Evaluation of Applicability of Inspection/Maintenance Tests on a Dodge Aspen Prototype

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by

Thomas J. Penninga

Technology Assessment and Evaluation Branch
Emission Control Technology Division
Office of Air, Noise and Radiation
U.S. Environmental Protection Agency

Abstract

This report presents testing results which were gathered to determine the suitability of existing I/M testing scenarios on a Chrysler car with a computer based emission control system. This car had a microprocessor based three-way catalyst control as well as computerized spark control. 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 suite these automobiles. This report presents the data collected on the second such automobile tested by the EPA, a 1979 Dodge Aspen with an EFC and ESC microprocessor controlled emission control system.

History

The Aspen was a late 1979 certification vehicle which was delivered to MVEL for I/M testing on March 20, 1979. Three baseline sets of data were run. The vehicle was shipped to Gulf Research Laboratory on March 29, 1979 where it underwent ambient emission testing. On June 8, 1979 the vehicle was delivered to MVEL.

The I/M testing began on June 29, 1979. After two baseline sequences were run, the vehicle was tested with five different system deactivations. A final confirmatory baseline sequence was then run.

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 closed, fan off, idle-neutral.

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

d. Raw HC/CO measurement, hood closed, fan off, idle-neutral.

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

f. Raw HC/CO measurement, hood closed, fan off, idle-neutral.

g. Federal Three Mode. The dynamometer was set at 1750 lbs. inertia and horsepower was set at 6.4 hp at 25 mph and 13.7 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 at 17.3 IHP 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 closed and the auxiliary cooling fan turned off.

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 closed and the auxiliary cooling fan turned off.

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.

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

Vehicle Description

The Dodge Aspen supplied by Chrysler for this testing was not a production vehicle but a 4000 mile emission-data-vehicle. 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 constitutent in each mode in every test type. Confirmatory baseline tests were run at the end of the test program. 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. EGR Sensor Disconnected - Test Numbers 79-8152 and 79-8153 was done with the exhaust gas oxygen (EGO) sensor disconnected. This unit supplies a voltage signal to the FBC computer based on the oxygen content of the exhaust stream. By disconnecting the sensor the output voltage goes to zero and the closed loop system is deactivated. These tests are designated EGO Sensor disconnected.

b. Coolant Temperature Switch Disconnected - Test Numbers 79-8154 and 79-8155 were run with the Coolant Temperature Switch 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 EGO sensor temperature is reached.

3. Solenoid Actuated Vacuum Regulatory Disconnected - Test Numbers 79-8156 and 79-8157 were run with the solenoid actuated Vacuum Regulator disconnected. This device connects the electrical signal from the FCC to a vacuum signal to control the carburetor in maintaining the A/F ratio at stoichiometric. Disconnecting the solenoid forces the system to run in a full rich condition.

d. Air Pump 100% Bypassed - Test Numbers 79-8158 and 79-8159 were run with the air pump diverted to atmosphere and both upstream and downstream air injection lines plugged. This air injection oxidizes HC and CO at the exhaust port during warm-up and at the oxidation catalyst during regular operation.

e. EGR Valve Disconnected - Test Numbers 79-8160 and 79-8161 were run with Exhaust Gas Recirculation (EGR) valve line disconnected and plugged. This device recirculates exhaust gas into the inlet manifold which reduces combustion temperature thereby reducing NOx formation.

f. Solenoid Actuated Vacuum Regulator - Full Lean - Additional tests were attempted with the solinoid wired to 12 volt DC. This condition would result in driving the FCC to a full lean condition. Because the vehicle stalled over 15 times in the preconditioning LA-4, this testing mode was terminated.

Test Results

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 was run twice, two sets of values are given.

c. Attachment 5 also presents the Prolonged Idle Cycle Data.

