EPA/AA/TDG/93-03

Technical Report

Evaluation of Specialized Catalysts for Methanol (M100) Vehicles

by

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Technical Reports do not necessarily represent final EPA decisions or positions. They are intended to present technical analysis of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position, or regulatory action.

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OFFICE OF
AIR AND RADIATION

MEMORANDUM

SUBJECT: Exemption from Peer and Administrative Review

FROM: Karl H. Hellman, Chief
Technology Development Group

TO: Charles L. Gray, Jr., Director
Regulatory Programs and Technology

The attached report entitled, "Evaluation of Specialized Catalysts for Methanol (M100) Vehicles," EPA/AA/TDG/93-03, presents the emission test results of two catalyst systems, one developed by GM and the other by Nippon Shokubai, which are specially formulated for use with methanol-fueled vehicle applications. This report presents the data from vehicle tests using these catalysts with and without air injection on a vehicle equipped with a lean burn engine and a vehicle equipped with an engine operated at the stoichiometric air/fuel ratio.

Since this report is concerned only with the presentation of data and their analysis and does not involve matters of policy or regulation, your concurrence is requested to waive administrative review according to the policy outlined in your directive of April 22, 1982.

Concurrence: ______________________ Date: 7-12-93
Charles L. Gray, Jr., Director, RPT

Nonconcurrence: ______________________ Date: __________
Charles L. Gray, Jr., Director, RPT

Attachment

cc: E. Burger, RPT

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Evaluation of Specialized Catalysts for Methanol (M100) Vehicles

I. Summary

A test program was performed at EPA's National Vehicle and Fuel Emissions Laboratory (NVFEL) to evaluate two different methanol vehicle catalyst systems on both lean burn and stoichiometric port injected engine-equipped vehicles using M100 (neat methanol) fuel.[1,2] Emission levels, particularly formaldehyde emissions, were significantly reduced by both catalysts. Air injection strategies were implemented to obtain very low cold start emissions of unburned fuel and formaldehyde.

II. Introduction

Recently, an abstract for a Japanese patent application for a novel alcohol-fueled engine exhaust catalyst was published in Platinum Metals Review.[3] EPA contacted the catalyst manufacturer, Nippon Shokubai Co., Ltd., and requested catalyst samples for evaluation on methanol-fueled vehicles at NVFEL.

Nippon Shokubai America, Inc. responded stating that they would be willing to participate in a cooperative program, with provisions to keep proprietary certain aspects of their catalyst and its development. The Nippon Shokubai catalyst system includes two catalysts, one for oxidation of unburned fuel, CO and formaldehyde and the other for reduction of NOx emissions, in separate beds with an air injection nozzle inlet before the oxidation catalyst.

EPA also learned of specialized catalyst development for methanol application at General Motors. EPA requested and received catalyst samples from GM. EPA then tested the GM catalyst samples on the same vehicles in similar fashion as the Nippon Skokubai catalysts. The GM catalyst system does not contain separate catalyst beds, but EPA inserted an air injection nozzle inlet upstream of the catalyst in the exhaust pipe to evaluate catalyst conversion efficiencies under very lean conditions.

III. Test Program

Both catalyst systems were expected to be tested on both lean burn and stoichiometrically calibrated neat methanol vehicles. The lean burn vehicle mentioned above is a Toyota Corolla with a 1.8L methanol engine using a second generation Toyota Lean Combustion System and is originally equipped with both close-coupled exhaust manifold start catalysts and a main underfloor catalyst. Both the Nippon Shokubai and GM catalysts were evaluated on the Toyota Corolla in place of the stock underfloor catalyst.

The stoichiometrically calibrated vehicle is a Volkswagen Rabbit with a 1.6L methanol engine. The Rabbit was equipped with a stock underfloor catalyst (i.e., no close coupled exhaust manifold start catalyst) which was removed for placement of the GM catalyst. The Nippon Shokubai catalyst was not tested on the VW Rabbit.

