

Testing of the Chemico
FCCIP Candidate Vehicle

March 1973

Emission Control Technology Division
Office of Air and Water Programs
Environmental Protection Agency

Summary

The Chemico Oldsmobile was tested by the Test and Evaluation Branch (TEB) over a span of approximately seven months and 19,000 miles. The car displayed generally poor cold startability but acceptable driveability, performance and fuel consumption when compared to the stock version of the same car. Control of gaseous emissions was generally good but erratic; the best test results were at 1976 levels but test-to-test variability was large. Emissions of oxides of nitrogen (NOx) were controlled best and most consistently. Large variations in unburned hydrocarbons (HC) and carbon monoxide (CO) emissions were partially the result of poor startability and choke operation.

Durability of the system was poor. There were three converter failures, several additions of catalyst pellets, and replacement and adjustment of air pump and exhaust gas recirculation (EGR) system components.

Background

The Chemico Low Emission Car was the first candidate car to be submitted for Phase I testing of the Federal Clean Car Incentive Program. Under Contract No. 68-04-0009, the vehicle was to be evaluated according to FCCIP-SPEC-004, "Prototype Vehicle Test Specification", over a period of ninety days.

Vehicle Description

The car was a 1972 Oldsmobile Delta 88 with modifications made by Chemico to reduce exhaust emissions. The car was a four-door sedan with power steering and power brakes, having a curb weight of 4,200 pounds. The engine was a carbureted V-8 of 350 cubic inches displacement, driving through a three-speed automatic transmission. For emissions tests an inertia weight of 4,500 pounds was used.

The Chemico modifications included choke control, air injection, exhaust gas recirculation (EGR) introduced upstream of the carburetor air cleaner, and a dual bed catalytic converter. The factory-installed crankcase ventilation and fuel evaporative emission control systems were left intact. The same pellet-supported catalyst developed by Chemico was used in both reduction and oxidation beds. Exhaust gas from both banks of cylinders was presented first to the NOx reduction bed and then to the oxidation bed, where compressed air was injected to encourage combustion of HC and CO.

Test Program

The FCCIP Prototype Vehicle Test Specification was followed in part. The TEB Test Conductor authorized some omissions and deviations from FCCIP Spec-004 in the interests of time, or if it was felt that no test was necessary due to the vehicle's essentially stock condition.

The main concerns were to acquire gaseous exhaust emissions data and to establish the durability of the Chemico system. Other tests were run to define startability, driveability, performance, and particulate emissions. All gaseous emissions tests were conducted according to the 1975 Federal Test Procedure (FTP). The test fuel was Clear Indolene. (Chemico operated the car extensively on commercial unleaded gasoline - Amoco Super Premium)

The particulate emission tests were run by the Dow Chemical Company. In the Dow procedure the vehicle is driven on the 1975 FTP driving schedule, with all exhaust routed into a dilution duct. Samples from the diluted exhaust are drawn through isokinetic probes and captured on filters which are weighed before and after the test. The difference in weight yields particulate emissions in grams per mile.

In durability testing the car was operated over the MVMA durability schedule, first on a tape-controlled dynamometer and later on a test track.

Performance and roadability testing was conducted at Willow Run Airport by the University of Michigan Highway Safety Research Institute (HSRI).

Test Results

The test program was divided into four parts, which resulted from vehicle or converter system malfunctions.

Part 1:

The chronological sequence of events is presented in Table 1.

Four initial emissions tests were followed by a familiarization drive on the road and a cold startability test. The car had no choke and cold starting even at 70°F was difficult. Fuel economy, calculated both from a carbon balance and by weighing the fuel, averaged about 10 miles per gallon over the driving schedule. After a full 1975 FTP, including measurement of evaporative emissions, the car was readied for performance and roadability tests, conducted by HSRI with a TEB observer. The facility was an unused taxiway at Willow Run Airport. The taxiway was too short to allow us to safely conduct all the performance tests, so certain of the acceleration tests were not run. Another problem was with the transmission in the car: it would up-shift too quickly and could

not be "kicked down" as required during the 25 to 60 mph acceleration. The resulting performance was felt to be not typical of this car, but it did meet FCCIP specifications. Investigation the next day by TEB personnel revealed that the kickdown linkage was disconnected, perhaps never having been assembled at the factory. After this linkage was repaired a road test demonstrated that shifting and kickdown were satisfactory, and the performance was greatly improved.

Durability testing began with accumulation on the road and on a tape-controlled mileage accumulation dynamometer (MAD). Emissions tests were conducted at increments of 500 and 1,000 miles from initial tests.