List of Attachments

Attachment 1	I/M Test Result Work Sheet
Attachment 2	Test Vehicle Description
Attachment 3	Chrysler FCC and ESC 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 closed, fan off			
Transmission-neutral	____	____	____________
AFTER HWFET			
Hood closed, fan off			
Transmission-neutral	____	____	____________
AFTER NYCC			
Hood closed, fan off			
Transmission-Neutral	____	____	____________
FEDERAL 3 MODE I.W. = 1750			
Hood open, fan on			
Set 13.7 on thumbwheel			
52 MPH-max 3 min.	____	____	____________
Set 6.4 IHP @ 25 MPH			
with Pendent			
25 MPH-max 3 min.	____	____	____________
Idle (Drive)	____	____	____________
Idle (Neutral)	____	____	____________
LOADED 2 MODE I.W. = 1750			
Hood open, fan on			
Set dyno at 17.3			
Thumbwheel or ______			
on Pendent at 30 MPH			
30 MPH	____	____	____________
Idle (Neutral)	____	____	____________
TWO SPEED IDLE CYCLE			
Hood closed, fan off			
Idle (Neutral)	____	____	____________
Increase Idle speed to 2500			
± 100 RPM	____	____	____________
Idle (Neutral)	____	____	____________
ABBREVIATED I/M IDLE CYCLE			
Hood closed, fan off			
Idle (N)	____	____	____________
Momentary rev. to 2500 RPM			
Idle (N)	____	____	____________

		HC	CO	COMMENTS
R[illegible]	FEDERAL THREE MODE I.W. =1750#			
	Hood open, fan on			
	Set 13.7 on Thumbwheel			
	52 MPH-Max 3 min.			
	Set 6.4 IHP@25 MPH			
	with Pendent			
	25 MPH-Max 3 min.			
	Idle (Drive)			
	Idle (Neutral)			
REPEAT	LOADED TWO MODE I.W. =1750#			
	Hood open, fan on			
	Set dyno at 17.3			
	Thumbwheel or _____			
	on Pendent at 30 MPH			
	30 MPH			
	Idle (Neutral)			
REPEAT	TWO SPEED IDLE CYCLE			
	Hood closed, fan off			
	Idle (Neutral)			
	Increase Idle Speed to			
	2500 ± 100 RPM			
	Idle (Neutral)			
R[illegible]T	ABBREVIATED I/M CYCLE			
	Hood closed, fan off			
	Idle (Neutral)			
	Momentary rev. to 2500 RPM			
	Idle (Neutral)			
	PROLONGED IDLE CYCLE			
	Hood closed, fan off			
	Idle (Neutral) Minutes			
	0			
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			

Test Vehicle Description

Model Year	1979
Make	Dodge Aspen
Emission Control System	EGR, AI, OC, 3-Way, Closed Loop
Engine Type	Otto Spark
Bore x Stroke	3.40 x 4.12 inches
Displacement	225 CID
Rated Horsepower	101 hp
Transmission	A-3
Axle Ratio	2.94
Chassis Type	Sedan
Tire Size	D78x14
Inertia Weight	3500 lbs.
VIN	B103
AHP	13.5
40% Fuel Tank Volume	7.20

Technical Service Bulletin

Service & Parts Division

SERVICE

Of Interest ☐ General Manager ☐ Sales Manager ☐ Service Manager ☐ Parts Manager ☐ Service Technicians

Models

1979 Volare/As[illegible] Equipped With 225-1BBL and California Emissions Package

Subject

Electronic Feedback Carburetor (EF[illegible]

Index

FUEL

Date:

April 30, 1979

No. 14-05-79

P-2518-C

A new concept in controlling exhaust emissions has been incorporated in production.

The new system is called the Electronic Feedback Carburetor Concept. A unique feature is the use of the Electronic Spark Control for the first time on six-cylinder engines. Both systems work together as the combustion computer controlling ignition timing and air-fuel ratios in the carburetor. The precise control of air-fuel ratio has permitted a three-way catalyst to be used in this system to simultaneously reduce all three major exhaust pollutants; hydrocarbons, carbon monoxide, and oxides of nitrogens.

The attached information provides a complete detailed description of the system, diagnosis, and service procedures. Testing procedures and specifications for the Electronic Spark Control portion are outlined in the 1979 Service Manual.