An electric air pump manufactured by Coltec Industries, Inc., was obtained to test each catalyst at constant air injection rates. The catalyst manufacturers were asked to provide optimum air injection strategies for the evaluation. Nippon Shokubai specified that the air injection should be supplied for the first 180 seconds of the Federal Test Procedure (FTP), or longer if the catalyst bed temperature did not exceed 500°C (932°F) after three minutes. Nippon Shokubai did not specify an air injection rate, but assumed it should be enough to achieve air/fuel ratios in excess of 18:1 (unless this caused high aldehyde emission rates to occur). GM did not specify an air injection strategy.

It was decided to use the maximum air flow rate of the air pump, 4.2 cfm, for all tests utilizing air assist. The flow duration of 100 seconds was chosen because this was the same duration as the catalyst preheating time used in preceding evaluations of electrically heated catalysts at NVFEL.[4] In order to avoid the creation of hot spots in the catalyst substrates, no attempt was made to measure catalyst bed temperature throughout the test program.

After one test on the Toyota Corolla with the Nippon Shokubai catalyst system, the Coltec air pump failed due to a faulty voltage regulator. An air compressor with a flow meter flowing shop air into the exhaust stream between the beds of the Nippon Shokubai system, and just upstream of the GM catalyst, was used for all subsequent tests involving air injection. The Nippon Shokubai catalyst was tested with shop air injection rates of 4.2, 6.0, and 2.0 cfm. On tests involving air injection, the GM catalyst was tested with 100 seconds of shop air injected at 5 cfm.

In addition to these air injection strategies evaluated, both catalyst systems were tested in a variety of other configurations as discussed below.

Initially, both vehicles were baseline tested for emissions over the FTP cycle (i.e., no catalyst installed) to determine an engine-out emissions baseline for calculating catalyst conversion efficiencies.

The methanol-fueled Toyota Corolla was tested with dummy (i.e., uncatalyzed) substrates in both the underfloor and the manifold close coupled catalyst locations. The Corolla was then tested with first the Nippon Shokubai and then the GM catalyst in place of the main underfloor catalyst and uncatalyzed substrates in the close coupled catalyst location. Neither catalyst system was tested with an electrically heated catalyst in the exhaust system. Finally, the Corolla was tested with the GM catalyst in place of the main underfloor catalyst and catalyzed substrates in the close coupled exhaust manifold catalysts. The Nippon Shokubai catalyst was not tested in combination with catalyzed close coupled manifold catalysts on the Toyota Corolla.

The Volkswagen Rabbit was tested with the GM catalyst in place of the stock underfloor catalyst. No close coupled catalysts were installed in the exhaust system of the VW Rabbit.

IV. Test Results

Tables 1 and 2 present the Bag 1 and FTP emission levels measured during the Nippon Shokubai catalyst evaluation on the Toyota Corolla vehicle. "Base" refers to baseline levels without any catalyst being present in the exhaust system. "No air" represents emissions measured with the catalyst in the exhaust system in an underfloor location without any secondary air injection to aid the oxidation reactions. The "4.2 cfm airpump" levels were obtained by using the Coltec electric air pump for secondary air injection at a 4.2 cubic feet per minute (cfm) flowrate for 100 seconds after key-on. The "6.0, 4.2, and 2.0 cfm" levels were obtained by using a shop air line for secondary air injection at these three flowrates for 100 seconds after key-on. The last row of data ("no air") was obtained with the catalyst in the exhaust system without any air assist. This was a repeated test sequence conducted at the end of the test program to determine if any drift in the "no air" data occurred.

