588	0.037	1712	3973	12.5×10^4	7.4×10^4
26 + 32	FTPC	Ford	NSI	0.09	0.50	0.416	0.022	2136	3359	8.9×10^4	3.7×10^4
21 + 23	FTP	None	NSI	0.10	0.78	0.442	0.034	1267	3129	12.0×10^4	5.3×10^4
6 + 13	HFET	Engl	NSI	0.10	0.04	0.919	0.026	2067	2822	4.0×10^4	3.7×10^4
20 + 27	HFET	None	NSI	0.08	0.50	0.381	0.029	2205	3038	11.6×10^4	4.4×10^4
1 + 12	50SS	Engl	NSI	0.09	0.04	0.840	0.032	3817	4496	8.6×10^4	7.2×10^4
11	FTPH	Engl	CBS	0.14	0.10	0.556	0.029	IS[6]	1269	3.3×10^4	1.8×10^4
28 + 33	FTPH	Ford	CBS	0.09	0.50	0.416	0.026	519	2147	6.7×10^4	2.8×10^4
30 + 36	50SS	Ford	CBS	0.03	0.09	0.390	0.021	245	840	2.3×10^4	0.9×10^4
24 + 25	50SS	None	CBS	0.08	0.47	0.366	0.035	362	1450	6.9×10^4	2.5×10^4

1 FTP = FTP, bags 1, 2, 3, 4; FTPC = FTP, bags 1, 2; FTPH = FTP, bags 3,4.

2 Engl = Engelhard catalyst, located in engine compartment close to exhaust manifold; Ford = Ford catalyst located in toeboard position; None = no catalyst used.

3 Test lab. = laboratory performing Ames test; NSI = Northrup Services, Inc.; CBS = Cellular Biology Section.

4 Average emissions for the given pollutant over the two filters that were combined for Ames testing. The FTP HC and CO emissions averages are for the entire FTP, not just the cold or hot portions. The particulate mass emissions data come from 47 mm filter data.

5 PBO = Particle bound organics; computed by taking PBO fraction data from 8 x 10 filters and applying to the 47 mm data.

6 Specific Activity in revertants per plate per ml of solution (solvent + PBO, in a ratio of 2 mg PBO/1 ml solvent); -MA = without metabolic activation; +MA = with metabolic activation; IS = insufficient sample.

7 Revertants per plate per gram of particulate sample. Based on Specific Activity with metabolic activation data.

8 Revertants per plate per mile. The practical significance of this unit has not yet been established.