POLICY: Information Only

J. W. Farley

J. W. Farley
Manager - Service Planning

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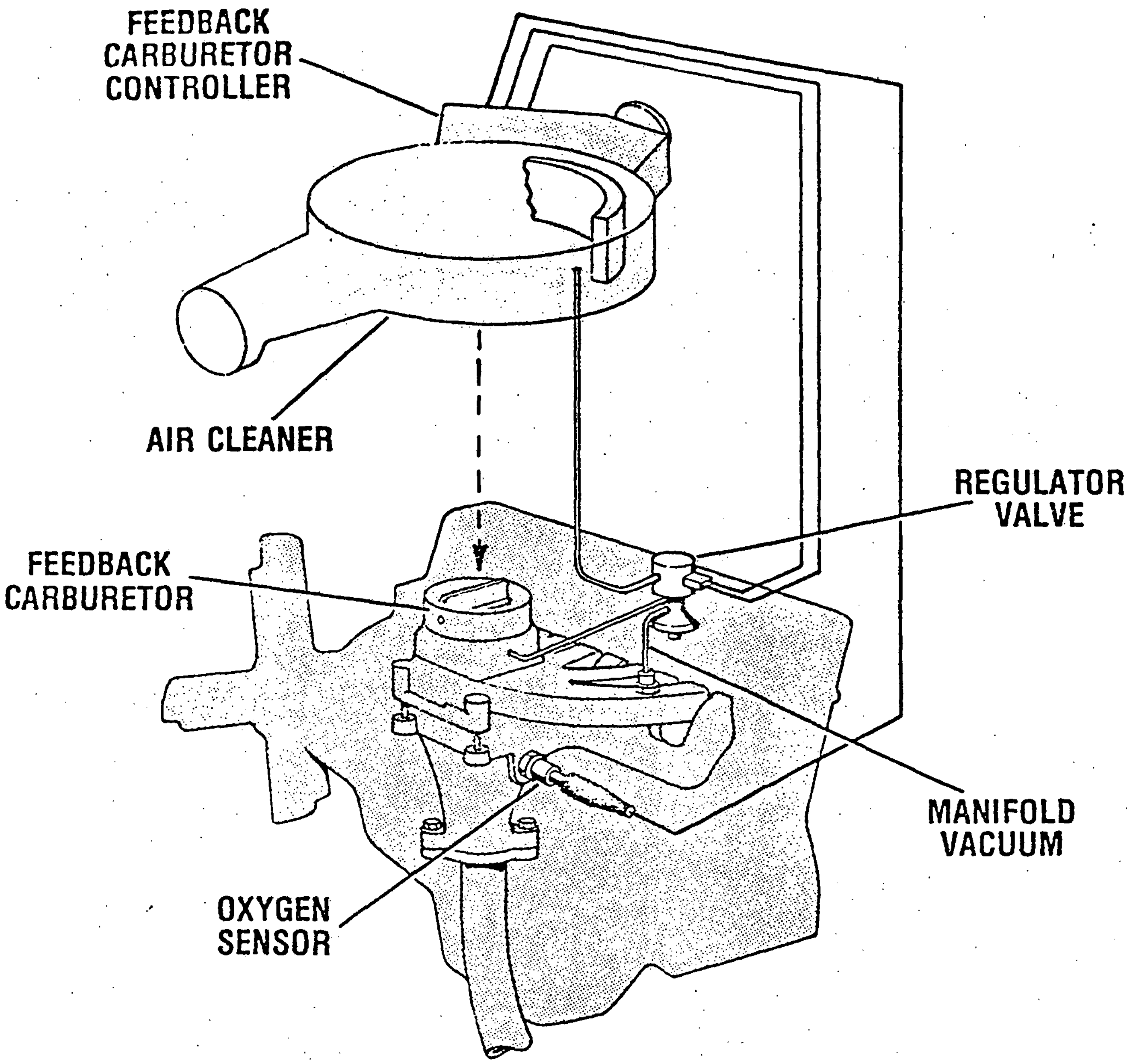


ELECTRONIC FEEDBACK CARBURETOR CONCEPT

ELECTRONIC FEEDBACK CARBURETOR (EFC) SYSTEM

The EFC system is essentially an emissions control system (Figure 1) which utilizes an electronic signal generated by an exhaust gas oxygen sensor to control, precisely, the carburetor air-fuel mixture ratio. This in turn allows the engine to produce exhaust gases of the proper composition to permit the use of a three-way catalyst, a device which can convert all three types of pollutants -- hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx) -- into harmless substances.