Table 1
Nippon Shokubai Catalyst Evaluation
Bag 1 Emissions Levels in Grams (HCHO in Milligrams)
Toyota Corolla Methanol-Fueled Vehicle

Config	*HC	NO_x	CO	CO_2	CH_3OH	HCHO	OMHCE	NMHC
Base	7.22	2.8	30.7	808	20.20	2118	10.38	0.61
No Air	2.22	2.0	16.0	864	6.41	49	2.92	0.14
4.2 cfm Airpump	2.51	1.9	18.9	859	6.90	202	3.35	0.22
6.0 cfm	2.94	2.0	24.2	858	8.06	269	3.93	0.26
4.2 cfm	2.38	1.9	20.3	862	6.95	253	3.25	0.16
2.0 cfm	2.49	2.4	20.8	879	7.10	255	3.38	0.12
No Air	2.89	1.9	22.8	850	8.51	298	3.96	0.08

* Gasoline-fueled vehicle measurement procedure.

Table 2
Nippon Shokubai Catalyst Evaluation
FTP Emission Levels in Grams/Mile (HCHO in Milligrams/Mile)
Toyota Corolla Methanol-Fueled Vehicle

Config	*HC	NO_x	CO	CO_2	CH_3OH	HCHO	OMHCE	NMHC
Base	1.67	0.6	5.8	214	4.71	624	2.47	0.13
No Air	0.15	0.4	1.1	231	0.40	4	0.20	**
4.2 cfm Airpump	0.17	0.4	1.9	229	0.44	15	0.22	0.01
6.0 cfm	0.20	0.5	2.2	230	0.55	20	0.27	0.02
4.2 cfm	0.16	0.4	1.8	233	0.45	19	0.21	0.01
2.0 cfm	0.16	0.5	1.9	235	0.43	19	0.21	**
No Air	0.19	0.4	2.2	230	0.55	24	0.26	0.01

* Gasoline-fueled vehicle measurement procedure.
** Less than 0.005 grams/mile measured.

From this data, it can be seen that unassisted catalyst levels did drift substantially. This is especially true with formaldehyde emissions. Bag 1 levels changed from 49 milligrams to 298 milligrams; the corresponding FTP formaldehyde levels were 4 to 24 milligrams per mile. Also, air assist to this catalyst during cold start had little effect in lowering emission levels and, in fact, increased the emissions of unburned fuel, CO, and formaldehyde.

Tables 3 through 6 present the test results of the second methanol catalyst evaluation; the catalyst was provided to EPA by General Motors. Table 3 presents individual bag results when the catalyst was used on the methanol-fueled Toyota Corolla test vehicle. The first row of data, "Base," represents Bag 1 emission levels with dummy substrates in the manifold and underfloor catalysts. The second row of data "GM Cat. Only" represents Bag 1 emission levels from the Corolla vehicle with the GM catalyst present in the exhaust system in an underfloor location. The third row of data "GM Cat. + cc cat" represent Bag 1 emission levels obtained with the GM catalyst again in the underfloor location in conjunction with the standard Toyota close-coupled catalysts that were originally equipped on the vehicle. The last configuration "GM Cat. + cc cat + Air" again utilized the GM catalyst in the underfloor location and the Toyota close-coupled catalyst in conjunction with secondary air assist to promote catalyst oxidation reactions. This air assist was provided by the shop air line in the test cell and was supplied for 100 seconds after key-on in Bag 1 only at a flowrate of 5 standard cubic feet per minute. This table also contains emission levels measured during the Bag 2 and 3 segments of the FTP.

Table 3
GM Methanol Catalyst Evaluation
Toyota Corolla Methanol-Fueled Vehicle

Config.	HC g	NOx g	CO g	CO_2 g	CH_3OH g	HCHO mg	OMHCE g	NMHC g
BAG 1:								
Base	6.70	2.5	29.1	802	19.62	2089	9.79	0.40
GM Cat. Only	2.14	1.7	16.8	859	6.19	257	2.93	0.08
GM Cat. +cc cat	1.62	1.7	17.9	894	4.77	122	2.20	0.01
GM Cat. +cc cat + Air	1.24	1.8	15.4	887	3.76	102	1.69	**
BAG 2:								
Base	6.56	1.8	19.2	830	18.80	2628	9.80	0.42
GM Cat. Only	0.05	0.8	0.1	913	0.12	26	0.07	**
GM Cat. +cc cat	0.03	1.1	***	939	0.07	10	0.04	**
GM Cat. +cc cat + Air	0.04	1.0	0.1	930	0.10	8	0.05	**
BAG 3:								
Base	5.06	2.4	18.8	735	14.72	2167	7.66	0.34
GM Cat. Only	0.03	1.7	0.1	761	0.08	8	0.04	**
GM Cat. +cc cat	0.04	1.6	0.8	779	0.10	4	0.05	**
GM Cat. +cc cat + Air	0.03	1.4	1.0	778	0.08	2	0.04	**

