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Evaluation of Applicability of Inspection/Maintenance Tests on a Chevrolet Citation

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by

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Abstract

This report presents testing results which were gathered to determine the suitability of existing I/M testing scenarios on a Chevrolet car with a computer based emission control system. This car had a microprocessor based three-way catalyst control system. After suitable baselines were established, various components were made inoperative in the emission control system. Complete FTP, HFET, New York City Cycles, and I/M tests were run for each vehicle condition.

This report presents the measured data taken during the tests.

Background

It is anticipated that, in the near future, electronics and computers will control many of the vital functions of automotive operation now regulated by mechanical means. As the Inspection/Maintenance effort is expanded it is a prerequisite that the test procedure used by the Inspection/Maintenance program be capable of determining equipment failure and parameter misadjustment. With the advent of advanced electronics into automobiles, it is necessary to evaluate the suitability of existing and proposed I/M tests to these future automobiles. To accomplish this evaluation, several prototype cars containing the best projected electronics of the future will be tested according to both the Federal Test Procedures and I/M tests. The derived data should indicate which I/M test best suits these automobiles. This report presents the data collected on the third such automobile tested by the EPA, a 1980 Chevrolet Citation with a microprocessor controlled emission control system.

History

The Citation is an early introduction 1980 production vehicle rented from a local Chevrolet dealer. This particular vehicle which has a California emission package, was delivered to EPA on May 25, 1979. After two baseline runs, mileage accumulation began. At 1700 miles the I/M baseline testing started.

After two baseline sequences were run, the vehicle was tested with seven different system deactivations. Two final confirmatory baseline sequences were then run. The testing was completed on September 28, 1979.

Testing Procedure

In order to test the vehicle, the following test scenario was used:

a. Federal Test Procedure (FTP) 1979 procedure, non-evaporative, no heat build.

b. Raw HC/CO measurement, hood open, fan on, idle-neutral (baseline only).

c. Highway Fuel Economy Test (HFET) immediately after FTP.

d. Raw HC/CO measurement, hood open, fan on, idle-neutral (baseline only).

e. New York City Cycle (NYCC) immediately after HFET.

f. Raw HC/CO measurement, hood open, fan on, idle-neutral, (baseline only).

g. Federal Three Mode. The dynamometer was set at 1750 lbs. inertia and horsepower was set at 6.5 hp at 25 mph and 11.0 hp at 52.0 mph. The hood was open and the auxiliary cooling fan turned on. Idle HC and CO measurements were taken in drive and in neutral on a garage type analyzer.

h. Loaded Two Mode. The dynamometer was set a 9.0 AHP at 30 mph with the I.W. = 1750 lbs. The hood was open and the auxiliary cooling fan turned on. Idle HC and CO measurements were then taken in neutral.

i. Two Speed Idle Test with raw HC/CO garage type analyzer tested at 2500 rpm (neutral) and idle (neutral). The hood was open and the auxiliary cooling fan turned on.

j. Abbreviated I/M cycle with raw HC/CO garage analyzer tested at idle (neutral momentarily accelerated to 2500 rpm (neutral), and then tested again at idle (neutral). The hood was open and the auxiliary cooling fan turned on.

k. Federal Three Mode (same as above).

l. Loaded Two Mode (same as above).

m. Two Speed Idle Test (same as above).

n. Abbreviated I/M Cycle (same as above).

o. Prolonged Idle Cycle. With the cooling fan off and hood closed, idle (neutral) HC and CO measurements were taken every minute for 10 minutes on a garage type analyzer (baseline testing only).

A work sheet recording the I/M test results is shown in Attachment 1.

Vehicle Description

The Chevrolet Citation used for this testing was a production vehicle with a California Emission Package. Attachment 2 lists specific vehicle parameters. The most important aspect of this automobile's emission control system were the sensors, actuators, and microprocessor units. A complete description of these components is given in Attachment 3.

Baseline Data

To accurately determine the effect of the various vehicle conditions, it was necessary to have an accurate baseline determined for each constituent in each mode in every test type. This baseline data is displayed with the configuration data.

Test Configurations

After the baseline testing and sorting out of the testing procedures, several components of the emission control system were, one by one, deactivated prior to vehicle testing.

a. Coolant Temperature Switch Disconnected - Test Numbers 79-8691, 79-8692, and 79-8693 were run with the Coolant Temperature disconnected. Because the EGO sensor does not perform properly until it reaches temperature, the coolant sensor informs the FCC to operate in open-loop mode until the EGO sensor temperature is reached.

b. EGO Sensor Disconnected - Test Numbers 79-8694 and 79-8695 were done with the exhaust gas oxygen (EGO) sensor disconnected. This unit supplies a voltage signal to the feedback carburetor computer based on the oxygen content of the exhaust stream. By disconnecting the sensor the output voltage goes close to zero and the closed loop system is deactivated. These tests were designated EGO Sensor Disconnected.

c. Mixture Control Solenoid - Test Numbers 79-8696 and 79-8697 were run with the mixture control solenoid disconnected. This solenoid oscillates at a duty cycle determined by the microprocessor. The duty cycle determines the fuel/air ratio of the intake air. With this device deactivated the system faults to a full rich condition.

d. EGR Disconnected - Test Numbers 79-8698, 79-8699, 79-8700 and 79-8701 were run with the Exhaust Gas Recirculation Valve(EGR) vacuum line disconnected and plugged. This device resubmits a portion of the burned exhaust gas into the combustion chamber. This exhaust gas lowers the peak combustion chamber temperature resulting in reduced NOx formation. The first two tests, numbers 79-8698 and 79-8699 were void due to exhaust analysis on the incorrect ranges.

e. <u>EGR Valve and Mixture Control Solenoid Disconnected</u> - Test numbers 79-9557 and 79-9558 were run with the components in both (c) and (d) deactivated.

f. <u>Closed Throttle Sensor Disconnected</u> - Test Numbers 79-9559 and 79-9560 were run with the Closed Throttle Sensor electrically disconnected. This device informs the microprocessor that the carburetor is closed. Disconnecting the device electrically gives a fixed throttle input to the microprocessor.

g. <u>EGO Sensor Short Circuited</u> - Test Numbers 79-9561 and 79-9562 were tested with the Exhaust Oxygen Sensor (EGO) disconnected. This shorting of the sensors guaranteed a zero voltage input and a full rich duty cycle.

<u>Test Results</u>

The test results are given in several attachments.

a. The FTP, HWFET, and NYCC with the corresponding raw HC/CO readings are given for baseline configuration studies in Attachment 4. The HC, CO, CO_2 and NOx readings are in gms/mile while the fuel economy is in miles per gallon. The raw HC readings are in ppm/hexane and the raw CO readings are in percent.

b. Attachment 5 presents the standard I/M test data. As each test were run twice, two sets of values are given.

c. Attachment 6 also presents the Prolonged Idle Cycle Data.

<u>List of Attachments</u>

Attachment 1	I/M Test Result Work Sheet
Attachment 2	Test Vehicle Description
Attachment 3	GM C-4 Description
Attachment 4	Dilute and I/M Sample Data
Attachment 5	I/M Sample Data
Attachment 6	I/M Prolonged Idle Test Data

Attachment 1

I/M Prototype Testing: Raw Exhaust HC, CO Data Sheet

Technicians:______________ ______________ Location:___________ Date: _______________

Vehicle: ____________________ _Baseline __Other:__________________________________

	HC	CO	COMMENTS
AFTER FTP			
Hood open fan on			
Transmission-neutral (Baseline only)	____	____	____
AFTER HWFET			
Hood open fan on			
Transmission-neutral (Baseline only)	____	____	____
AFTER NYCC			
Hood open fan on			
Transmission-Neutral (Baseline only)	____	____	____
FEDERAL 3 MODE			
Hood open, fan on			
Set 8.8 on thumbwheel			
52 MPH-max 3 min.	____	____	____
Set 5.8 IHP @ 25 MPH with Pendent			
25 MPH-max 3 min.	____	____	____
Idle (Drive)	____	____	____
Idle (Neutral)	____	____	____
LOADED 2 MODE			
Hood open, fan on			
Set dyno at ____ Thumbwheel or 7.9 on Pendent at 30 MPH			
30 MPH	____	____	____
Idle (Neutral)	____	____	____
TWO SPEED IDLE CYCLE			
Hood open fan on			
Idle (Neutral)	____	____	____
Increase Idle speed to 2500 ± 100 RPM	____	____	____
Idle (Neutral)	____	____	____
ABBREVIATED I/M IDLE CYCLE			
Hood open fan on			
Idle (N)	____	____	____
Momentary rev. to 2500 RPM			
Idle (N)	____	____	____