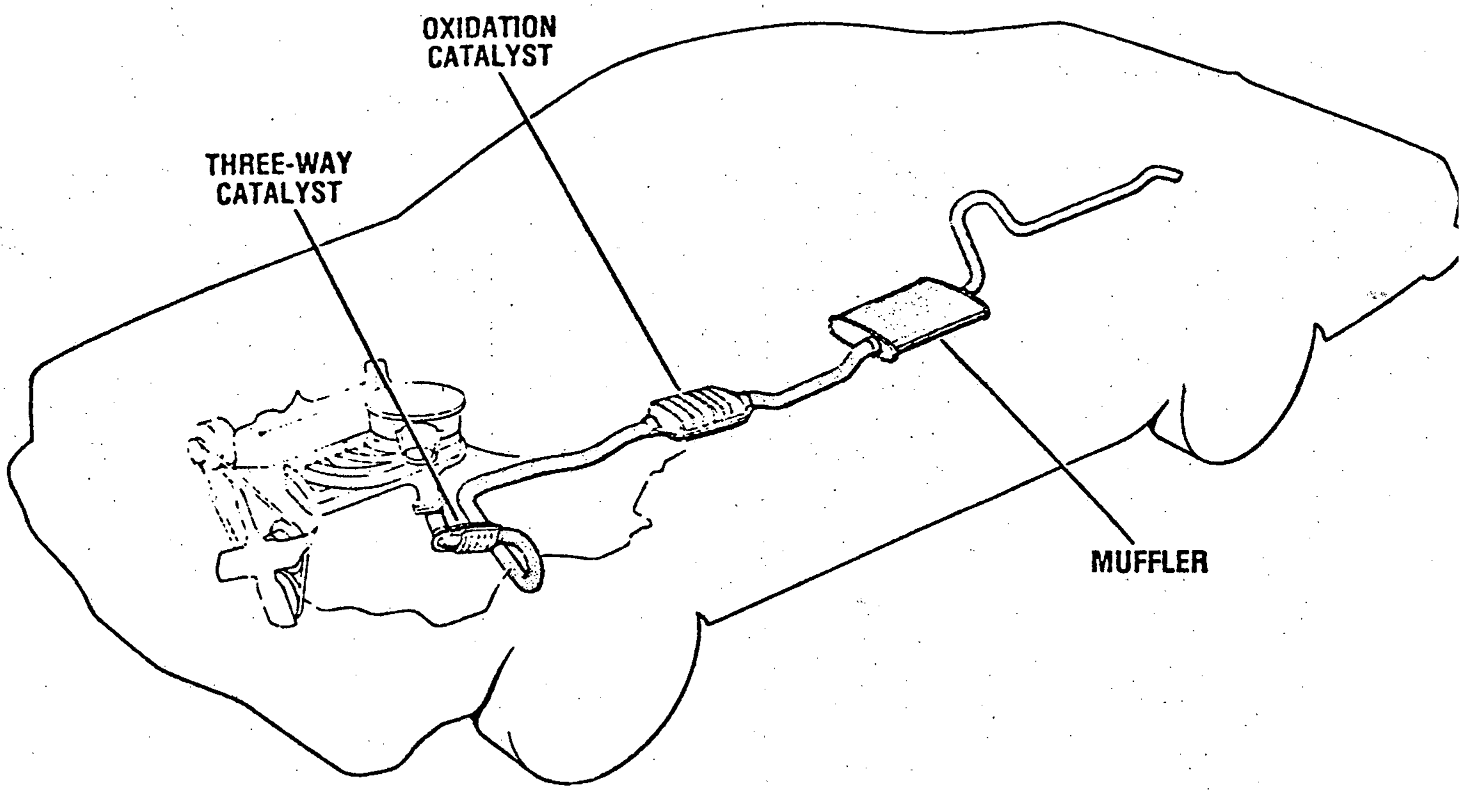
SYSTEM COMPONENTS AND DESCRIPTION

The major components of the EFC system are as follows:

- Dual Catalytic Converters
  - Oxidation catalyst
  - 3-way catalyst
- Oxygen Sensor
- Mileage Counter
- Combustion Computer
- Feedback Carburetor
- Solenoid-Operated Vacuum Regulator Valve

Dual Catalytic Converters

Catalytic converters are devices which decrease HC and CO emissions, or NOx emissions, or all three of these exhaust pollutants. They are muffler-like in appearance and are mounted on the underside of a vehicle as part of the exhaust system. Two converters, mounted in tandem, are used with the EFC system (Figure 2).