** Represents less than 0.005 grams measured.
*** Represents less than 0.05 grams measured.

Table 4 presents individual bag emission levels when using the same GM methanol catalyst on the methanol-fueled Volkswagen Rabbit vehicle. "Base" again refers to levels obtained without any catalyst in the exhaust stream. "GM Cat. Only" represents emission levels when using the GM catalyst in an underfloor location. The last configuration with the VW Rabbit utilized the GM catalyst with the same air assist as described previously.

Table 4
GM Methanol Catalyst Evaluation
Volkswagen Rabbit Methanol-Fueled Vehicle

Config.	HC g	NOx g	CO g	CO_2 g	CH_3OH g	HCHO mg	OMHCE g	NMHC g
BAG 1:								
Base	5.79	7.0	33.3	1058	16.45	1728	8.37	0.39
GM Cat. Only	2.72	3.4	14.4	1094	8.04	389	3.77	0.06
GM Cat. + Air	2.38	3.9	14.8	1100	6.90	395	3.31	0.09
BAG 2:								
Base	3.13	4.3	23.7	1156	8.42	1649	4.81	0.36
GM Cat. Only	0.15	1.9	0.1	1194	0.04	30	0.16	0.10
GM Cat. + Air	0.14	2.0	**	1203	0.02	16	0.15	0.10
BAG 3:								
Base	2.99	7.4	18.7	933	8.30	1297	4.49	0.27
GM Cat. Only	0.05	3.2	0.5	966	0.06	9	0.06	0.01
GM Cat. + Air	0.05	3.3	0.4	970	0.04	5	0.06	0.01

** Represents less than 0.05 grams measured.

Table 5 presents weighted composite emission levels obtained over the FTP cycle with the Toyota vehicle using the same catalyst configurations as described previously. All levels are in grams per mile except for formaldehyde, which are in milligrams per mile.

Table 5
GM Methanol Catalyst Evaluation
Toyota Corolla Methanol-Fueled Vehicle

Config.	HC g/mi	NOx g/mi	CO g/mi	CO_2 g/mi	CH_3OH g/mi	HCHO mg/mi	OMHCE g/mi	NMHC g/mi
Base	1.66	0.6	5.7	214	4.79	640	2.47	0.12
GM Cat. Only	0.13	0.3	1.0	231	0.38	19	0.18	**
GM Cat. +cc cat	0.10	0.4	1.1	236	0.29	9	0.14	**
GM Cat. +cc cat + Air	0.08	0.3	1.0	236	0.24	7	0.11	**

** Represents less than 0.005 grams/mile measured.

Table 6 contains weighted composite FTP emission levels using the VW Rabbit vehicle over the same catalyst configurations described above.

Table 6
GM Methanol Catalyst Evaluation
Volkswagen Rabbit Methanol-Fueled Vehicle

Config.	HC g/mi	NOx g/mi	CO g/mi	CO_2 g/mi	CH_3OH g/mi	HCHO mg/m	OMHCE g/mi	NMHC g/mi
Base	0.99	1.5	6.5	288	2.72	421	1.48	0.09
GM Cat. Only	0.18	0.7	0.9	298	0.48	27	0.25	0.02
GM Cat. + Air	0.16	0.7	0.9	299	0.41	26	0.21	0.02

All emission data values in Tables 1 through 6 were obtained by averaging at least three individual test results. The catalysts were fresh and tested right out of the box.

