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Technical Report

Disablement Testing of 1981-1982 Model Year Vehicles with Closed-Loop Emission Control Systems

by

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1.0 INTRODUCTION

The purpose of this report is to present the results of emission control system disablement testing of recent model year vehicles. Starting in 1981, Federal vehicles were designed to meet more stringent emission standards such that most employed computer controls utilizing exhaust emission feedback. Some vehicles prior to 1981 also used feedback systems, but it was not until 1981 that large quantity production of the systems occurred, along with a relatively finalized system design. Because EPA had little data on the emissions of these vehicles when they experienced emission control problems, a test program was designed to test many types of these vehicles. Included in the test program were four vehicles equipped with throttle body fuel injection (TBI). One was a 1981 Ford and the other three were 1982 GM cars. The GM cars are the first with TBI produced in large quantity, and it was necessary to know if they differed in emission levels from normally carbureted vehicles. Included in this report is a fifth TBI vehicle (GM) that EPA tested separately in its Ann Arbor laboratory. All other vehicles were tested by a contractor for EPA, Hamilton Test Systems Inc., in Portland, Oregon.

The results of this program can be used to evaluate the likely effectiveness of Inspection and Maintenance (I/M) short tests in order to identify problems with these vehicles, and provide general knowledge of the emission performance of these vehicles when problems may occur. The results by themselves cannot determine the air quality impact of these vehicles, however, since the rate of occurrence of the failures in the field is also a major contributing factor.

2.0 SUMMARY AND CONCLUSIONS

The results showed that several types of problems which might occur with new technology vehicles result in very high FTP emissions. The HC emissions often were 10 times as great as the certification standards and CO emissions often were 20 or more times the standards. It would only take a small percentage of the vehicles having these problems to greatly increase fleet average emission levels.

Nearly all of the problems which result in very high emission levels can be detected by short emission tests (I/M tests). These short tests were able to identify about 95% of the excess FTP emissions for the tested vehicles.

Vehicles with throttle body fuel injection (TBI) appear to have the same probability of high emissons when problems occur as carbureted vehicles. The frequency of problems occurring with them might be less, however, due to the fact that their mixture control solenoids do not relax in such a way that they allow high fuel flow when de-energized. If power is lost to the solenoids in a TBI system, they will most likely close entirely, shutting off all fuel and forcing the owners to get repairs. Carbureted cars, in contrast, usually continue to run with no noticeable driveability problems, but with high emissions and usually poor fuel economy. Both types of vehicles may be equally subject to problems in which the computer sends improper signals to the solenoids.

3.0 TEST VEHICLES, PROCEDURES AND DISABLEMENTS

A description of the test vehicles is shown in Table 1. In addition to the five cars with TBI systems, there are two with more conventional ported fuel injection. Nearly all vehicles had exhaust gas recirculation (EGR) and most had some type of air injection (the Chevette was the only one with pulse air injection, the others having a regular air pump).

All vehicles were tested first in a correctly operating condition (baseline) and then with one or more disablements, each disablement occurring individually. For the baseline test, most vehicles were tested in their as-received condition, however a few vehicles received minor parts replacements or adjustments prior to the test in order to restore them to a correctly operating condition. The disablement types and the number of vehicles receiving each is shown in Table 2. Because there are several types of oxygen sensor disablements, each type is listed in the table. Three vehicles were tested with the oxygen sensor disabled in two different ways.

Each vehicle was given a specific test sequence at each configuration. The sequence is listed in Table 3. The first through third tests and the sixth test in Table 3 are performed on a dynamometer under load and measure mass emissions. The second and fourth through sixth tests measure concentrations of emissions; they are considered "short" tests, which could be used in State inspection programs.

Table 1

Description of Vehicles Tested

VEH	MFR	MODEL	MYR	CYL	CID	FUEL SYS	EMISSION CONTROLS	DIABLEMENT TESTS RUN
1	AMC	Concord	81	6	258	Carb	3-way, AIR, EGR	1, 5, 6
2	Chry	Horizon	81	4	105	Carb	3-Way+Ox, AIR, EGR	1, 5, 6
3	Chry	Reliant	81	4	135	Carb	3-Way+Ox, AIR, EGR	1, 5, 6
4	Ford	Mustang	81	4	140	Carb	3-Way+Ox, AIR, EGR	1, 5, 6
5	Ford	Lincoln	81	8	302	TBI	3-Way+Ox, AIR, EGR	1, 7
6	GM	Chevette	81	4	098	Carb	3-Way, PAIR, EGR	4, 5, 6
7	GM	Citation	82	4	151	TBI	3-Way, EGR	1, 5
8	GM	Skylark	82	4	151	TBI	3-Way, EGR	2, 5
9	GM	Citation	81	6	173	Carb	3-Way+Ox, AIR, EGR	3, 5, 6
10	GM	Cutlass	81	6	231	Carb	3-Way, AIR, EGR	3, 5, 6
11	GM	Caprice	81	8	267	Carb	3-Way+Ox, AIR, EGR	1, 3, 5, 6
12	GM	Riviera	81	8	307	Carb	3-Way+Ox, AIR, EGR	4, 5, 6
13	VW	Rabbit	81	4	105	Port FI	3-Way	1, 5
14	Toy	Corolla	81	4	108	Carb	3-Way, AIR, EGR	1
15	GM	Citation	82	4	151	TBI	3-Way, EGR	2, 5, 8
16	Chry	Reliant	81	4	135	Carb	3-Way+Ox, AIR, EGR	1, 5, 6
17	GM	Cutlass	81	6	231	Carb	3-Way, AIR, EGR	4, 5, 6
18	Ford	Mustang	81	4	140	Carb	3-Way+Ox, AIR, EGR	1, 5, 6
19	GM	Bonnevil	81	8	307	Carb	3-Way+Ox, AIR, EGR	1, 3, 5, 6
20	GM	Citation	81	4	151	Carb	3-Way+Ox, AIR, EGR	1, 5, 6
21	VW	Rabbit	81	4	105	Port FI	3-Way	2, 5
22	GM	Phoenix	82	4	151	TBI	3-Way, EGR	1, 2, 7, 8, 9