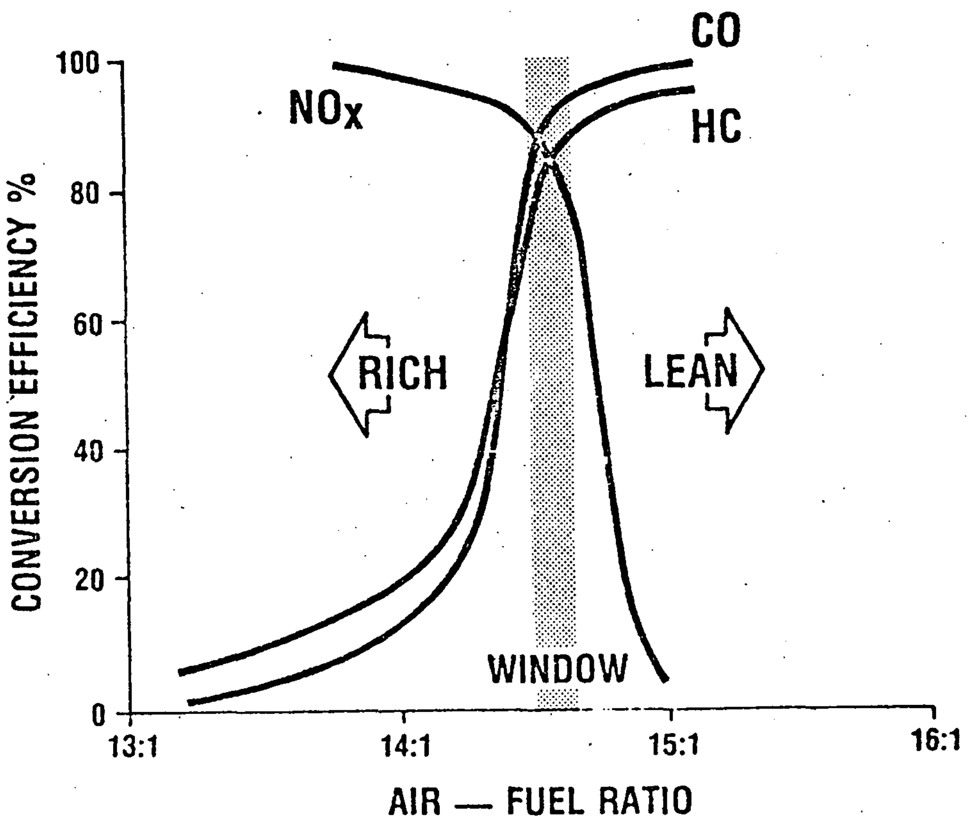
CATALYTIC CONVERTERS

Oxidation Catalyst: The oxidizing catalytic converter contains a platinum-coated, ceramic, honeycombed structure. Through a complex chemical reaction, the platinum stimulates the oxidation (burning) of hydrocarbons and carbon monoxide and converts them to harmless carbon dioxide and water vapor. Effective operation of this type of catalyst requires temperatures of 600°F (315°C) or higher as well as an adequate supply of oxygen in the exhaust gas. Oxidation catalysts in current use will normally "light off" (start oxidizing) within two minutes after the first start of a cold engine.

Three-way Catalyst: Research scientists and catalyst supplier companies determined that by adding rhodium, a rare and costly "noble" metal, the oxidizing converter could also "reduce", or separate, oxides of nitrogen into nitrogen and oxygen, basic components of pure air. This reducing action provides inherently better exhaust emissions control that was obtainable using only exhaust gas recirculation, an oxidation catalyst, or engine modification techniques. Its use also allows richer air-fuel mixtures, more spark advance, and less exhaust gas recirculation -- which collectively improve both driveability and fuel economy.

Effective catalytic control of all three pollutants is possible when the correct balance of excess CO is reached for reduction and excess oxygen is reached for oxidation. It is necessary, therefore, to maintain precise control of the air-fuel mixture entering the engine, keeping it very close to the stoichiometric level (chemically correct for theoretically complete combustion).