V. Conclusions

Catalyst formaldehyde conversion efficiencies with the Nippon Shokubai catalyst on a lean-calibrated methanol vehicle were quite high and ranged from 86 to 98 percent in Bag 1, and 96 to 99 percent over the full FTP on all tests.

Air assist to the Nippon Shokubai catalyst during cold start had little effect in lowering emission levels and, in some instances, increased the emissions of unburned fuel, CO, and formaldehyde. Conversion efficiencies of these pollutants were quite high over the FTP with or without air injection.

Emission results on tests with the Nippon Shokubai catalyst without air injection varied considerably from the beginning to the end of the test program. Formaldehyde emissions in particular increased over 500 percent in Bag 1 of the FTP on tests without air injection at the beginning of the test program, as compared to similar tests run at the end of the test program.

The best catalyst formaldehyde conversion efficiencies with the GM catalyst were obtained on tests with air injection and catalyzed close coupled exhaust manifold catalysts. Bag 1 HCHO conversion efficiencies ranged from 88 to 95 percent on the lean calibrated Toyota Corolla and were 77 percent on the VW Rabbit with and without air injection.

HCHO conversion efficiencies with the GM catalyst system were higher on the lean calibrated Toyota Corolla than on the stoichiometric calibrated VW Rabbit. It is not known whether this is due to the relative air/fuel ratio calibration of the respective vehicles, or the fact that engine-out emissions of the VW Rabbit were considerably lower than those of the Toyota Corolla.

Though somewhat improved with air injection, the conversion efficiencies of the GM catalyst were quite high with or without air injection, particularly those of HC, HCHO, and CH_3OH.

Tests with the GM catalyst and catalyzed close coupled catalysts without air injection on the Toyota Corolla did not improve conversion efficiencies over results of tests where the manifold catalysts were uncatalyzed or where the GM catalyst was tested in combination with catalyzed close coupled catalysts and air injection.

Both catalyst systems are highly selective and active for conversion of formaldehyde emissions. Conversion efficiencies of hydrocarbons, CO, and methanol are also significant. Carbon dioxide emissions increase slightly, between 3 and 10 percent, over engine-out levels with both catalyst systems.

The lowest levels of formaldehyde with the Nippon Shokubai catalyst on the Toyota Corolla were obtained with an air injection rate of 4.2 cfm. HCHO conversion efficiencies of similar quality were obtained with only 2.0 cfm of air injected, but were degraded significantly with 6.0 cfm of air injection.

VI. Acknowledgments

The authors wish to acknowledge the cooperative efforts of the Nippon Shokubai and General Motors Corporations for supplying the methanol catalysts for evaluation.

The authors also thank technicians Jim Garvey, Bob Moss, and Ray Ouillette for assisting with the test program.

VII. References

1. "Test Plan for Evaluation of Nippon Shokubai Methanol Catalysts," Piotrowski, Gregory P. and Ronald M. Schaefer, memorandum to Charles L. Gray, Jr., EPA/OAR/OMS/RPT/TDG, September 24, 1992.

2. "Test Plan for Evaluation of GM Production Catalyst for Methanol Vehicle Application," Piotrowski, Gregory P. and Ronald M. Schaefer, memorandum to Charles L. Gray, Jr., EPA/OAR/OMS/RPT/TDG, February 11, 1993.

3. Platinum Metals Review, 36:(1), "Exhaust Purification Catalysts for Alcohol Fueled Engines," patent abstract of Nippon Shokubai Kagaku, January 1992.

4. "Start Catalyst Systems Employing Heated Catalyst Technology for Control of Emissions from Methanol-Fuelled Vehicles," Hellman, Karl H., Gregory K. Piotrowski, and Ronald M. Schaefer, U.S. EPA, SAE Paper 930382, International Congress and Exposition, Detroit, Michigan, March 1-5, 1993.