Abbreviations:

A. Emission Controls

3-Way - Three-way catalyst
3-Way+Ox - Three-way catalyst plus oxidation catalyst
AIR - Air pump
PAIR - Pulse air injection
EGR - Exhaust gas recirculation

B. Disablements

1. O_2 sensor disconnected - lead(s) open
2. O_2 sensor disconnected - lead(s) grounded
3. O_2 sensor disconnected - leads shorted
4. O_2 sensor disconnected - leads shorted and grounded
5. Coolant temperature sensor disconnected
6. Mixture control solenoid disconnected
7. EGR vacuum line disconnected and plugged
8. Manifold absolute pressure sensor disconnected
9. Throttle position sensor disconnected

Table 2

Types of Emission System Disablements

	Type of Disablement	N
1.	Oxygen Sensor Disconnected	
	a. Lead(s) Open	14
	b. Lead(s) Grounded	4
	c. Leads Shorted Together	4
	d. Leads Shorted and Grounded	3
2.	Coolant Temperature Sensor Disconnected and Open	19
3.	Mixture Control Solenoid Disconnected and Open	14
4.	EGR	2
5.	Manifold Absolute Pressure Sensor Disconnected and Open	2
6.	Throttle Position Sensor Disconnected and Open	1

Table 3

Emission Test Sequence

1. Federal Test Procedure
2. 50 mph Cruise Test
3. Highway Fuel Economy Test
4. Four-Mode Idle Test
5. Ford Idle Test (Ford vehicles only)
6. Loaded Two-Mode

4.0 SUMMARY OF EMISSION RESULTS

All vehicles were tested in a baseline condition and with at least one type of oxygen sensor disablement. All but one vehicle were also tested with at least one additional disablement.

Table 4 presents the average Federal Test Procedure (FTP) emission and fuel economy results for each specific condition. Baseline results are also shown for each condition. Figures 1 and 2 show bar charts of the HC and CO levels for several specific conditions.

The emissions changes due to O_2 sensor disablements vary greatly depending on the manner in which the disablements are performed and also on the manufacturer and engine family. (These variations are summarized here, but discussed more fully in Section 6.) Disconnecting the sensor and not doing anything else ("open" condition) usually causes a somewhat rich condition, but not always. For example, the range of FTP CO emissions is from 1.46 to 109.6 grams per mile (g/mi) for the 14 cars. Similar wide variations were seen for the "shorted" and "shorted and grounded" cases. For the grounded condition, the emission results are quite uniform, although the sample is small and three of the four vehicles are of the same type (GM TBI cars). Here, the CO ranges from 157.7 to 186.1 g/mi. Grounding the sensor lead (and not doing anything else to it) apparently always causes the fuel metering to go to a very rich condition for the vehicles tested. Shorting the sensor leads and then grounding them should give the same result of high emissions as just grounding the leads. However, one of the three vehicles tested had emissions below the Federal standards, although it is possible that the wires shorting and/or grounding the leads became loose; an inconsistency was noted in the 50 mph cruise test before and after the FTP. Prior to the FTP the 50 mph cruise CO for this vehicle appeared to be several percent (there was only chart recorder data), but after the FTP the contractor recorded 0.0% on the test.

Only one vehicle responded adversely to the disablements such that the owner would probably not continue to drive the car without getting it fixed. This was a Plymouth Reliant which overheated badly for all the disablements. Emissions tests were able to be conducted, however, and the data from this car is averaged with the others in Table 4. Including its emissions does not change the mean levels greatly, therefore separate mean levels are not shown. Its emissions were similar to the averages of the others for the O_2 sensor and CTS disablement, but were quite a bit lower for the mixture control solenoid disablement (1.16 HC and 24.8 CO).

FTP and short test data for each vehicle are listed in the Appendix.

Table 4

Average FTP Emission Results for All Vehicles for Each Disablement

		FTP emissions (grams per mile)			
Condition	N	HC	CO	NOx	MPG
Baseline	22	0.32	3.77	0.76	21.22
O_2 Sensor Disabled-All Vehicles*	22	2.15	69.0	0.57	17.31
O_2 Sensor Disconnect-Open	14	0.86	23.1	0.84	19.67
Baseline	14	0.36	3.73	0.82	20.98
O_2 Sensor Disconnect-Grounded	4	5.65	172.2	0.19	17.07
Baseline	4	0.18	3.59	0.73	25.01
O_2 Sensor Shorted	4	1.68	68.4	0.64	15.22
Baseline	4	0.30	2.25	0.74	18.78
O_2 Sensor Shorted & Grounded	3	2.37	84.3	0.82	16.12
Baseline	3	0.31	4.12	0.64	19.30
CTS Disconnect	19	1.14	32.7	0.88	19.18
Baseline	19	0.34	4.05	0.76	21.43
Mixture Control Solenoid	14	4.24	110.0	0.35	16.40
Baseline	14	0.41	4.39	0.82	20.43
EGR Disconnect	2	0.22	2.36	2.35	18.59
Baseline	2	0.21	2.50	0.79	18.72
MAP Sensor Disconnect	2	1.81	79.6	0.17	19.41
Baseline	2	0.13	2.81	0.54	24.39
TPS Disconnect	1	0.16	2.27	0.35	23.46
Baseline	1	0.12	1.59	0.70	24.37
Highest Test on Each Vehicle	22	3.73	109.9	0.40	17.06