The car was driven to Midland, Michigan, a round trip of about 220 miles, for particulate tests by Dow Chemical. The Dow tests required approximately 85 miles of dynamometer operation.

At approximately 2,200 miles after delivery to EPA, the converter failed and the car was returned to the Chemico facility for repair.

Part 2:

The test car was repaired and tested by Chemico over a three month period and delivered to EPA for testing on July 31, 1972. After a driveability evaluation and inspection of the catalyst beds three cold start emission tests were made, as listed in Table 2. Following the third test the car was driven to the Dana Tech Center, Ottawa Lake, Michigan, for mileage accumulation per the MVMA durability schedule on the Dana test track.

Emissions tests were run at mileage accumulation totals of 600, 1,200, 4,000, and 5,900 miles. Catalyst levels in the converter were periodically checked, and although the levels dropped, no catalyst was added.

At about the 5,400-mile point a gasket in the converter blew out and was replaced by Chemico.

After the emissions test of September 15, Chemico personnel returned the car to their facility for further work as they were not satisfied with the level of emissions and startability of the car.

Part 3:

The car was delivered to EPA on October 1, after Chemico adjusted the carburetor air-fuel ratio. The converter was not changed, although pellets were added. After emissions tests (see Table 3)

the car was immediately taken to the Dana test track to begin a 4,000-mile durability run. On October 10, at about 3,000 miles, the converter outer can failed, in the plenum downstream of the oxidation bed. This allowed hot exhaust gas to impinge on the radiator, melting solder and allowing engine coolant to escape. Chemico returned the car to their facility for repair on October 16.

Part 4:

Repairs to the converter and radiator were completed in late November and the car was delivered to the EPA on November 25. The sequence of events is listed in Table 4. A test of cold startability was made on November 27, after a two-day soak at approximately 30°F. Starting was very difficult; total cranking time was about two minutes and there were three false starts. Once started, the car had acceptable driveability. The choke, which had been in use in Part 2 of our tests, had been removed for the tests beginning in October. The absence of a choke was the major reason for poor cold startability whether at 30°F or 70°F.

Following two emissions tests mileage accumulation at the Dana track began. Four thousand miles were accumulated with only minor delays. A catalyst bed thermocouple was replaced and misalignment of the air pump pulley caused the drive belts to be twisted and thrown off the pulley. Catalyst was added at 4,000 miles.

Two emissions tests at 4,000 miles revealed a small leak in the exhaust system upstream of the converter. To expedite durability testing it was decided to put the car back on the track without fixing the leak, as this would have required disassembling the exhaust system.

On December 20, at about 6,000 miles, a crack developed in the Chemico-built exhaust system upstream of the converter. Repairs by Chemico were completed and the car was back on the test track on December 26.

Following emissions tests at 8,000 miles (total accumulation since November 25) a hole in the converter was discovered. Because repairing the converter would be a lengthy task, not justified by the short time remaining on the FCCIP evaluation contract, the car was returned to Chemico and the test program terminated.

Conclusions

The Chemico Oldsmobile demonstrated good but erratic control of emissions. Oxides of nitrogen were controlled best and most consistently. Poor startability and choke operation contributed to

the large variations in HC and CO emissions. The catalyst material apparently maintained good activity for 6,000 miles during Part 2 testing and for 8,000 miles during Part 4 testing. It will tolerate trace levels of lead in its fuel. Durability of the converter structure, including the pellet support screens and outer shell, was poor, as attested by the three failures during the 19,000 miles the car was under test by EPA.

The Chemico converter system had no adverse effect on driveability, performance or fuel consumption.

TABLE 1
Chemico Test Program

<u>Date</u>	<u>Test No.</u>	<u>Odo- meter</u>	<u>Emissions, gm/mi</u>			
			<u>HC</u>	<u>CO</u>	<u>CO₂</u>	<u>NOx</u>
1972 3-7	18- 179	2820	.23	3.41	848.44	.33
3-8	180	2831	.15	1.36	811.96	.26
3-9	184	2843	.29	2.63	873.33	.32 Hard start
3-10	187	2855	.19	2.29	869.19	.31
3-10		2866	Low speed familiarization drive			
3-13		2900	Cold startability @35°F. Six attempts, 45 sec. total cranking.			
3-16	197	2914	.18	1.50	875.45	.24 Evaporative emissions were .15 gm/mi
3-21		2935 2978	Performance and roadability tests at Willow Run Airport			
3-22		2990	Repair kick down, road test			
3-27	223	3016	.28	1.67	930.38	.43 Hard start
3-28		3027	Generating road load data, tuning MAD *			
3-30		3100	MAD not ready; TEB and Chemico personnel drive car on the road to complete 500 mile increment.			
3-31		3345	Catalyst added			
3-31	231	3345	.38	2.17	869.56	.30
3-31		3356	Start durability on MAD.			
4-6	241	3882	.46	1.81	865.98	.30 Hard start;
4-7	243	3893	.63	2.05	833.54	.34 Very hard start; six false starts.
4-11	253	3913	.37	1.27	879.47	.32 Two false starts.