		HC	CO	COMMENTS
I. .T	FEDERAL THREE MODE			
	Hood open, fan on			
	Set 8.8 on Thumbwheel			
	52 MPH-Max 3 min.			
	Set 5.8 IHP@25 MPH with Pendent			
	25 MPH-Max 3 min.			
	Idle (Drive)			
	Idle (Neutral)			
REPEAT	LOADED TWO MODE			
	Hood open, fan on			
	Set dyno at ____ Thumbwheel or 7.9 on Pendent at 30 MPH			
	30 MPH			
	Idle (Neutral)			
REPEAT	TWO SPEED IDLE CYCLE			
	Hood open fan on			
	Idle (Neutral)			
	Increase Idle Speed to 2500 ± 100 RPM			
	Idle (Neutral)			
. .T	ABBREVIATED I/M CYCLE			
	Hood open fan on			
	Idle (Neutral)			
	Momentary rev. to 2500 RPM			
	Idle (Neutral)			
	PROLONGED IDLE CYCLE			
	Hood closed, fan off			
	Idle (Neutral) Minutes			
	(Baseline only) 0			
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			

Test Vehicle Description

Model/Year	1980
Make	Chevrolet Citation
Emission Control System	EGR, Pulse-Air, 3-Way, Closed Loop
Engine Configuration	I-4
Engine Type	Otto Spark
Bore x Stroke	101.6mm x 76.2mm
Displacement	2500 cc
Rated Horsepower	90
Transmission	A-3
Axle Ratio	2.53
Chassis Type	Sedan
Tire Size	P 185 x 80 R13
Inertia Weight	2750 lbs.
VIN	1 X 685 A W 140457
40% Fuel Tank Volume	5.6 gallons
AHP	7.3
Engine Family	02X2NC
Evap Family	0 B6-2
N/V Ratio	35.7
Fuel Type	Unleaded-Ind H 0
Compression Ratio	8.2
Model Designation	IXX11

8. Re-connect vacuum hoses per vacuum hose schematics.

California Engines

1. Allow engine to cool off to a temperature below 80°F. (26°C.). This may require not starting the engine for a period of 12 hours. If this is not possible, refer to off-car functional checks of individual components in this section.

2. Disconnect vacuum hose at distributor and connect a hand vacuum pump to the distributor spark vacuum unit and apply 15 inches of mercury vacuum. Observe vacuum reading for 20 seconds. If vacuum drops more than one inch, replace vacuum unit.

3. "Tee" a vacuum gage into the vacuum retard hose at the distributor spark vacuum unit.

4. Start engine and observe vacuum reading. With carburetor on high step of fast idle cam, vacuum should be within one inch of manifold vacuum. If not, trace back along the vacuum source until the vacuum leak or plugged condition is located. Correct as necessary.

5. With engine at fast idle allow vacuum reading to stabilize. Turn off the ignition and observe the vacuum gage. **Vacuum reading should not drop immediately, but should drop slowly (taking about 24 to 36 seconds to go from 15 to 5 inches).**

6. If the vacuum drops too fast, the VDV is defective or there is a leak in the distributor vacuum advance unit. If the vacuum drops too slowly, the VDV is defective.

7. Allow engine to warm up until coolant temperature is above 160°F (71°C). With engine at fast idle allow vacuum reading to stabilize. Turn ignition off and observe vacuum reading. Vacuum should drop immediately. If vacuum does not drop immediately, either the vacuum hoses between the DS-TVS and VDV are plugged or the DS-TVS is defective; repair as required.

8. With engine at normal operating temperature and slow idle, check for vacuum at hose to distributor. There should be less than 1 inch of mercury vacuum. If vacuum is present, check idle speed and reset as necessary. If vacuum is still present, check DS-TVS. Replace DS-TVS if necessary.

9. Open throttle slightly and observe an increase in vacuum at the distributor. If vacuum is not present at fast idle, check for plugged or leaking vacuum hoses. Replace as necessary.

10. Re-connect vacuum hoses per vacuum hose schematics.

COMPUTER CONTROLLED CATALYTIC CONVERTER SYSTEM (C-4 SYSTEM)

GENERAL DESCRIPTION

The C-4 is a system that controls emissions by close regulation of the air-fuel ratio and by the use of a three way Catalytic Converter which lowers the level of oxides of Nitrogen, Hydrocarbons and Carbon Monoxide.

The essential components are an exhaust gas Oxygen Sensor (OS), an Electronic Control Module, (ECM) an electronically controlled air-fuel ratio carburetor and a a three way Catalytic Converter (ORC). See Figures 6E-31 thru 6E-35.

OXYGEN SENSOR

(Figure 6E-31)

The oxygen sensor used in the C-4 system consists of a closed end Zirconia sensor placed in the engine exhaust gas stream. The sensor generates a voltage which varies with the oxygen content in the exhaust gas stream. As oxygen content increases, (which indicates a lean mixture) voltage falls, and as oxygen content decreases, (indicating a rich mixture) voltage rises.

NOTICE: Oxygen sensor used for 1980 engines has a permanently attached wiring pig-tail and connector. This pig-tail should not be removed from the oxygen sensor. (Figure 6E-31). Damage to pig-tail or connection could affect proper operation of the oxygen sensor

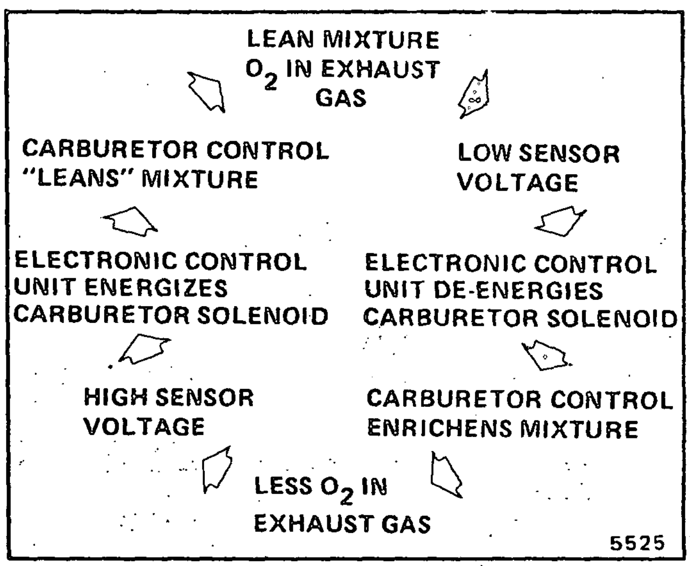

Figure 6E-25 Cycle of Operation

ELECTRONIC CONTROL MODULE (ECM)

(Figure 6E-33)

The Electronic Control Module (ECM) monitors the voltage output of the oxygen sensor along with information from other input signals to generate a control signal to the carburetor solenoid. (Figure 6E-25) The control signal is continually cycling the solenoid between ON (lean