* For vehicles 11, 19 and 22, the O_2 sensor disablement which produced the higher FTP CO emissions was selected for this average.

Figures 1 and 2

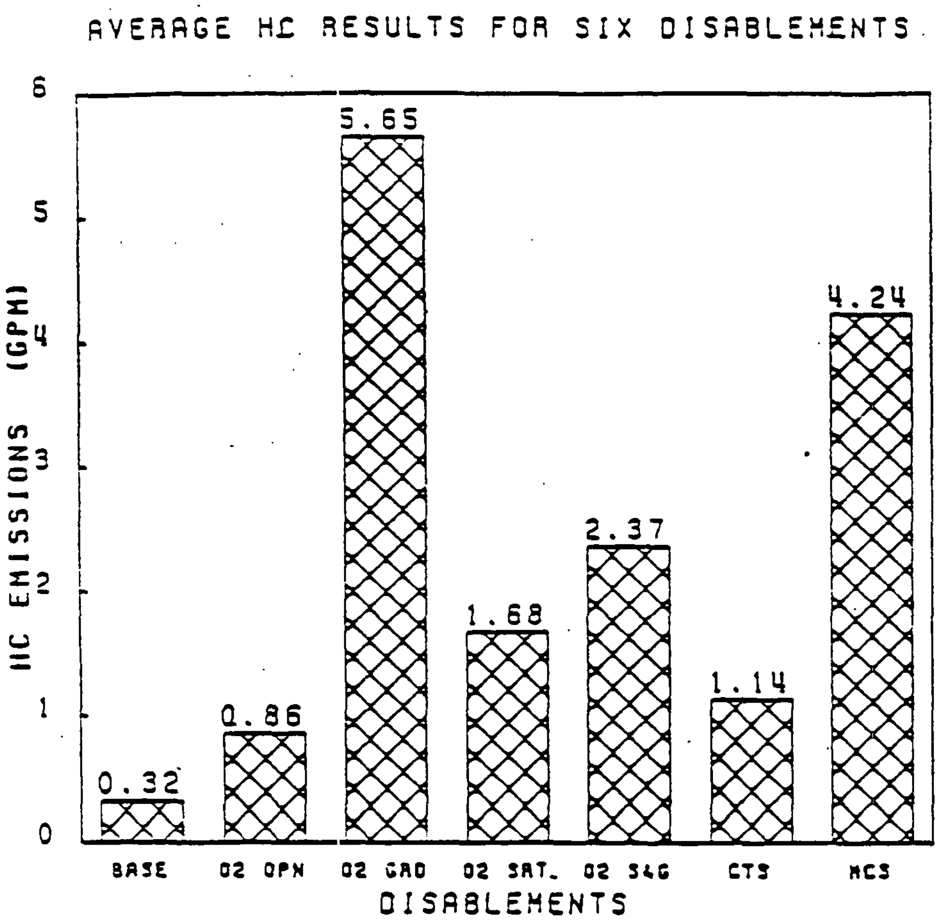
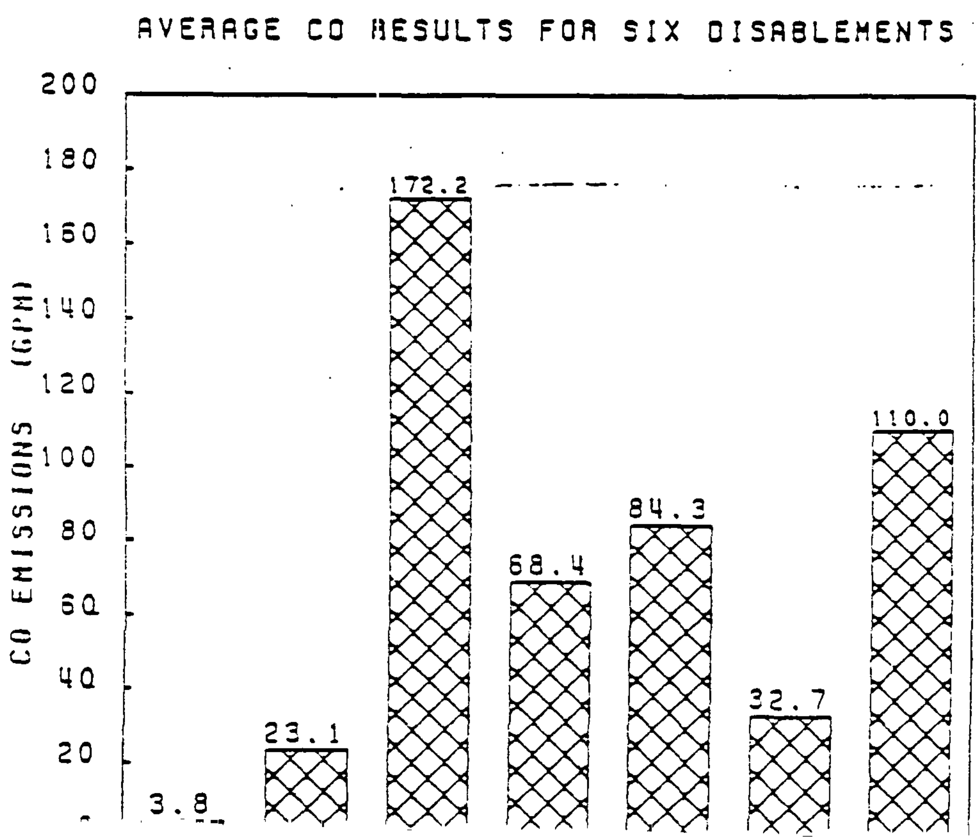