Appendixes

APPENDIX A

DESCRIPTION OF SECOND-GENERATION TOYOTA LCS-M PROTOTYPE VEHICLE

Engine:

General	L4, 4A-FE engine, 1.6-liter, dual overhead cam design
Compression ratio	11.0:1
Fuel metering	D-Jetronic sequential port fuel injection
Ignition	W27ESR-U Nippondenso spark plugs
Combustion Chamber	Compact pent roof design
Bore x Stroke (mm)	81 x 77
Idle Speed	700 rpm, 10° BTDC ignition timing at idle
Spark Timing Control	Electronic spark advance
Fuel	M100 or M85 (Toyota provided different calibrations for each fuel)
Exhaust Gas Recirculation	EGR used

Vehicle:

Base vehicle	1988 Corolla sedan
Test weight	2,750 lbs
Test HP	8.9 hp
Transmission	5-speed manual transmission, shifting schedule 15-25-40-45 MPH
Gear ratio	1st 3.545 2nd 1.904 3rd 1.233 4th 0.885 5th 0.725

APPENDIX A (CONT'D)

DESCRIPTION OF SECOND-GENERATION TOYOTA LCS-M PROTOTYPE VEHICLE

Differential Ratio	3.722
Tire Size	155SR13
Catalytic Converter System	0.71-liter Pt:Rh (manifold close coupled) 0.51-liter Pd (underfloor)

Other Modifications Made:

Engine Oil	Multiweight oil specially formulated for use with methanol
Fuel Tank, Inlet, Delivery Pipes	Nickel/phosphorus plated
Intake Valves	Martensitic steel with stelliting
Exhaust Valves	Austenitic steel with stelliting
Fuel Injectors	Modified to accommodate greater flowrate of methanol
Fuel Lines	Nickel plated
Fuel Hose	NBR modified
Fuel Pump	In-tank fuel pump body nickel plated

Appendix 1

Test Vehicle Description*

A. VEHICLE DESCRIPTION

1981 Volkswagen Rabbit "L" 4-Door Sedan - Model 177243
VI# 1VWF80175BV012728 Engr. Car # 1285

Automatic transmission, air conditioning, 155 80R13 tires, radio and cloth interior. (A vehicle with Vinyl "leatherette" interior was not available at time prototype was built. This may have a small influence on evaporative losses, but this will be negligible once the "new car" background level deteriorates.)

B. DETAILED COMPARISON OF PRODUCTION vs. METHANOL POWERTRAIN AND FUEL SYSTEM

ITEM	1980 PRODUCTION	METHANOL VEHICLE
Basic Engine		
o Type	- 827	- 827
o Displacement	- 1.6 liter (1588cc)	- 1.6 liter (1588cc)
o Bore	- 3.13 inches	- 3.13 inches
o Stroke	- 3.15 inches	- 3.15 inches
o Compression Ratio	- 8.2:1	- 12.5:1 (new pistons)
o Valvetrain	- Overhead camshaft	- Overhead camshaft
o Rated Power	- 76 HP SAE net @ 5500 RPM	- Not measured
o Rated Torque	- 82.7 Ft. lbs. SAE net @ 3200 RPM	- Not measured
o Other	-	- GTI basic engine - European high performance engine to withstand higher loads - U.S. cylinder head.
Fuel System	- Bosch CIS Fuel Injection with Lambda feedback control.	- Same as Production with calibration for Methanol operation.

*Reproduced from Reference 2.

ITEM	1980 PRODUCTION	METHANOL VEHICLE
Fuel System (Continued)		
o Fuel Pump		
Pump Life	- Life of Vehicle	- 6 months to 1 year due to corrosiveness of Methanol.
Other	-	- Improved insulation on wiring exposed to fuel.
o Accumulator		
Maximum holding pressure	- 2.5 Bar	- 3.0 bar (due to fuel difference).
o Fuel Filter		- Bonding glue changed for fuel compatability. - One way check valve deleted (Incompatable with fuel).
o Fuel Distributor		
System pressure	- 4.6 - 4.8 bar	- 5.0 - 5.3 bar
Calibration	- Optimized for gasoline	- Optimized for Methanol.
Other	-	- Material changes for fuel compatability.
o Air sensor	-	- Modified airflow charteristics.
o Fuel Injectors	-	- Material change for fuel compatability. - Plastic screen replaced by metal screen.
o Cold Start Injector		
Quantity	- One	- Two
Function	- On for start only.	- Cold start valves pulse for 8 seconds beyond start mode, below zero degrees centigrade.