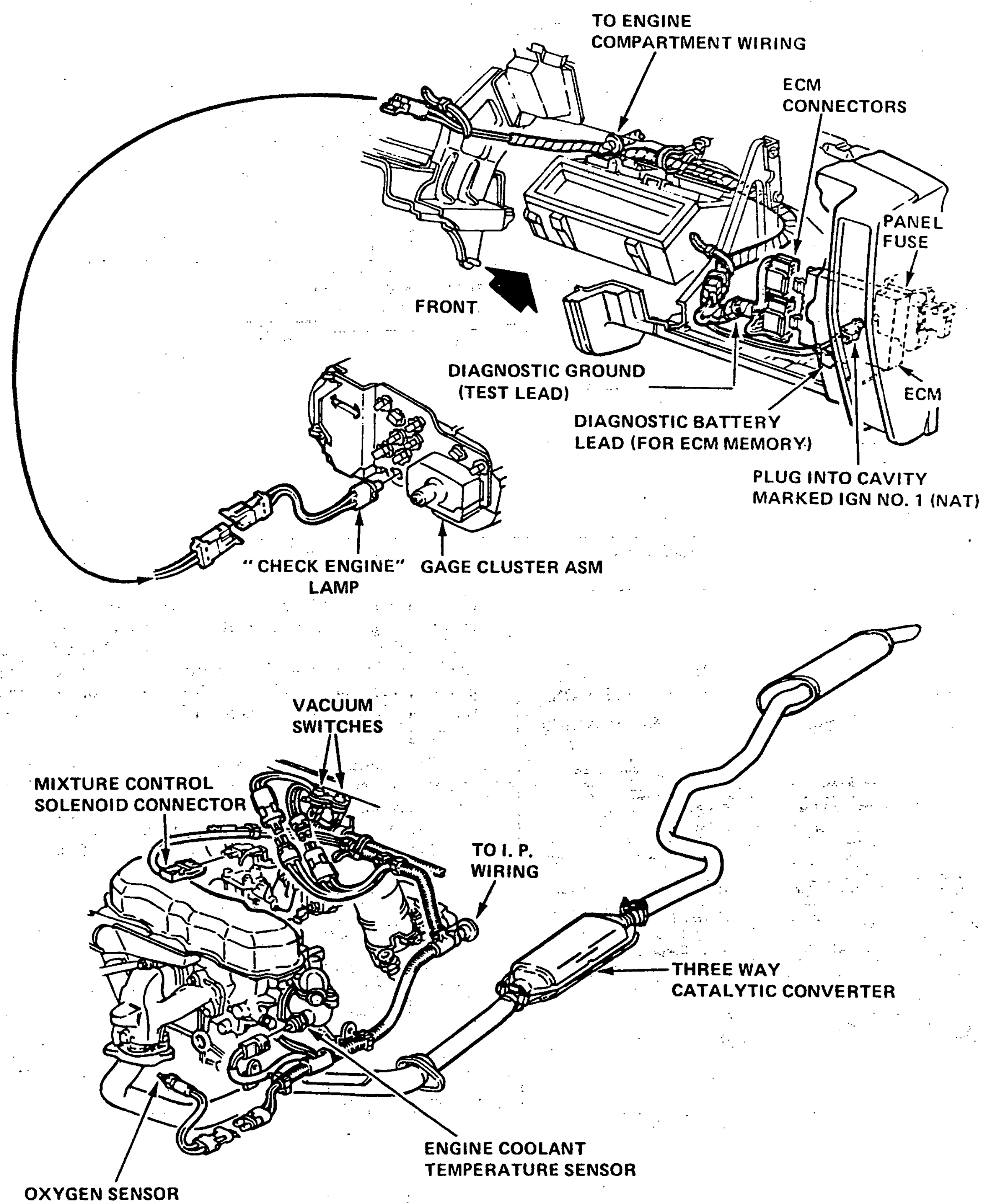

Figure 6E-26 Computer Controlled Catalytic Converter System - Typical

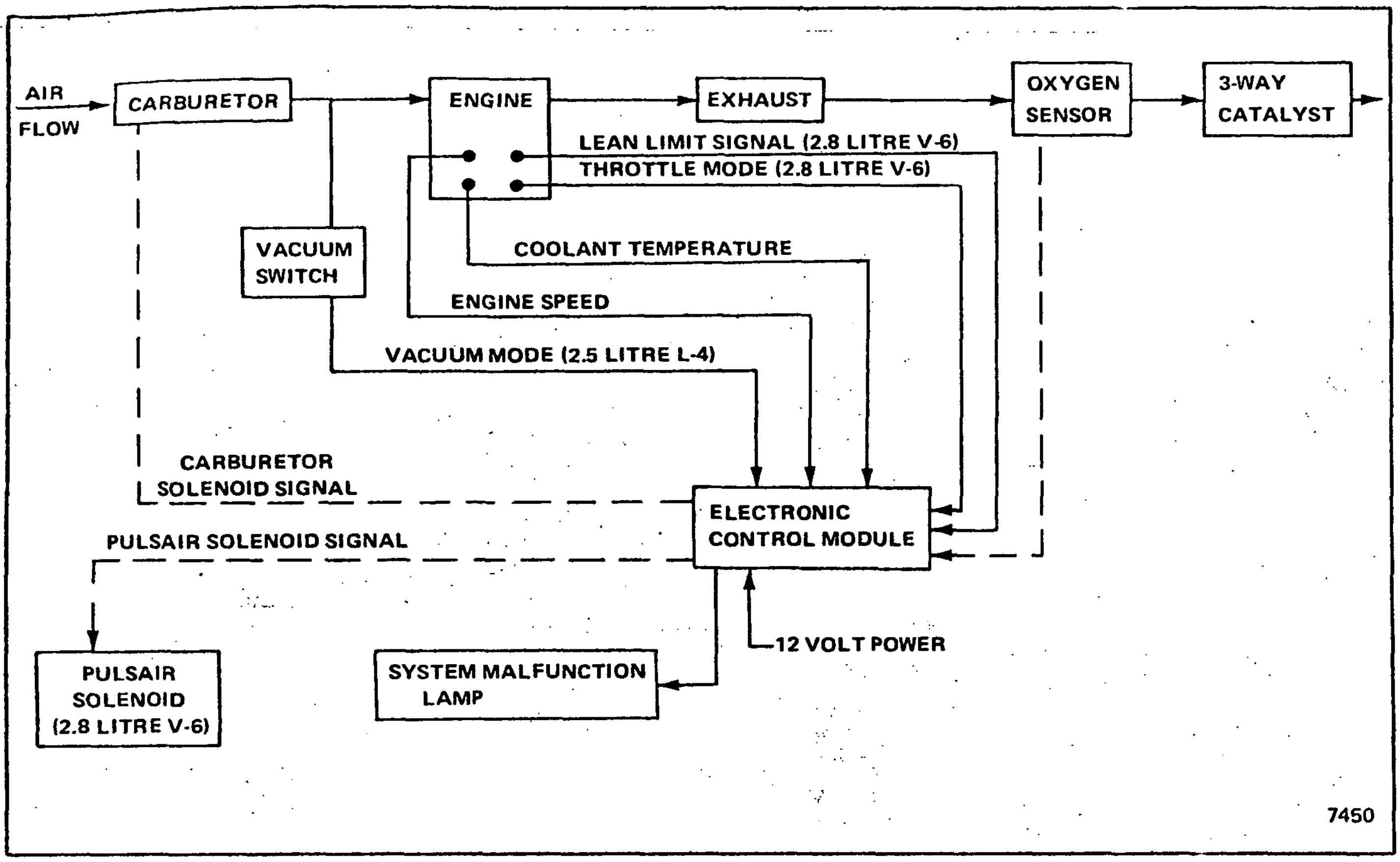

Figure 6E-27 Computer Controlled Catalytic Converter System Schematic

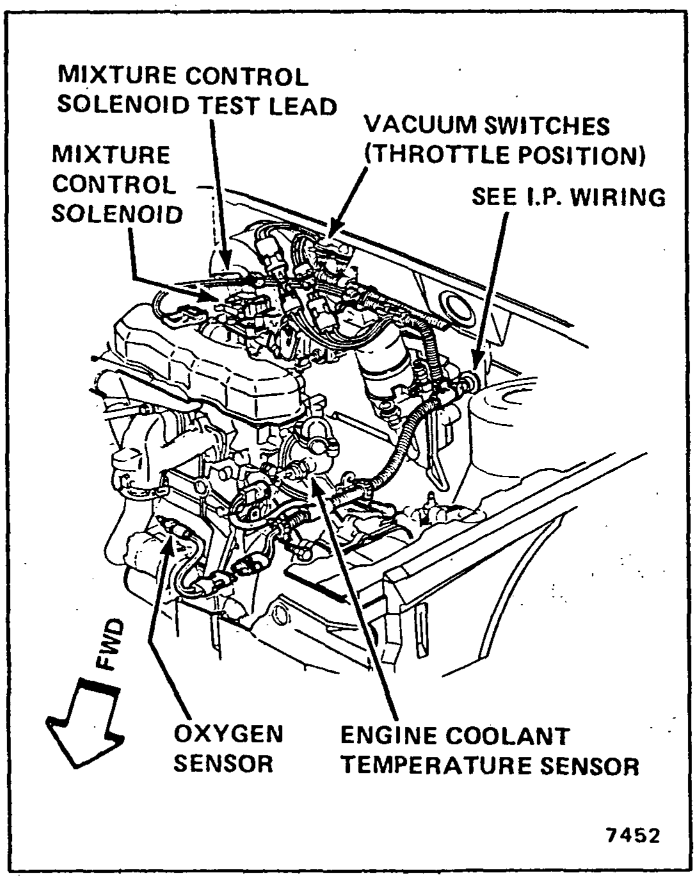

Figure 6E-28 Wiring System - L4

command) and OFF (rich command). When the solenoid is ON (energized) the solenoid pulls down a metering rod which reduces fuel flow. When the solenoid is OFF (de-energized) the spring-loaded metering rod returns to the up position, increasing fuel flow. The amount of ON time relative to OFF time is a function of the input voltage from the oxygen sensor.

To maintain good idle and driveability under all condition other input signals are used to modify the ECM output signal. (Figure 6E-27) These input signals are supplied by Engine Temperature Sensor, Vacuum Control Switch(s), Throttle Position Switch, and Distributor (Engine Speed).

ENGINE TEMPERATURE SENSOR

The Engine Temperature Sensor is a thermistor which inputs engine coolant temperature information to the ECM. This information is used to modify the ECM output signal to adjust for cold engine condition and maintain good driveability during warm up.

VACUUM CONTROL SWITCHES (FIGURE 6E-34)

2.5 Litre L4 Engine - The vacuum control switches monitor the vacuum signal enabling the ECM to recognize closed throttle (idle) or open throttle operation (also see Throttle Position Sensor, 2.8 Litre V6).