Figure 1



5.0 ABILITY OF I/M TESTS TO DETECT PROBLEMS

Because many of these disablements result in such high emission levels, it is very important that I/M tests be able to identify most, or all of them as needing repair. Table 5 shows the percent of vehicles which passed and failed the I/M short tests versus their FTP HC and CO pass-fail status. The cutpoints used to determine pass-fail status of the short tests were those recommended for the 207(b) Emission Performance Warranty. The short tests failed about two-thirds of all FTP failures. The AMC vehicle passed the FTP during two of its disablements and failed the Idle Test (Errors of Commission, or Ec) after it had been idling for 6 minutes (First Idle), but passed each time after it had received a 2500 rpm preconditioning (Second Idle). These were the only two Ec tests.

Table 6 shows the amount of excess emissions, i.e., emissions above the FTP standards, that were identified by each short test. Two of the short tests could identify 95% of the excess HC and CO emissions of these vehicles. This compares with a 60-70% excess identification of a sample of 1981 model year vehicles tested in their as-received condition.*

The I/M test failure rate and amount of excess emissions identified depends, of course, on the I/M cutpoints chosen. Readers may note from the individual data in the Appendix that the I/M pass-fail status of several vehicle disablement tests is sensitive to the cutpoints chosen.

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* Memo titled "New Technology Emission Status" from Bruce Michael to Charles Gray, Director, ECTD, December 12, 1981.

Table 5

Identification Rates for I/M Tests
All Disablements Combined (N = 60)

	Pass FTP Pass Short Test (Correct Pass)	Fail FTP Fail Short Test (Correct Fail)	Pass FTP Fail Short Test (Ec)	Fail FTP Pass Short Test (Eo)
Two-Speed Idle	24.1%	53.4%	0.0	22.4%
Loaded Two-Mode	24.1%	55.2%	0.0	20.7%
Idle Test (First Idle)	20.7%	44.8%	3.4%	31.0%
Idle Test (Second Idle)	25.5%	36.4%	0.0	38.2%

Table 6

Excess FTP Emissions Identified
(Emissions in grams per mile)

	Excess FTP Emissions			
	HC	No. of HC Failing Vehicles	CO	No. of CO Failing Vehicles
Total Amount of Excess Emissions	111.3	44	3573.7	46
Amount Identified by Two-Speed Idle	105.0	31	3415.3	31
Percent of Total	94%		96%	
Amount Identified by Loaded Two-Mode	104.5	32	3353.0	32
Percent of Total	94%		94%	
Amount Identified by Idle Test (First)	94.9	26	2944.2	26
Percent of Total	85%		82%	
Amount Identified by Idle Test (Second)	88.1	20	2677.2	20
Percent of Total	79%		75%	

6.0 VARIATIONS IN TEST RESULTS

6.1 Variations in Oxygen Sensor Disablements

As was mentioned in Section 4.0, the oxygen sensor disablements gave quite varying results depending on the manner of disablement. Results also varied within manufacturer, but were usually more consistent with similar fuel systems within manufacturer. The three 1981 model year GM cars tested with the O_2 Sensor "open" all had HC emissions at about 0.3 and CO at 2 grams per mile (g/mi). The two 1982 GM TBI cars, however, had much higher HC and CO, ranging from 0.5 to 1.6 g/mi HC and 16 to 58 g/mi CO. Two of the three Chrysler cars tested in this configuration, "K" cars, had very similar CO emissions at about 32 g/mi while the third car, the Horizon, had CO at only 3 g/mi. Two of the three Fords were Mustangs, having CO emissions ranging from 10 to 15 g/mi, while the third, the Lincoln (with TBI), had CO emissions at only 4 g/mi. The VW had the highest CO emissions at 109 g/mi.

All four vehicles tested in the "shorted" condition were carbureted GM cars, three yielding quite high emissions, each over 80 g/mi CO, and one yielding only 2.6. (This latter car does not have suspicious emissions, because it was also tested "open" with similar results.) The three GM TBI cars tested with the O_2 sensor "grounded" gave consistent high emissions results, each over 150 g/mi CO.

Table 7 shows the range, mean and standard deviation of the results for each type of disablement. Only when the oxygen sensor was grounded were the results very consistent. Two probable reasons for the variation of the others are (1) that without grounding the oxygen sensor lead(s), the sensor can give erratic signals to the computer due to electromagnetic pick up and (2) that the computer can sense that a problem exists and, unless forced rich by grounding the lead(s), may "remember" past performance and try to copy it. GM representatives have indicated that both of these may happen with GM cars.