*Mileage Accumulation Dynamometer

TABLE 2
Chemico Test Program

<u>Date</u>	<u>Test No.</u>	<u>Odo-meter</u>	<u>HC</u>	Emissions, gm/mi		<u>NOx</u>	
				<u>CO</u>	<u>CO₂</u>		
1972	18-						
8-1	417	6628	.11	.96	853.36	.56	Good start
8-2	420	6640	.16	2.64	898.31	.30	
8-3	421	6652	.15	2.47	908.30	.30	
			Mileage accumulation at Dana				
8-7		7284	Check catalyst level in converter				
8-7	429	7284	.34	4.33	836.98	.33	
8-8	431	7296	.28	5.31	827.07	.31	
			Mileage accumulation				
8-10		7848	Check catalyst level				
8-10	12- 2298	7848	.27	1.49	820.98	.26	One false start
8-14	2301	7872	.31	2.03	809.66	.19	
			Mileage accumulation				
8-23		10648	Check catalyst level				
8-23	2329	10648	.65	5.61	862.90	.39	Five cranks, two false starts
			Repair choke mechanism				
8-25	2334	10663	.46	5.29	826.91	.41	
8-29	2352	10685	.46	7.20	783.41	.35	
			Change start procedure, reset catalyst temp.				
8-30	2359	10698	.34	6.00	792.84	.67	
			Adjust air pump delivery pressure				
8-31	2363	10711	.43	6.36	771.99	.38	One false start

Table 2 (cont'd)

<u>Date</u>	<u>Test No.</u>	<u>Odo-meter</u>	Emissions, gm/mi			
			<u>HC</u>	<u>CO</u>	<u>CO₂</u>	<u>NOx</u>
9-1	2364	10772	.34	3.82	917.31	.29
Mileage accumulation						
9-8 to 9-12		12000	Repair blown gasket in converter			
9-14	2392	12532	.34	4.13	916.98	.29 Hard start
9-15	2398	12570	.34	4.52	774.95	.69 Three false starts
9-15		12581	Chemico returns car to their facility for further work			
AVERAGE EMISSIONS			.33	4.14	840.13	.38

Table 3
Chemico Test Program

<u>Date</u>	<u>Test No.</u>	<u>Odo-meter</u>	<u>HC</u>	Emissions, gm/mi		<u>NOx</u>
				<u>CO</u>	<u>CO₂</u>	
1972	12-					
10-2	2421	13503	.46 start	4.25	952.54	.35 Very hard
10-3	2423	13514	.44	2.11	860.53	.31 Hard start
10-10		16300	Converter outer can fails while on mileage accumulation			
AVERAGE EMISSIONS			.45	3.18	906.04	.33

Table 4

Chemico Test Program

<u>Date</u>	<u>Test No.</u>	<u>Odo-meter</u>	Emissions, gm/mi			
			<u>HC</u>	<u>CO</u>	<u>CO₂</u>	<u>NOx</u>
1972	16-					
11-27		17180	Cold startability at 30°F. Twelve attempts, two minutes total cranking. Three false starts.			
11-28	91	17185	.19	2.11	777.59	.27 Good start
11-29	95	17196	.25	3.85	767.04	.66 One false start
Mileage accumulation						
12-6		19244	Fix thermocouple, replace air pump belt, add catalyst			
12-13		21247	Add catalyst			
12-13	122	21247	.28	4.74	655.05	1.05 One false start
12-15	127	21259	.30	4.86	704.24	.31 Idle held at 1300 rpm on start
Mileage accumulation						
12-20			Fix leak in exhaust system			
1973	16-					
1-3		25260	Add catalyst			
1-3	158	25260	.31	3.04	678.02	.87 Two false starts, one stall
1-4	161	25271	.23	2.23	655.76	.33 One false start
AVERAGE EMISSIONS			.26	3.47	706.28	.58
Total Catalyst Added,			Reduction Bed: 1025 cc Oxidation Bed: 2985 cc			