2.8 Litre V6 Engine - The vacuum control switch (Lean Authority Limiter) monitors heated carburetor inlet air

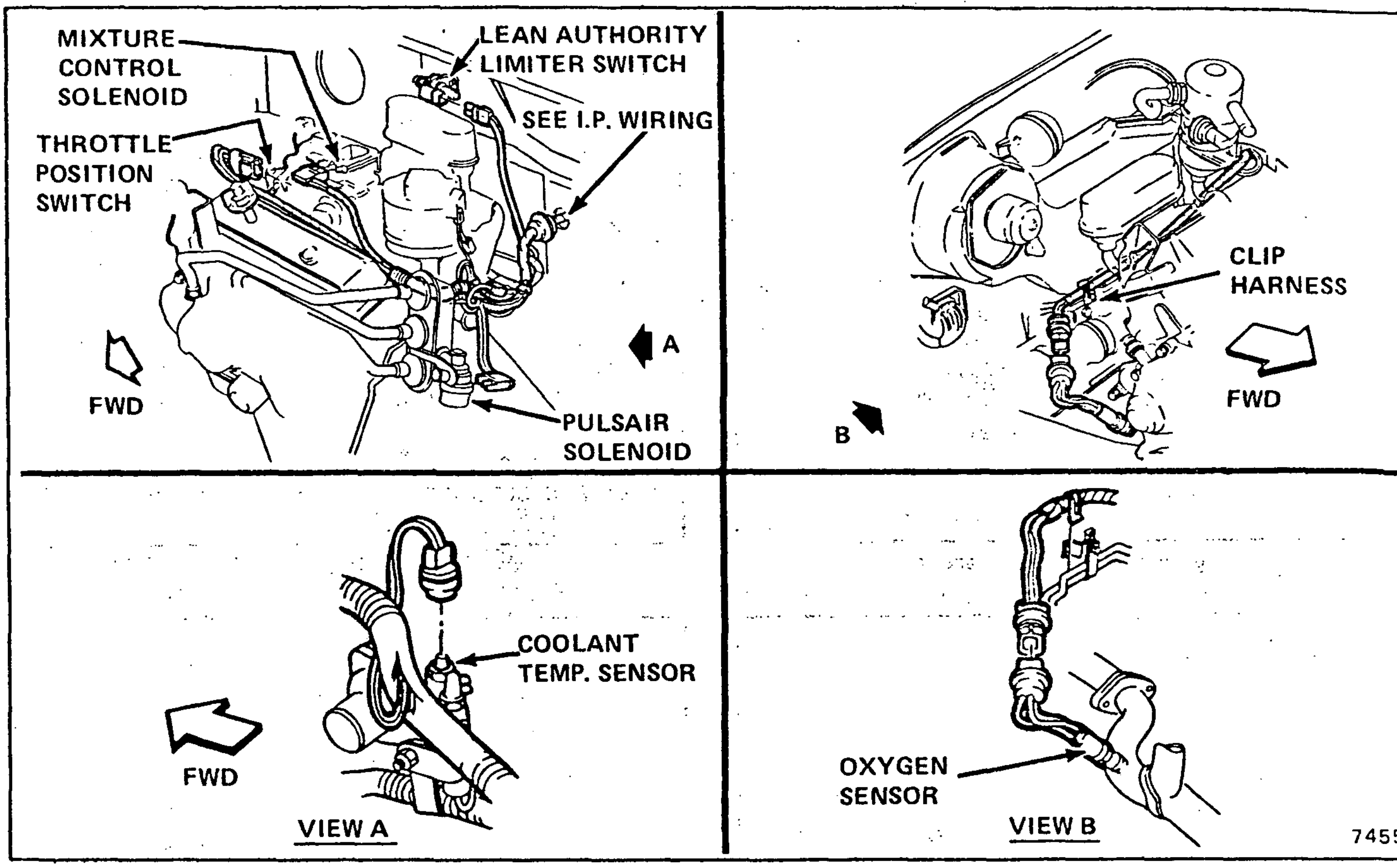

Figure 6E-29 Wiring System - V6

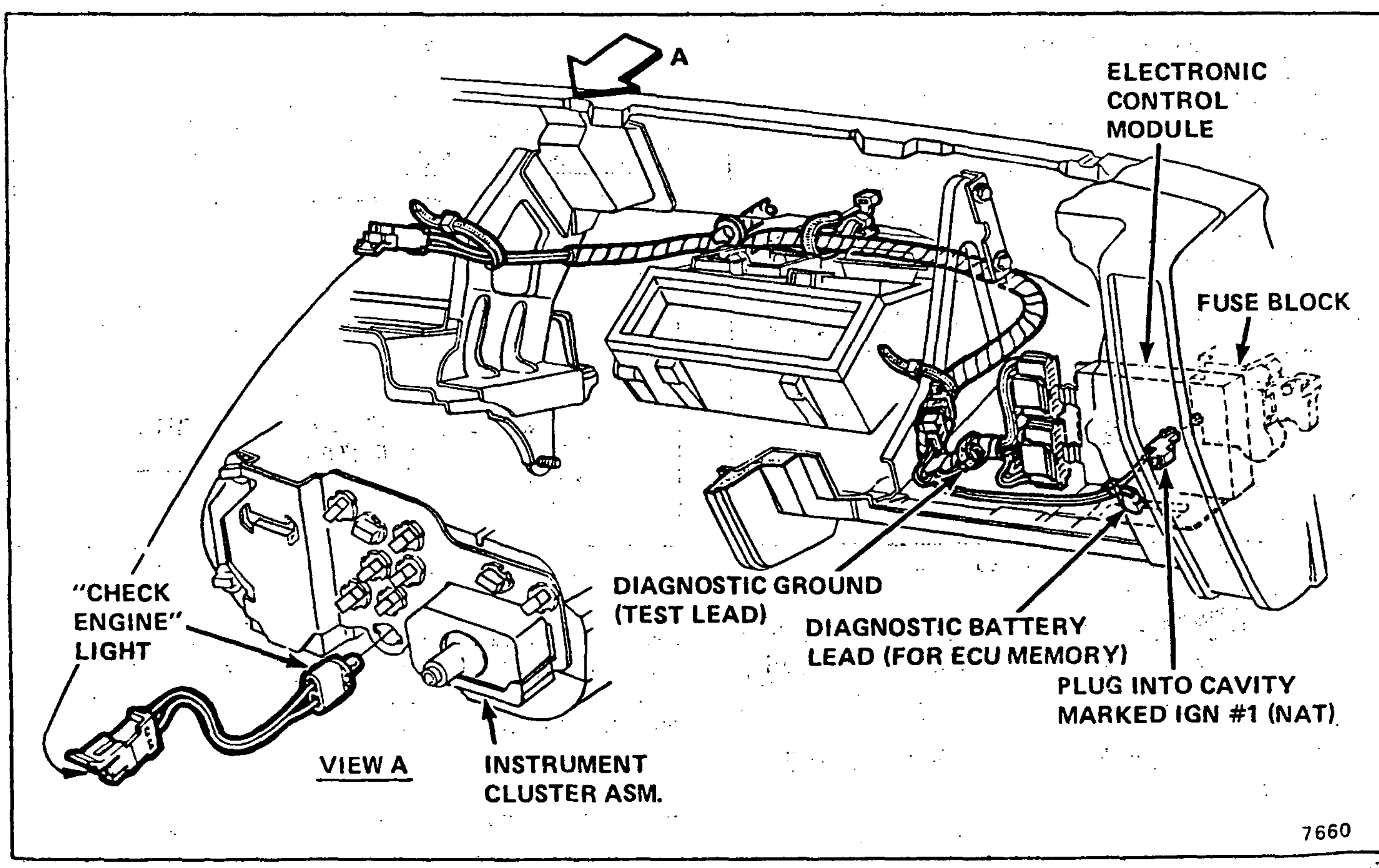

Figure 6E-30 IP Wiring System

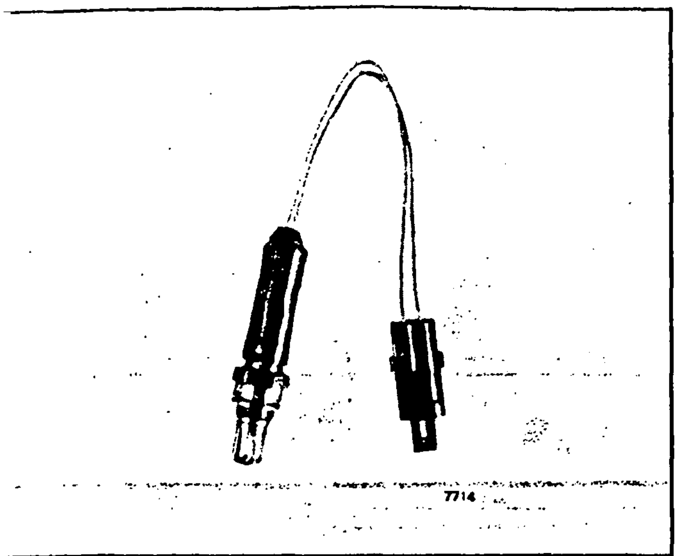

Figure 6E-31 Oxygen Sensor

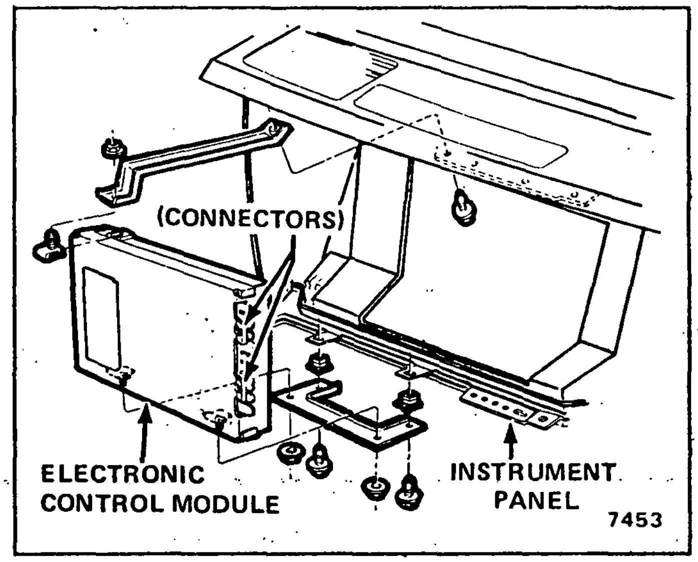

Figure 6E-33 Electronic Control Module (ECM)

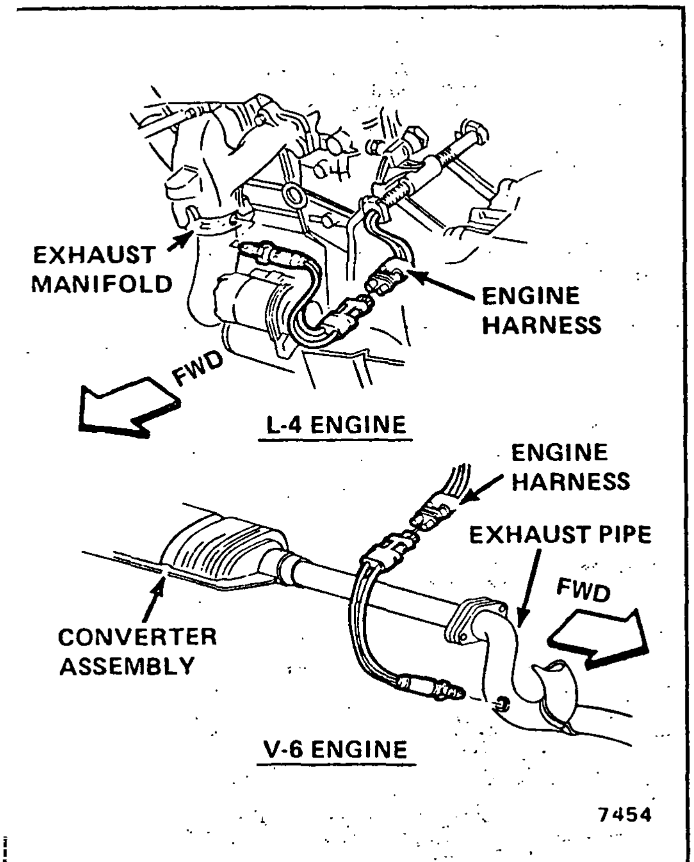

Figure 6E-32 Oxygen Sensor Mounting

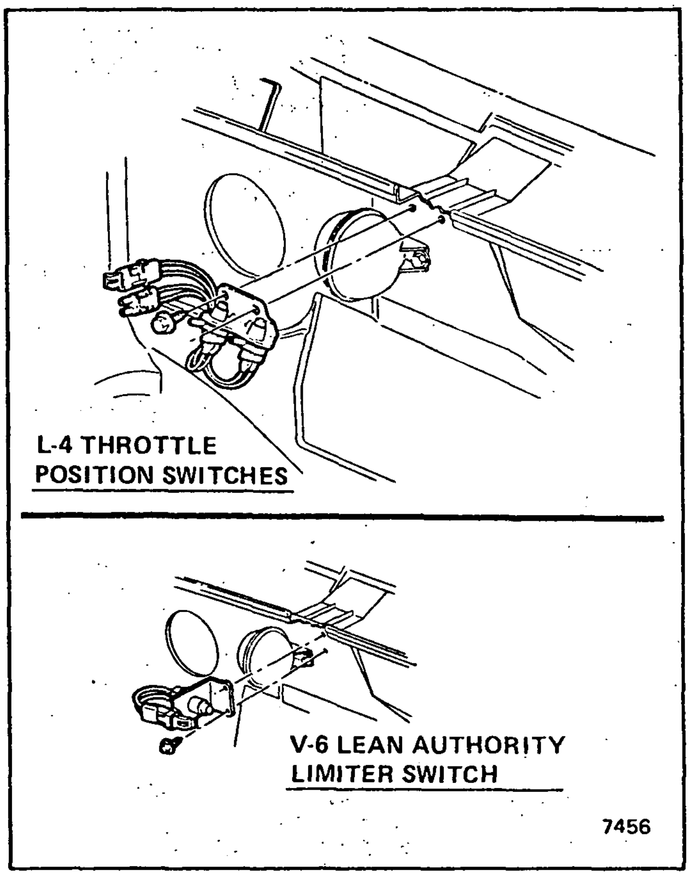

Figure 6E-34 Vacuum Control Switch

through an air cleaner TVS and prevents the ECM from driving the carburetor too lean for good driveability during cold operation.

Throttle Position Sensor (2.8 Litre V6 Engine) (Figure 6E-36)

The Throttle Position Sensor (2.8 Litre V6) and Vacuum Control Switch (2.5 Litre L4) supply throttle position information to the ECM. The ECM memory stores an average of operating conditions with ideal air fuel ratio for those operating conditions. When the ECM receives a signal that indicates throttle position change it immediately shifts to the last "remembered" set of operating conditions that resulted in ideal air-fuel ratio control. During normal operation the memory is continually being updated.

DISTRIBUTOR (ENGINE SPEED)

To assist in engine start-up the ECM at engine speeds under 200 RPM sends no signal to the carburetor mixture control solenoid.