EPA does not currently have an estimate of the frequency of oxygen sensor failures and disablements or of the specific manners in which they occur. Purposeful and inadvertent disablements are most likely to result in an "open" condition, perhaps with intermittent grounding if the lead(s) can touch the engine block, for example, but failures due to defect or wear may occur in other ways. What does seem certain though is that extremely wide variations in emissions will occur. EPA has tested vehicles in their as-received condition in its 1981 Emission Factors Program with FTP CO emissions well over 100 g/mi due to oxygen sensor problems.

Table 7

O_2 Sensor Disconnect HC and CO Results
Minimum, Maximum, Mean, and Standard Deviation
(FTP emissions in grams per mile)

Condition	N	Pollutant	MIN	MAX	MEAN	SD	Pollutant	MIN	MAX	MEAN	SD
Open	14	HC	0.25	2.41	0.86	0.69	CO	1.46	109.6	23.1	30.3
Baseline	14		0.09	0.97	0.36	0.26		0.96	9.73	3.73	3.20
Grounded	4	HC	3.19	10.7	5.65	3.42	CO	157.7	186.1	172.2	11.8
Baseline	4		0.12	0.33	0.18	0.10		1.59	5.17	3.59	1.49
Shorted	4	HC	0.24	3.12	1.68	1.19	CO	2.65	99.9	68.4	44.5
Baseline	4		0.23	0.40	0.28	0.08		1.34	2.94	2.25	0.73
Shrt. & Grnd	3	HC	0.21	5.56	2.37	2.82	CO	2.33	161.3	84.3	79.6
Baseline	3		0.22	0.44	0.31	0.12		2.96	5.24	4.12	1.14

6.2 Variations Between Throttle Body Injected and Carbureted Vehicles

Four 1982 GM cars with TBI were tested, all having the same engine sizes and emission control systems. A comparison of their FTP HC and CO results with the carbureted cars for two disablements is shown in Table 8. Also shown are the results of four 1981 low volume luxury TBI cars* tested in the 1980 Emission Factors Program and the one 1981 Lincoln TBI car tested in this program. One of the two 1982 model year GM TBI vehicles tested with the O_2 sensor disconnected (open) gave higher CO emissions, but not higher HC emissions, than all 10 of the carbureted cars. The other TBI car had CO emissions at about the mean of the 10 carbureted cars. All three GM TBI cars produced much lower emissions with the coolant temperature sensor (CTS) disconnected then the average of the 14 carbureted cars. The range of emissions was very wide for the 14 cars, however nearly all had substantially higher emissions than the three TBI cars. The very small sample size does not allow for specific conclusions, however.

Concerning the luxury TBI cars, the two Lincolns gave quite different emission levels in the first disablement mode. CO emissions from one were just 3.7 g/mi, and 166.4 from the other. These results are so different that they cause suspicion, but the data records were checked and appear to be correct. The two luxury GM cars also gave varied results, but not as dramatic. One had 24.3 g/mi CO while the other had 2.4. These two vehicles were also tested with the oxygen sensor leads disconnected and shorted. CO emissions ranged from 15 to 84 g/mi confirming that these two cars reacted quite differently to oxygen sensor disablements.

A comparison could not be made with any other disablements. Three of the four cars tested with the O_2 sensor grounded were the TBI cars. The fourth was a VW Rabbit with ported fuel injection. The Rabbit had much higher HC than the TBI cars (10.7 vs. average 3.96 g/mi) and somewhat higher CO (186 vs. average 168 g/mi). The TBI cars could not run with their mixture control solenoids disconnected, so no comparison could be made in this regard, and the only two cars tested with EGR disablements were both TBI cars.

Table 8

Comparison of GM TBI Vehicles with Other Vehicles Tested
(FTP emissions, in grams per mile)

	1982 GM TBI			Carbureted			1981 Luxury TBI		
Test	N	HC	CO	N	HC	CO	N	HC	CO
Specifications	4	0.12	2.63	15	.39	4.17	5	0.28	3.30
O_2 Sensor-Open	2	1.05	38.0	10	.72	13.3	5	0.79	45.7
CTS Disconnect	3	0.17	3.93	14	1.48	43.3	3	0.51	6.54

* Two GM Cadillacs, one Chrysler Imperial and one Lincoln Continental.