ITEM	1980 PRODUCTION	METHANOL VEHICLE
Fuel System (Continued)		
Other	-	- Calibration changed for Methanol. - Material changed for fuel compatability.
o Fuel Injection Wiring	-	- Modified for cold start pulse function and to accomodate relays and thermo switch.
o Air Conditioner		
Idle Load Compensation	- Ignition distributor vacuum advance controlled.	- Throttle body idle air flow bypass system controlled. (Same as 1982 Production)
o Idle Setting		- Specific to Methanol calibration
PCV	- PCV Valve with calibrated plunger and calibrated orifice.	- PCV valve with calibrated plunger - no orifice.
IGNITION		
o Distributor	- Transistor high energy with hall effect and digital idle speed control through spark advance.	- Slightly reduced maximum centrifugal advance and slightly modified vacuum advance/retard characteristics.
o Spark Plugs	- Bosch W175T30	- Bosch W260T2-Colder
OIL COOLING	- None	- Heat exchanged from engine oil to cooling water for high loads only (e.g. trailer hauling) not anticipated to be needed in normal operation.

TRANSMISSION	- Automatic 3-Speed	- Automatic 3-Speed (1981 Production Transmission)
o Torque Converter Ratio	- 2.44	- 2.44
o Stall Speed	- 1900-2200 RPM	- 2000-2200 RPM
o Gear Ratios		
1	- 2.55	- 2.55
2	- 1.45	- 1.45
3	- 1.00	- 1.00
Axle	- 3.76	- 3.57
FUEL TANK		- (European)
o Material	- Steel	- Steel
o Coating	- Terneplate	- Phosphated steel, exterior painted
o Seams & Fittings	- Soldered	- Brazed
o Cap -	- Non-Locking	- European neck and locking cap
FUEL	- Unleaded gasoline	- Methanol with 5.5% Isopentane

Catalyst Formulations

Nippon Shokubai Kagaku:

Japanese Appls. 3/72,949-50

Catalysts for purifying exhaust gas from internal combustion engines using alcohol as a fuel consist of a 3-dimensional structure coated with a catalyst composition containing: (a) 0.5-4.0 g of Pt, Pd or Rh and 1.0-20 g of Ag on stable Ce oxide (50-200 g) containing at least Mg, Ba, Ca, Sr or Y; or (b) 0.5-1.5 g/l Pd and 5-10 g/l Ag on Al_2O_3 (80-150 g/l) containing at least one oxide of Ti, Si, and Zr. The catalysts decompose CO, CH_3OH and HCHO in the exhaust gas at low temperature, and catalyst (a) shows improved heat stability of the Ce oxide.

According to Nippon Shokubai, the catalyst specifications are:

	Size	Volume	Active Material
Front Catalyst	105 mm dia. 114 mm long	1.0 L	1.5 g 5/1 Pt/Rh
Rear Catalyst	105.7 mm dia. 114 mm long	1.0 L	Base Metal

General Motors Corporation:

The GM catalyst was a production unit for the flexible-fueled Chevrolet Lumina equipped with a 3.1-liter engine. Two monolithic elements were canned in the same shell. The first monolith was coated with Palladium only, and the second element was coated with a Platinum/Rhodium mixture. Additional catalyst specifications were provided by GM and presented below.

	Size	Volume	Active Material
Front Catalyst	169.67 mm by 80.77 mm oval 117.5 mm long	1.6 L	3.88 g Pd Only
Rear Catalyst	169.67 mm by 80.77 mm oval 117.5 mm long	1.6 L	1.53 g 6/1 Pt/Rh