Figure 3 shows the characteristics of a three-way catalyst. The curve of efficiency as a function of air-fuel indicates that when the air-fuel ratio is lean (excess of oxygen), the control of HC and CO is very good, but control of NOx is poor. On the other hand, when the air-fuel mixture is rich (deficiency of oxygen), the control of NOx is very good but control of HC and CO is poor. At the chemically correct mixture, a narrow window exists where the control of all three pollutants is quite good. Maintaining the exhaust constituents at this precise value at which the three-way catalyst is most effective is the purpose of the EFC closed loop system.



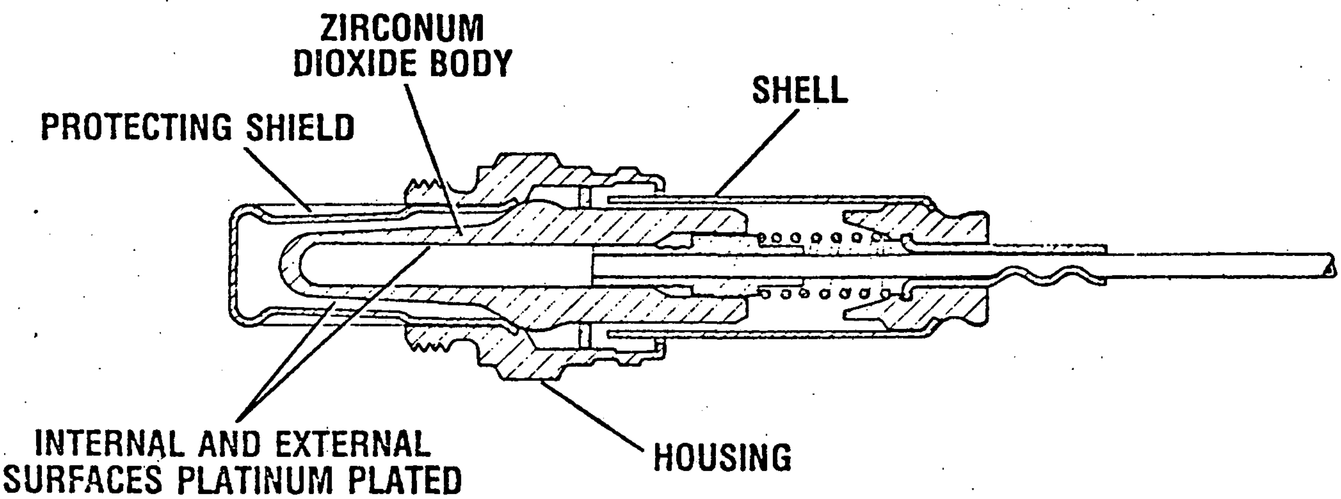
CHARACTERISTIC CONVERSION EFFICIENCIES
THREE-WAY CATALYST

A downstream oxidation catalyst with oxygen supplied by an air pump is used to clean up the remaining HC and CO left after the exhaust gases have passed through the three-way catalytic converter.

Oxygen Sensor

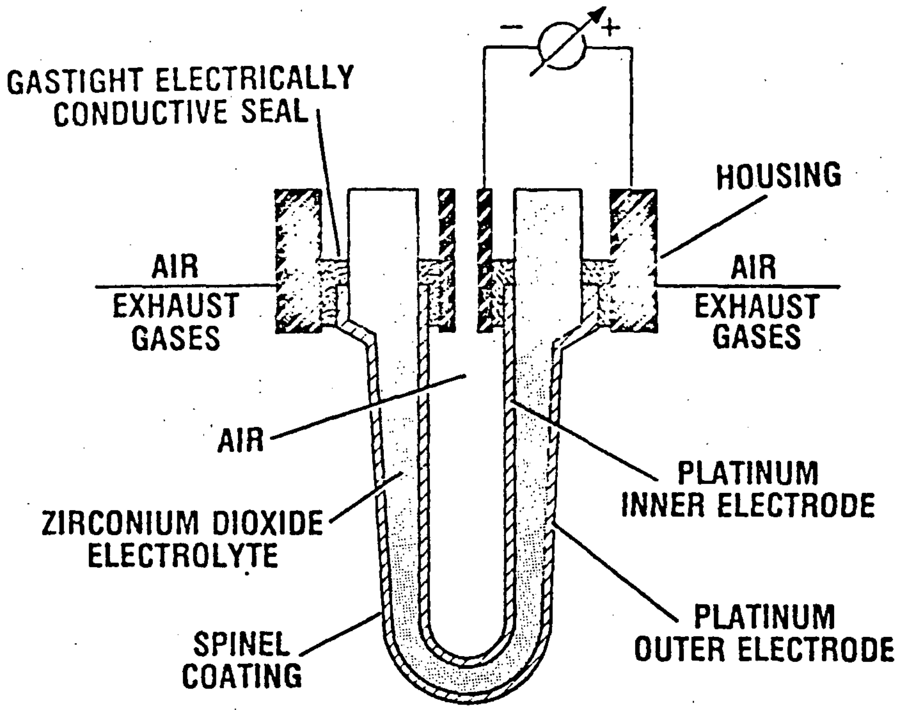
If the air-fuel mixture is just a fraction above or below the ideal ratio, the composition of exhaust by-products will be altered, impairing the efficiency of the three-way catalyst. To provide the EFC system with an indication of the exhaust gas composition, an oxygen sensor (Figure 4) is threaded into the exhaust manifold where it is directly in the exhaust gas stream.