APPENDIX

TEST RESULTS OF INDIVIDUAL VEHICLES

APPENDIX

FTP EMISSIONS AND FUEL ECONOMY

		--- FTP Standards ---			---------- FTP Data -----------				HFET
VEH	TEST	HCST	COST	NOST	HC	CO	NOX	MPG	MPGH
1	0	.41000	7.0000	2.0000	.25000	2.0500	.96000	17.290	25.270
1	1	.41000	7.0000	2.0000	.27000	2.5700	.88000	17.030	23.440
1	5	.41000	7.0000	2.0000	.28000	5.0400	2.0900	17.420	25.680
1	6	.41000	7.0000	2.0000	1.9200	41.390	.88000	17.090	25.120
2	0	.41000	7.0000	1.0000	.24000	1.7200	1.1200	29.720	46.400
2	1	.41000	7.0000	1.0000	.25000	3.2800	.64000	26.720	42.220
2	5	.41000	7.0000	1.0000	.22000	1.5900	1.1200	29.650	46.620
2	6	.41000	7.0000	1.0000	.22000	4.0000	.58000	26.330	38.020
3	0	.41000	7.0000	1.0000	.50000	9.2100	.80000	20.680	32.610
3	1	.41000	7.0000	1.0000	.87000	32.900	.31000	18.500	27.680
3	5	.41000	7.0000	1.0000	.68000	20.170	.34000	19.400	26.240
3	6	.41000	7.0000	1.0000	1.1600	24.750	.28000	18.870	-0- — —
4	0	.41000	3.4000	1.0000	.63000	6.5800	1.2400	23.570	35.580
4	1	.41000	3.4000	1.0000	.74000	9.9500	.41000	21.700	30.520
4	5	.41000	3.4000	1.0000	.48000	5.9900	1.0000	22.920	34.280
4	6	.41000	3.4000	1.0000	.93000	17.960	.32000	20.760	29.420
5	0	.41000	3.4000	1.0000	.30000	3.4000	.88000	15.230	24.510
5	1	.41000	3.4000	1.0000	.27000	3.7100	1.2600	15.310	24.010
5	7	.41000	3.4000	1.0000	.30000	3.1500	1.9200	15.170	24.100
6	0	.41000	7.0000	1.0000	.27000	2.9600	.42000	28.130	38.670
6	4	.41000	7.0000	1.0000	.21000	2.3300	1.7600	28.310	39.480
6	5	.41000	7.0000	1.0000	1.0500	31.120	.24000	23.020	31.070
6	6	.41000	7.0000	1.0000	3.1100	85.060	.15000	22.420	33.070
7	0	.41000	7.0000	1.0000	.90000 -1	1.3500	.50000	23.600	34.080
7	1	.41000	7.0000	1.0000	1.5800	59.710	.39000	21.520	31.410
7	5	.41000	7.0000	1.0000	.13000	2.1400	.36000	23.610	34.310

TEST TYPES

0. As Received
1. O_2 Disc. - open
2. O_2 Disc. - ground
3. O_2 Disc. - shorted
4. O_2 Disc. - shrt & grd
5. Coolant sensor disc.
6. Mixture solenoid disc.
7. EGR disc.
8. Manifold P sens disc.
9. Throttle pos [illegible] disc.

8	0	.41000	7.0000	1.0000	.15000	3.5600	.54000	23.220	33.250
8	2	.41000	7.0000	1.0000	3.1900	157.66	.22000	16.920	26.370
8	5	.41000	7.0000	1.0000	.14000	4.1400	.48000	22.930	31.530
9	0	.41000	7.0000	1.0000	.25000	2.7300	.40000	23.140	29.570
9	3	.41000	7.0000	1.0000	1.9000	81.280	.28000	16.010	22.200
9	5	.41000	7.0000	1.0000	2.0700	53.610	.70000	18.470	24.470
9	6	.41000	7.0000	1.0000	5.4100	190.87	.11000	15.140	22.000
10	0	.41000	7.0000	1.0000	.23000	2.9400	.58000	19.250	27.960
10	3	.41000	7.0000	1.0000	3.1200	99.890	.36000	16.420	24.250
10	5	.41000	7.0000	1.0000	1.7800	65.920	1.2400	15.350	20.320
10	6	.41000	7.0000	1.0000	3.5300	121.24	.52000	16.010	24.220
11	0	.41000	3.4000	1.0000	.31000	2.0000	.89000	17.960	26.890
11	3	.41000	3.4000	1.0000	.24000	2.6500	1.7400	17.940	26.600
11	5	.41000	3.4000	1.0000	1.8600	71.160	.55000	14.490	19.820
11	6	.41000	3.4000	1.0000	8.3400	229.81	.14000	12.670	19.390
11	1	.41000	3.4000	1.0000	.25000	1.6200	1.5900	17.770	26.330
12	0	.41000	3.4000	1.0000	.44000	4.1700	1.0000	15.210	21.570
12	4	.41000	3.4000	1.0000	1.3500	89.370	.26000	12.200	14.730
12	5	.41000	3.4000	1.0000	2.3100	60.540	1.7000	13.340	18.300
12	6	.41000	3.4000	1.0000	7.4400	250.78	.12000	11.100	14.330
13	0	.41000	3.4000	1.0000	.11000	1.3800	.32000	24.950	41.680
13	1	.41000	3.4000	1.0000	2.4100	109.59	.70000 -1	19.830	31.440
13	5	.41000	3.4000	1.0000	.13000	1.3100	.27000	24.700	40.560
14	0	.41000	3.4000	1.0000	.10000	.96000	.58000	22.930	33.830
14	1	.41000	3.4000	1.0000	1.6800	32.900	.20000	23.340	34.570
15	0	.41000	7.0000	1.0000	.14000	4.0300	.37000	24.440	38.930
15	2	.41000	7.0000	1.0000	4.1700	175.08	.11000	17.060	31.350
15	5	.41000	7.0000	1.0000	.23000	5.5200	.39000	23.740	36.580
15	8	.41000	7.0000	1.0000	1.9000	82.520	.13000	19.230	28.630
16	0	.41000	7.0000	1.0000	.72000	9.7300	1.0000	22.780	34.250