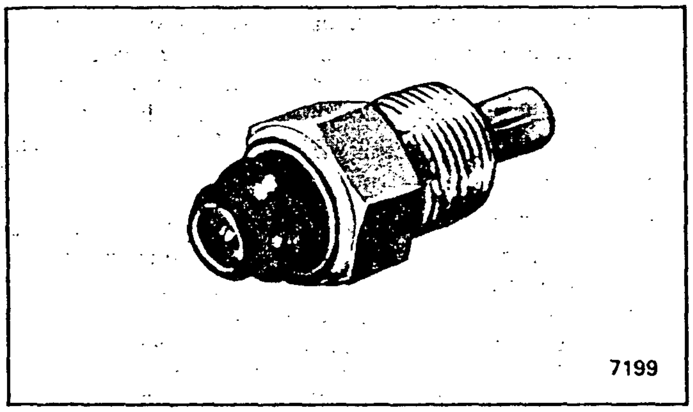

Figure 6E-35 Coolant Temperature Sensor - L4

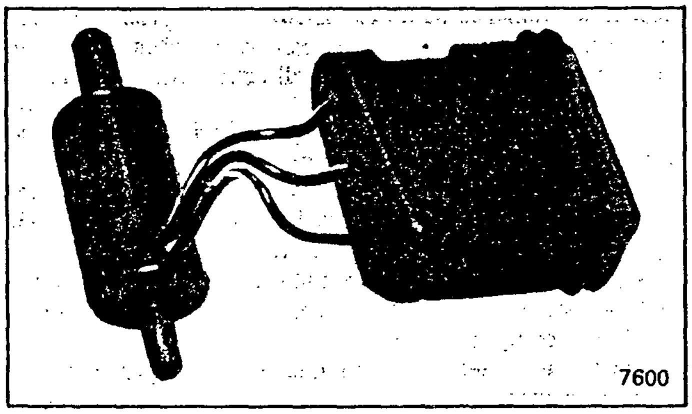

Figure 6E-36 Throttle Position Sensor - V6

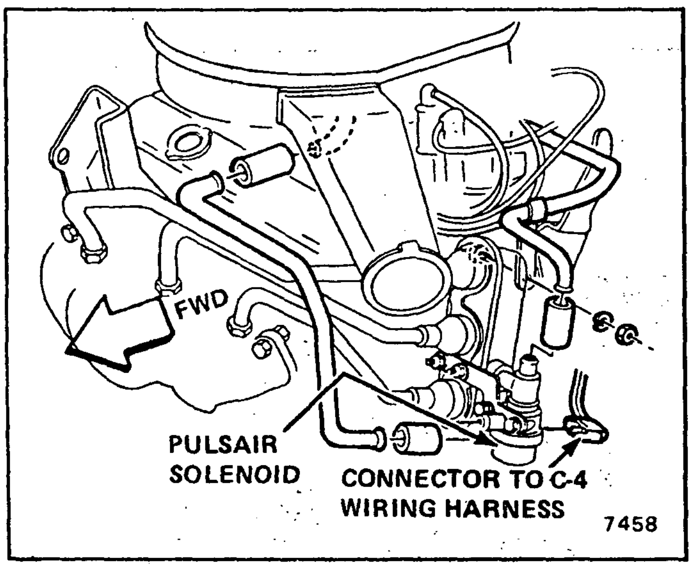

Figure 6E-37 Pulsair Solenoid - V6

CARBURETOR

The Model E2SE carburetor used with the C-4 System is a controlled air-fuel ratio carburetor of a two barrel, two stage down draft design with the primary bore smaller in size than the secondary bore. Air-fuel ratio control is accomplished with a solenoid controlled on/off fuel valve which supplements a preset flow of fuel supplying the idle and main metering systems. The solenoid on/off cycle is controlled by a 12 volt signal from the ECM. The solenoid also controls the amount of air bled into the idle system. The air bleed valve and fuel control valve work together such that the fuel valve is closed when the air bleed valve is open, resulting in a leaner air-fuel mixture. Air-fuel mixture enrichment occurs when the fuel valve is open and air bleed valve closed.

THREE WAY CATALYTIC CONVERTER

The Three Way Catalytic Converter reduces oxides of nitrogen while improving the characteristics of inducing oxidation of Hydrocarbons and Carbon Monoxide. To maintain high conversion efficiency it is necessary to closely control the air fuel ratio.

DIAGNOSTIC SYSTEM

The Computer Controlled Catalytic Converter (C-4) System should be considered as a possible trouble source of engine performance, fuel economy and exhaust emission complaints. A built-in diagnostic system catches problems most likely to occur.

Before suspecting the C-4 system or any of its components as a trouble source, check ignition system including distributor, timing, spark plugs and wires. Check air cleaner, Evaporative Emissions Systems, EFE System, PCV System, EGR valve and engine compression. Also inspect intake manifold, vacuum hoses, and hose connections for leaks, and carburetor mounting bolts.

The following symptoms could indicate a possible problem with the C-4 system.

1. Detonation
2. Stalls or rough idle - cold
3. Stalls or rough idle - hot
4. Missing
5. Hesitation
6. Surges
7. Sluggish or spongy
8. Poor gasoline mileage
9. Hard starting - cold
10. Hard starting - hot
11. Objectionable exhaust odor
12. Cuts out

The self diagnostic system lights a "CHECK ENGINE" light on the instrument panel when a malfunction occurs. By grounding a "TROUBLE CODE" test lead (white/black wire with green connector) under the instrument panel (See Figure 6E-38) the "CHECK ENGINE" light will flash a numerical code if the diagnostic system has detected a fault.

As a bulb and system check, the light will come "ON" when the ignition is turned "ON" with the engine stopped. The "Check Engine" light will remain "ON" approximately 4 seconds after the engine is started. If the "TROUBLE CODE" test lead is grounded with ignition switch "ON" and engine stopped, the light will flash a code "12" which indicates the diagnostic system is working. **This consists of one flash followed by a pause and then two more flashes.** After a longer pause the code will be repeated two more times. The cycle will then repeat itself until the engine is started or the ignition turned off. If the light does not flash the code "12" refer to Figure 6E-42, "Diagnostic System Check".

If the "TROUBLE CODE" test lead is grounded with the engine running and a fault has been detected by the system, the trouble code will flash three times. If more than one fault has been detected, its code will be flashed three times after the first code set. The series will then repeat itself.

A trouble code indicates a problem with a given circuit, for example, code 14 indicates a problem in the coolant sensor circuit. This includes the coolant sensor, harness and Electronic Control Module (ECM). The procedure for finding which of the three it is, can be found in Diagnosis chart #14. The same applies to all other trouble codes.

Since the self diagnostics do not include all possible faults, the absence of a code does not mean there is no problem with the system. To determine this, a system performance check is necessary. See Figure Figure 6E-43, "System Performance Check". It is made when the "CHECK ENGINE" light does not indicate a problem but the C-4 system is suspected because no other reason can be found for a complaint. A dwell meter, ohmmeter, test light, voltmeter, tachometer, vacuum gauge and jumper wires are required to diagnose the system.

The dwell meter, set on the 6 cylinder position and connected to a lead from the mixture control (M/C)

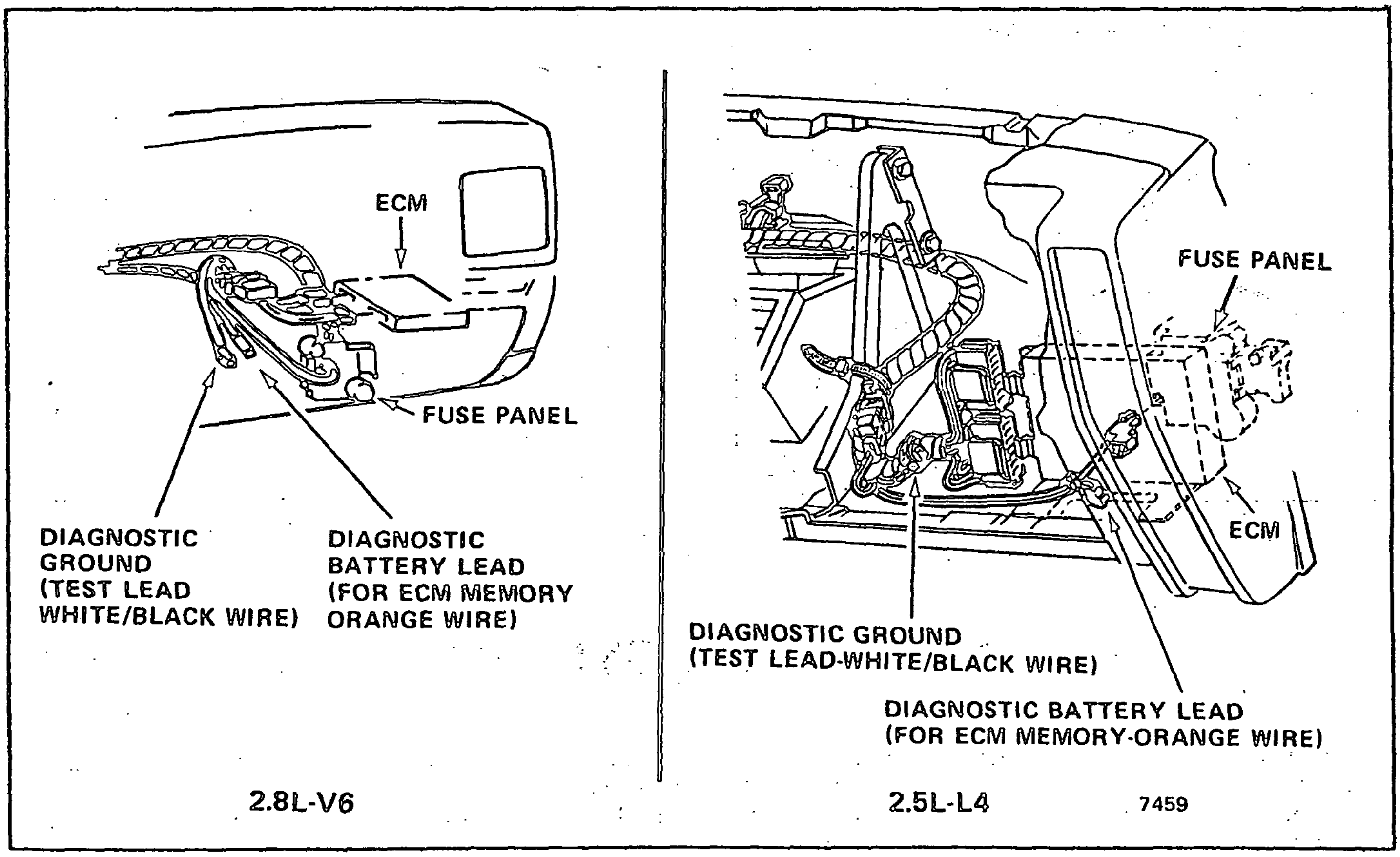

Figure 6E-38 C-4 System Diagnostic Test Leads solenoid in the carburetor, is used to measure the output of the ECM.

NOTICE: When the dwell meter is connected, do not allow the lead to touch ground. This includes hoses because they are conductive.