The sensor is a sophisticated device supersensitive to the presence of oxygen. This sensitivity to oxygen is crucial. With an oxygen deficiency in the exhaust gas, outside oxygen diffuses through the sensor, acting as an electrolyte and generating a voltage.

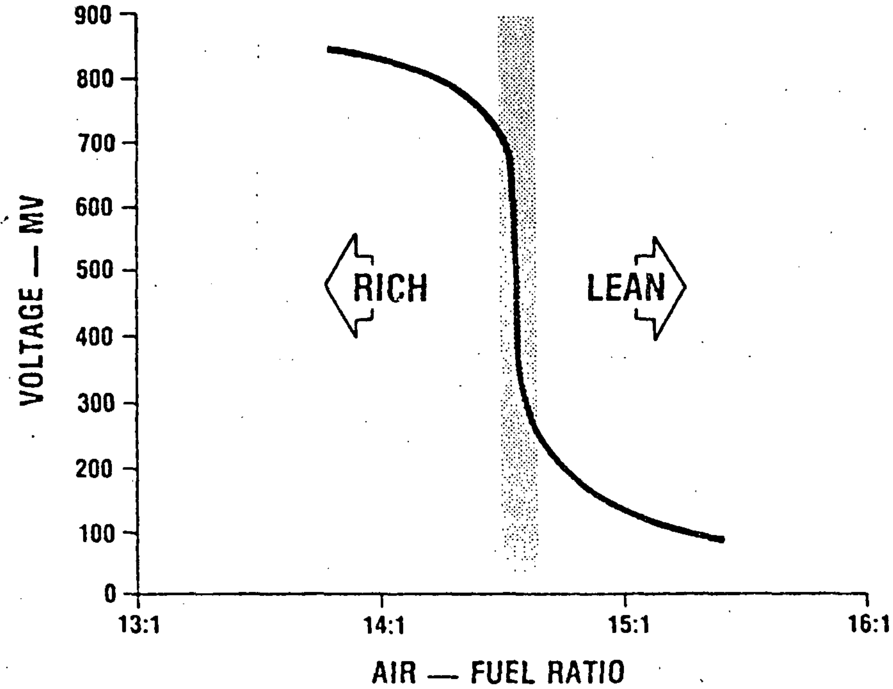


OXYGEN SENSOR

The oxygen sensor is essentially a galvanic battery consisting of a cylindrical electrolyte element of zirconium dioxide which is coated inside and out with platinum. The outer platinum electrode is exposed to the hot exhaust gases while the inner platinum electrode is exposed to the atmosphere (Figure 5). A porous ceramic (spinel) coating protects the fragile platinum against damage.