VEH	TEST	HCST	COST	NOST	HC	CO	NOX	[illegible]	[illegible]
16	1	.41000	7.0000	1.0000	1.5200	31.250	.37000	19.990	27.270
16	5	.41000	7.0000	1.0000	2.0100	25.250	.59000	20.410	28.860
16	6	.41000	7.0000	1.0000	1.0600	17.470	.43000	20.670	28.630
17	0	.41000	7.0000	1.0000	.22000	5.2400	.49000	18.460	27.740
17	4	.41000	7.0000	1.0000	5.5600	161.32	.43000	14.530	22.240
17	5	.41000	7.0000	1.0000	3.2100	133.64	.22000	13.320	18.200
17	6	.41000	7.0000	1.0000	11.800	219.79	.15000	13.160	21.130
18	0	.41000	3.4000	1.0000	.97000	8.1200	.67000	21.840	34.750
18	1	.41000	3.4000	1.0000	1.0000	14.670	.45000	20.120	31.070
18	5	.41000	3.4000	1.0000	.69000	5.1800	1.2900	21.640	33.660
18	6	.41000	3.4000	1.0000	.79000	15.310	.39000	20.230	31.700
19	0	.41000	3.4000	1.0000	40000	1.3400	.99000	16.090	27.130
19	1	.41000	3.4000	1.0000	.31000	1.4600	3.0200	16.140	26.040
19	5	.41000	3.4000	1.0000	3.1800	89.530	1.9100	13.540	20.330
19	6	.41000	3.4000	1.0000	12.920	304.60	.12000	10.470	16.430
19	3	.41000	3.4000	1.0000	1.4500	89.870	.18000	11.960	19.660
20	0	.41000	3.4000	1.0000	.26000	2.7400	.79000	22.360	36.680
20	1	.41000	3.4000	1.0000	.31000	2.8800	1.8300	20.310	45.460
20	5	.41000	3.4000	1.0000	.95000	36.810	1.0000	20.150	33.880
20	6	.41000	3.4000	1.0000	.75000	17.740	.68000	22.360	36.760
21	0	.41000	3.4000	1.0000	.33000	5.1700	1.3000	28.640	44.720
21	2	.41000	3.4000	1.0000	10.700	186.06	.11000	17.670	26.190
21	5	.41000	3.4000	1.0000	.26000	3.4800	1.2800	28.400	43.610
22	0	.41	7.0	1.0	.12	1.59	.69	24.37	33.77
22	1	.41	7.0	1.0	.53	16.34	.26	23.19	33.29
22	2	.41	7.0	1.0	4.53	170.2	.30	16.64	27.34
22	7	.41	7.0	1.0	.14	1.58	2.78	23.91	33.19
22	8	.41	7.0	1.0	1.72	76.64	.21	19.62	27.12
22	9	.41	7.0	1.0	.16	2.27	.35	23.46	34.20

SHORT TEST DATA

		--- Loaded Two-Mode -------				-------- Four-Mode Idle Test ----------------					
1. VEH	TEST	12. HC30	13. CO30	14. HC1	15. CO1	16. HCN1	17. CON1	18. HC25	19. CO25	20. HCN2	21. CON2
1	0	10	0.	8	0.	16	.12000	6	0.	8	0.
1	1	53	.15000	22	0.	172	4.8600	28	.22000	15	0.
1	5	23	0.	6	0.	118	2.4900	13	0.	7	0.
1	6	17	.10000 -1	126	2.7900	126	3.0100	68	1.4600	126	2.7100
2	0	9	.10000 -1	25	0.	20	0.	10	0.	34	.10000 -1
2	1	5	.10000 -1	6	0.	14	0.	14	0.	15	0.
2	5	7	.10000 -1	21	.10000 -1	16	.10000 -1	10	0.	29	.10000 -1
2	6	5	0.	7	0.	14	0.	13	0.	15	0.
3	0	4	0.	22	0.	5	0.	5	0.	9	0.
3	1	11	.17000	8	.10000 -1	8	.10000 -1	3	.10000 -1	4	0.
3	5	0	0.	0	0.	0	0.	0	0.	0	0.
3	6	0	0.	0	0.	0	0.	0	0.	0	0.
4	0	12	.10000 -1	7	0.	8	0.	10	0.	9	0.
4	1	28	.30000	10	0.	21	0.	26	.20000 -1	12	0.
4	5	14	0.	6	0.	14	0.	12	0.	12	0.
4	6	33	.34000	8	0.	16	0.	26	.20000 -1	10	0.
5	0	16	0.	5	0.	8	0.	8	0.	8	0.
5	1	13	0.	7	0.	8	0.	8	0.	8	0.
5	7	8	0.	4	0.	8	0.	12	0.	8	0.
6	0	30	.13000	7	0.	6	0.	16	.12000	8	0.
6	4	19	.10000 -1	6	0.	14	0.	11	0.	12	0.
6	5	49	.82000	131	1.5900	120	.71000	17	.20000	113	1.0000
6	6	189	4.7600	320	6.0500	224	5.3100	206	6.9300	277	5.4500
7	0	2	.10000 -1	1	0.	3	0.	3	0.	2	0.
7	1	155	3.3500	104	2.3900	144	2.9800	36	.82000	143	3.3700
7	5	4	.10000 -1	2	0.	2	0.	2	0.	2	0.