On a normal operating engine, the dwell at both idle and part throttle reads somewhere between 10° and 50° and will be varying. "Varying" means the needle continually moves up and down the scale. The amount it moves does not matter, only the fact that it does move. This is called closed loop operation, meaning the dwell is being varied by the signal sent to the ECM by an oxygen sensor in the exhaust pipe. Under certain operating conditions such as wide open throttle (WOT) or a cold engine, the dwell will be a fixed value and the needle will be steady. This is called open loop, meaning the oxygen sensor has no effect on the dwell.

Normally, checks are made on a warm engine (upper radiator hose hot).

Trouble Code Memory

When a fault develops in the system, the "check engine" light will come on and a trouble code will be set in the memory of the ECM. However, if the fault is intermittent, the "CHECK ENGINE" light will go out when the trouble goes away, but the trouble code will remain in the memory of the ECM.

Temporary vs Long Term Memory

The ECM as it comes on the car has a temporary memory. That is, the trouble code will be lost as soon as the ignition switch is turned off. Some trouble codes will not be recorded in the ECM until the car has been operated for about 5 minutes at part throttle. For this reason and in order to remember intermittent problems, a long term memory is desirable. Then codes would not be lost when the ignition switch is turned off.

The ECM can be made to have long term memory by connecting the orange connector/lead from terminal "S" of the ECM to fuse block cavity marked "GAUGES. (See Figure 6E-38).

It is not normally connected because it causes a small current drain even when the ignition switch is turned off. This could cause a run down battery if the car were not run for a long time.

If the long term memory has been activated, the orange connector/lead must be disconnected when repairs are completed.

When the "CHECK ENGINE" light is not "ON" with the engine running, but a trouble code can be obtained, the diagnosis charts cannot be used because the system is operating properly at the time. All that can be done is a physical inspection of the circuit indicated by the trouble code. It should be checked for poor connections, frayed wires, etc.

THROTTLE POSITION SWITCHES

The 2.5L L4, VIN Code 5 engine uses two vacuum switches to inform the ECM of closed throttle vs open throttle operation. The 2.8L V6 VIN Code 7 engine uses a throttle position sensor to signal wide open throttle as well as idle vs part throttle.

The two systems have to be diagnosed differently, so where necessary, it will be so indicated in diagnostic procedures.

ELECTRONIC CONTROL MODULE (ECM)

ECMs have a calibration unit called a PROM (Programable Read Only Memory) which contains the specific instructions for a given application. It is a replaceable assembly which plugs into a socket and requires a special tool for removal and replacement.

The PROM and the socket each have a mark on one end that must be aligned when installing and care must be used to not bend the twenty, pin contacts on the PROM.

Trouble code 51 indicates the PROM is installed improperly or is defective. When code 51 is obtained on a factory installed ECM, the ECM should be replaced. On a service unit the PROM installation should be checked for bent pins or being installed 180° rotated.

Service ECMs will come without PROMs, so the proper PROM will also have to be ordered and installed.

Connecting a Tachometer

The lead from the distributor tachometer terminal to the ECM has a filter in series with it. The tachometer must be connected to the distributor side only. (Figure 6E-39).

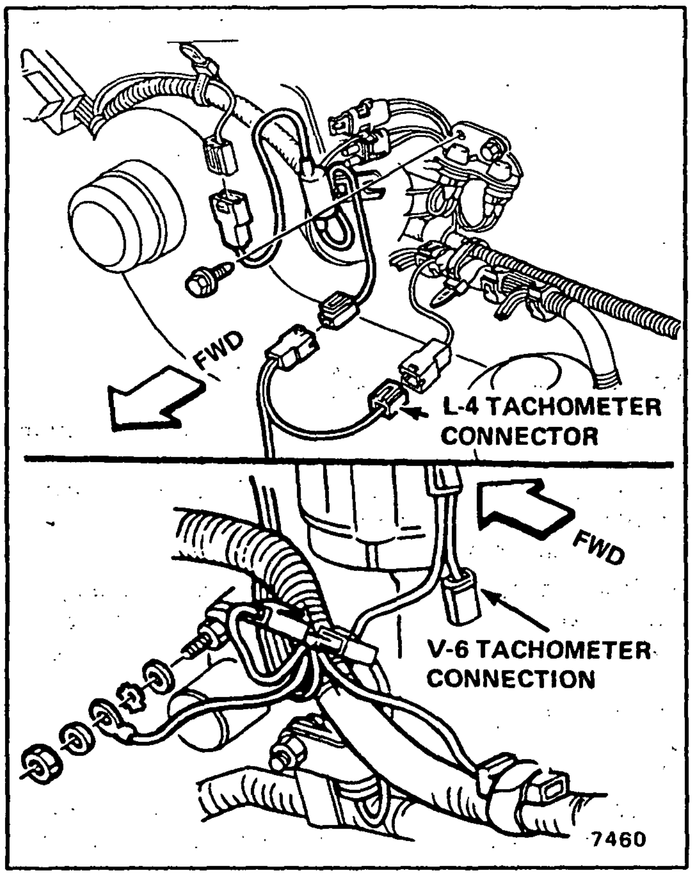

Figure 6E-39 Tachometer Test Leads

TROUBLE (FAULT) CODES

The trouble codes indicate faults or problem areas listed below. Refer to the Diagnostic Chart with same numerical trouble code (see Figure 6E-44 through 6E-62).

NOTICE: The system performance check (Figure 6E-43) should be performed after any repairs to this system have been made and then long term memory cleared. If long term memory is left connected battery could be run down.

Trouble Code	Problem Area - Refer to Corresponding Diagnostic Chart
12	No tachometer signal to the ECM
13	Oxygen sensor circuit. The engine has to operate for about 5 minutes at part throttle before this code will show.
13 & 43	Same time - See Code 43. (Code 43 - 2.8L V6 only)
14	Shorted coolant sensor circuit. The engine has to run 2 minutes before this code will show.
15	Open coolant sensor circuit. The engine has to operate for about 5 minutes at part throttle before this code will show.
21	Throttle position sensor circuit (2.8L V6)
21 & 22	(At same time) grounded WOT switch circuit. (2.5L L4)
22	Grounded closed throttle or WOT switch circuit. (2.5L L4)
23	Carburetor solenoid circuit.
	(2.8L V6)
44	Lean Oxygen Sensor
45	Rich Oxygen Sensor
51	On Service Unit, check calibration unit (PROM) installation. On factory installed unit, replace ECM.

54	Faulty carburetor solenoid and/or ECM.
52, 53	Replace ECM.
55	Faulty throttle position sensor (2.8L V6) or ECM
55	Replace ECM (2.5L L-4).

EXPLANATION OF ABBREVIATIONS

C-4 - Computer Controlled Catalytic Converter
PROM - Calibration Unit
ECM - Electronic Control Module
OEM - Original Equipment Manufacture
WOT - Wide Open Throttle
TPS - Throttle Position Sensor
M/C SOLENOID - Mixture Control Solenoid
BAT+ - Battery Positive Terminal

Attachment 4

Dilute Sampling Testing

Date	Test Numbers	FTP (gms/mile) HC	FTP CO	FTP CO_2	FTP NOx	FTP F.E.	Raw (ppm/%) HC	Raw CO	HWFET (gms/mile) HC	HWFET CO	HWFET CO_2	HWFET NOx	HWFET F.E.	Comments
7-17-79	79-8686,87,88	.251	3.08	392	.53	22.3	5	0	.008	.01	266	.43	33.3	Baseline
8-1-79	79-8689,90	.195	3.33	389	.52	22.5	0	.012	.013	.063	259	.459	34.2	Baseline
8-8-79	79-8691,92,93	.225	5.18	378	.69	22.9	N/A	N/A	.011	.07	258	.41	34.4	Coolant Temp. Switch Disc
8-9-79	78-8694,95	.295	6.85	374	.64	23.0	N/A	N/A	.028	.574	254	1.164	34.8	EGO Sensor Disconnected
8-14-79	79-8696,97	2.361	111.24	282	.06	19.1	N/A	N/A	1.184	68.44	197.5	.054	28.7	Mixture Control Solenoid
8-15-79	79-8698,99	.176	2.20	383	1.14	22.9	N/A	N/A	VOID	VOID	VOID	VOID	VOID	EGR Disconnected Void-Wrong Rang
8-23-79	79-8700,8701	.181	2.78	378	1.29	23.2	N/A	N/A	.011	.069	257.5	1.738	34.4	EGR Disconnected
9-6-79	79-9557,58	2.544	120.98	287	.17	18.3	N/A	N/A	1.294	72.7	200.4	.167	27.8	EGR Disc. and Mixture Solenoid D
9-13-79	79-9559,60	.202	4.21	393	.45	22.2	N/A	N/A	.010	.025	258.4	.457	34.3	Closed Throttle Sensor Disc.
9-19-79	79-9561,62	2.073	95.62	304	.13	19.2	N/A	N/A	1.062	48.73	213.5	.064	30.2	EGO Sensor Short Circuited
9-20-79	79-9563,64	.190	3.38	360	.43	24.2	N/A	N/A	.010	.032	242.6	.350	36.5	Baseline
9-28-79	79-9565,66	.178	2.59	406	.79	21.6	0	.013	.010	.080	261.8	.488	33.9	Baseline

All Raw HC Readings in ppm Hexane.