VEH	TEST	HC30	CO30	HC1	CO1	HCN1	CON1	HC25	CO25	HCN2	CON2
16	1	287	7.3300	31	.20000 -1	30	0.	83	1.6900	15	10000 -1
16	5	28	.40000 -1	42	0.	30	.10000 -1	13	.10000 -1	25	0.
16	6	30	.40000 -1	35	0.	28	.10000 -1	18	.10000 -1	26	0.
17	0	3	0.	2	.20000 -1	5	.30000 -1	5	0.	4	.50000 -1
17	4	282	9.0700	771	10.770	701	10.790	144	8.5700	692	10.990
17	5	131	6.7900	161	5.2000	151	4.0900	55	3.2700	151	4.8500
17	6	334	8.9200	796	11.090	659	10.960	151	8.3500	740	11.180
18	0	32	0.	46	0.	511	7.0500	44	.10000 -1	50	0.
18	1	30	.90000 -1	39	0.	476	7.0800	50	.60000 -1	44	0.
18	5	29	0.	38	0.	492	7.3300	24	0.	39	0.
18	6	28	.60000 -1	36	0.	485	7.3500	44	.30000 -1	39	0.
19	0	49	.10000 -1	16	0.	29	0.	13	0.	10	0.
19	1	46	0.	10	0.	19	0.	9	0.	6	0.
19	5	184	3.8800	271	3.6700	318	4.7700	132	4.9400	238	3.7700
19	6	401	9.7400	573	8.6500	571	8.5700	381	10.920	599	8.8600
19	3	6	1.0500	2	.40000 -1	6	.70000 -1	4	1.2600	2	.10000 -1
20	0	8	0.	8	0.	12	0.	9	0.	8	0.
20	1	13	0.	8	0.	12	0.	14	0.	10	0.
20	5	73	2.2600	8	.10000 -1	26	0.	53	2.6300	9	0.
20	6	81	1.4300	8	0.	17	0.	19	.32000	10	0.
21	0	5	.10000 -1	6	0.	8	0.	10	.47000	8	0.
21	2	439	11.210	975	11.210	780	11.210	856	11.210	939	11.210
21	5	5	0.	6	0.	14	0.	12	0.	10	0.
22	0	20	.02	11	.02	8	.02	12	.03	10	.02
22	1	55	1.5	72	.75	25	.02	15	.02	20	.03
22	2	185	6.4	100	2.0	120	2.1	25-85	.7-4.7	115	1.8
22	7	20	.04	20	.04	30	.1	19	.04	19	.04
22	8	360	10.0	790	10+	940	10+	2000+	10+	780	10.2
22	9	19	.04	11	.04	12	.04	15	.04	15	.04

[illegible]	TEST	[illegible]	[illegible]	[illegible]									
8	0	2	0	2	0.	3	0.	4	0.	4	0.		
8	2	163	5.1300	109	2.0200	101	1.6900	95	5.9700	94	1.5800		
8	5	3	0.	2	0.	2	0.	2	0.	2	0.		
9	0	17	0.	9	0.	15	0.	203	5.4400	21	.10000 -1		
9	3	139	4.0100	13	0.	32	0.	2001	11.210	49	.10000 -1		
9	5	155	3.4500	17	0.	24	0.	120	5.0800	15	0.		
9	6	386	9.6300	256	6.0500	238	5.6100	659	11.210	256	5.8900		
10	0	6	.30000 -1	2	0.	66	.40000 -1	5	.50000 -1	5	.10000 -1		
10	3	234	4.8500	361	3.9000	205	3.0800	92	5.2500	206	4.1100		
10	5	124	3.8400	156	1.0000	133	.64000	19	.75000	135	1.0500		
10	6	220	4.8600	215	4.5700	194	3.6400	93	5.0800	196	4.1300		
11	0	25	.20000 -1	20	0.	25	0.	12	0.	18	0.		
11	3	30	0.	19	0.	25	0.	10	0.	14	0.		
11	5	80	2.9200	14	.10000 -1	19	0.	52	2.9000	16	.10000 -1		
11	6	321	9.5700	372	5.5800	318	4.3600	384	10.670	357	5.1600		
11	1	25	0.	15	0.	20	0.	8	0.	11	0.		
12	0	19	0.	28	0.	13	0.	6	0.	21	0.		
12	4	16	.37000	10	0.	21	0.	36	3.1000	8	.10000 -1		
12	5	168	3.2300	38	.10000 -1	23	0.	107	4.7500	26	.10000 -1		
12	6	314	7.5900	330	1.9000	345	1.4000	399	11.210	318	1.7500		
13	0	2	0.	2	0.	2	0.	4	0.	4	0.		
13	1	196	7.9800	99	3.5700	96	3.4900	241	6.4100	108	3.5600		
13	5	6	.40000 -1	3	0.	7	0.	8	0.	6	0.		
14	0	18	.10000 -1	12	0.	18	0.	11	.20000 -1	10	0.		
14	1	156	2.1500	13	0.	14	0.	155	3.2800	15	0.		
15	0	0	0.	1	0.	2	0.	2	0.	2	0.		
15	2.	189	5.9100	186	4.4100	241	4.3500	125	6.8800	168	3.0300		
15	5	7	.10000 -1	8	.40000 -1	5	.10000 -1	2	0.	4	.10000 -1		
15	8	256	8.5700	701	10.910	840	10.860	2001	11.210	895	10.890		
16	0	25	0.	57	0.	18	0.	10	0.	30	0.		