All Raw CO Readings in percent.

Dilute Sampling Testing

Date	Test Numbers	Following HFET Raw (ppm/%) HC	CO	NYCC (gms/mile) HC	CO	CO_2	NOx	F.E.	Raw (ppm/%) HC	CO	Comments
7-17-79	79-8686,87,88	8	.025	.280	8.565	722.3	.415	12.0	8	.025	Baseline
8-1-79	79-8689,90	0	.006	.217	5.869	752.5	.598	11.6	0	.010	Baseline
8-8-79	79-8691,92,93	N/A	N/A	.093	2.764	748.7	.755	11.8	N/A	N/A	Coolant Temperature Switch Disconnected
8-9-79	79-8694,95	N/A	N/A	.317	10.086	700.3	1.062	12.4	N/A	N/A	EGO Sensor Disconnected
8-14-79	78-8696,97	N/A	N/A	4.303	215.3	574.6	.107	9.6	N/A	N/A	Mixture Control Solenoid
8-15-79	79-8698,99	N/A	N/A	.16	4.07	829.7	.710	12.6	N/A	N/A	EGR Disconnected Void-Wrong Ranges
8-23-79	79-8700,8701	N/A	N/A	.107	4.08	740.6	.983	11.9	N/A	N/A	EGR Disconnected
9-6-79	79-9557,58	N/A	N/A	4.289	217.86	551.8	.157	9.8	N/A	N/A	EGR Disconnected and Mixture Solenoid Disconnected
9-13-79	79-9559,60	N/A	N/A	.175	5.492	754.9	.551	11.6	N/A	N/A	Closed Throttle Sensor Disconnected
9-19-79	79-9561,62	N/A	N/A	3.834	170.1	596.2	.055	10.1	N/A	N/A	EGO Sensor Short Circuited
9-20-79	79-9563,64	N/A	N/A	.151	3.984	711.9	.565	12.3	N/A	N/A	Baseline
9-28-79	79-9565,66	0	.015	.271	8.881	827.5	1.287	10.5	0	.010	Baseline

All Raw HC Readings in ppm Hexane.

All Raw CO Readings in percent.

I/M Cycle Testing

		Federal Three Mode								Loaded Two Mode			
		HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO
Date	Test #s	52 mph		25 mph		Idle (Drive)		Idle (Neutral)		30 mph		Idle (Neutral)	
7-17-79	79-8686,87,88	10/.02	8/.025	10/.02	8/.025	8/.02	8/.025	8/.02	10/.025	10/.025	8/.025	8/.025	8/.02
8-1-79	79-8689,90	5/.012	0/.010	2/.010	0/.009	2/.010	0/.003	3/.010	0/.005	3/.010	0/.010	3/.010	0/.010
8-8-79	79-8691,92,93	0/.012	0/.010	0/.010	0/.009	0/0	0/0	0/0	0/0	0/.008	0/.008	0/0	0/.001
8-9-79	79-8694,95	10/.011	2/.015	4/.001	0/.010	1/.011	0/.009	0/.010	0/.010	1/.010	1/.018	1/.011	1/.012
8-14-79	79-8696,97	150/6.6	162/6.7	172/6.8	183/7.5	159/7.5	170/7.5	152/7.6	158/7.2	185/6.9	182/7.1	151/7.5	152/7.3
8-15-79	79-8698,99	18/.04	18/.022	14/.022	13/.019	13/.010	13/.006	13/.007	13/.010	15/.025	13/.031	15/.012	12/.010
8-23-79	79-8700,01	10/.02	5/.045	10/.015	2/.03	10/.01	2/.01	10/.013	2/.012	5/.05	2/.043	2/.01	5/.020
9-6-79	79-9558,57	140/6.8	159/6.6	170/6.9	188/6.9	172/7.6	173/7.6	154/7.2	155/7.2	170/6.8	180/6.7	152/7.4	158/7.4
9-13-79	79-9559,60	19/.02	10/.011	29/.015	8/.009	29/.012	7/.007	30/.010	9/.010	35/.010	0/.016	35/.009	0/.013
9-19-79	79-9561,62	150/4.8	196/4.9	182/4.4	208/4.6	172/5.95	190/4.7	160/5.5	180/4.4	210/5.2	213/5.2	165/5.8	180/5.45
9-20-79	79-9563,64	10/.018	20/.010	10/.012	17/.010	10/.012	17/.07	11/.011	18/.008	13/.012	18/.010	12/.010	18/.008
9-28-79	79-9565,66	0/.012	0/.015	0/.020	0/.018	0/.012	1/.015	1/.010	0/.012	1/.012	0/.012	0/.011	0/.005

All HC readings in ppm (Hexane).

All CO readings in percent.

I/M Cycle Testing

Date	Test #s	Two Speed Idle Cycle						Abbreviated I/M Cycle				Comments
		Idle (Neutral)		2500 rpm		Idle (Neutral)		Idle (Neutral)		Idle (Neutral)		
		HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	
7-17-79	79-8686,87,88	8/.025	8/.02	8/.025	10/.025	10/.025	8/.02	8/.025	8/.02	10/.025	10/.025	Baseline
8-1-79	79-8689,90	3/.010	0/.010	7/.010	0/.010	4/.010	0/.010	5/.009	0/.010	4/.010	0/.010	Baseline
8-8-79	79-8691,92,93	0/0	1/.003	0/.008	0/.010	0/.002	1/.003	0/.002	0/0	0/.001	0/0	Coolant Temp. Switch Disc.
8-9-79	79-8694,95	1/.011	2/.013	5/.012	4/.017	0/.011	3/.013	0/.012	1/.013	0/.011	0/.012	EGO Sensor Disconnected
8-14-79	79-8696,97	152/7.3	153/7.2	120/4.6	118/4.0	150/7.4	157/7.3	152/7.3	158/7.2	160/7.2	158/7.0	Mixture Control Solenoid
8-15-79	79-8698,99	15/.012	12/.010	20/.015	15/.012	18/.012	13/.011	19/.012	14/.012	18/.01	16/.011	EGR Disc. Void-Wrong Ranges
8-23-79	79-8700,01	2/.01	2/.01	5/.009	3/.012	2/.08	3/.01	2/.008	3/.01	2/.008	3/.012	EGR Disconnected
9-6-79	79-9558,57	155/7.3	162/7.25	83/2.9	76/2.2	149/6.9	157/6.9	152/6.9	160/6.9	160/6.85	164/6.8	EGR Disc. and Mix. Solenoid Disc
9-13-79	79-9559,60	38/.003	0/.012	47/.001	1/.012	48/0.0	0/.010	3/.01	0/.010	6/.011	0/.010	Closed Throttle Sensor Disc.
9-19-79	79-9561,62	168/5.6	182/5.4	110/2.0	126/2.3	168/5.5	181/5.3	170/5.5	182/5.3	181/5.95	190/5.4	EGR Sensor Short Circuited
9-20-79	79-9563,64	15/.010	18/.008	17/.010	20/.009	15/.010	20/.009	16/.010	20/.008	18/.010	20/.008	Baseline
9-28-79	79-9565,66	0/.010	0/.012	1/.013	2/.013	0/.010	0/.010	1/.012	0/.012	2/.019	0/.012	Baseline

All HC readings in ppm (Hexane).

All CO readings in percent.

* HC background final = 6.2 ppm.

Attachment 5 cont.

Prolonged Idle Cycle (HC/CO in ppm hexane/%)

Date	Test Number	Initial	1 min.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	Comments
7-17-79	8686,87,88	10/.025	8/.02	8/.02	8/.02	10/.025	10/.025	10/.025	10/.025	10/.025	10/.025	10/.025	Baseline
8-1-79	8689,90	2/.012	5/.012	10/.012	12/.013	12/.011	17/.011	17/.011	20/.012	22/.010	22/.010	24/.010	Baseline - **
9-20-79		20/.007	20/.007	21/.008	25/.008	23/.008	26/.008	29/.008	29/.008	21/.009	32/.009	36/.009	Baseline*
9-28-79		0/.016	0/.013	1/.013	0/.014	0/.021	0/.017	0/.018	0/.016	0/.017	0/.014	0/.014	

* BKGD HC drifted from 0 ppm to 35 ppm.

** BKGD HC drifted from 0 ppm to 25 ppm.

All HC readings in ppm hexane.

All CO readings in percent CO.

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