OXYGEN SENSOR ELEMENT — SCHEMATIC



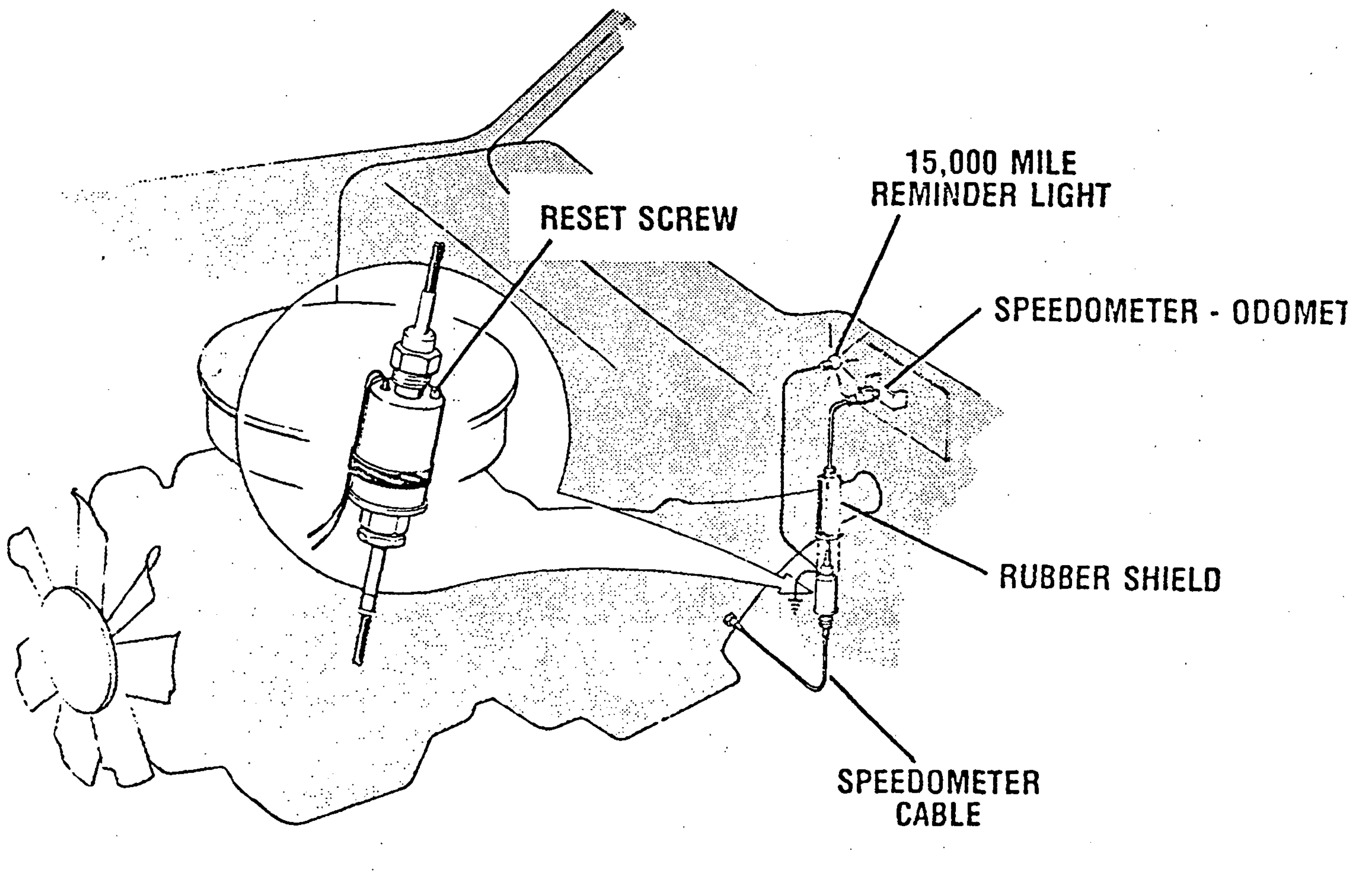
CHARACTERISTIC OXYGEN SENSOR OUTPUT VOLTAGE CURVE

When heated to operating temperature by the hot exhaust gases, the sensor will generate a voltage. When the oxygen content is high (lean mixture), it puts out a low voltage. When the oxygen content is low (rich mixture), the voltage output is high (Figure 6). This relationship between available oxygen and sensor output voltage causes the sensor to function as a rich-lean switch. The sensor output voltage is used by the Feedback Carburetor Controller to calculate and adjust the air-fuel mixture as needed for optimum catalytic converter efficiency.

The sensor's internal impedance, output voltage, and time response are all functions of temperature. This temperature-dependency is an important consideration during cold starts and other low-temperature operating modes.

In addition to the spinel coating which protects the sensor's platinum-coated outer electrode from exhaust gas erosion, a metal shield, louvered to admit exhaust gases, protects the fragile zirconium dioxide body from abrasion by exhaust particulates and from breakage during handling.

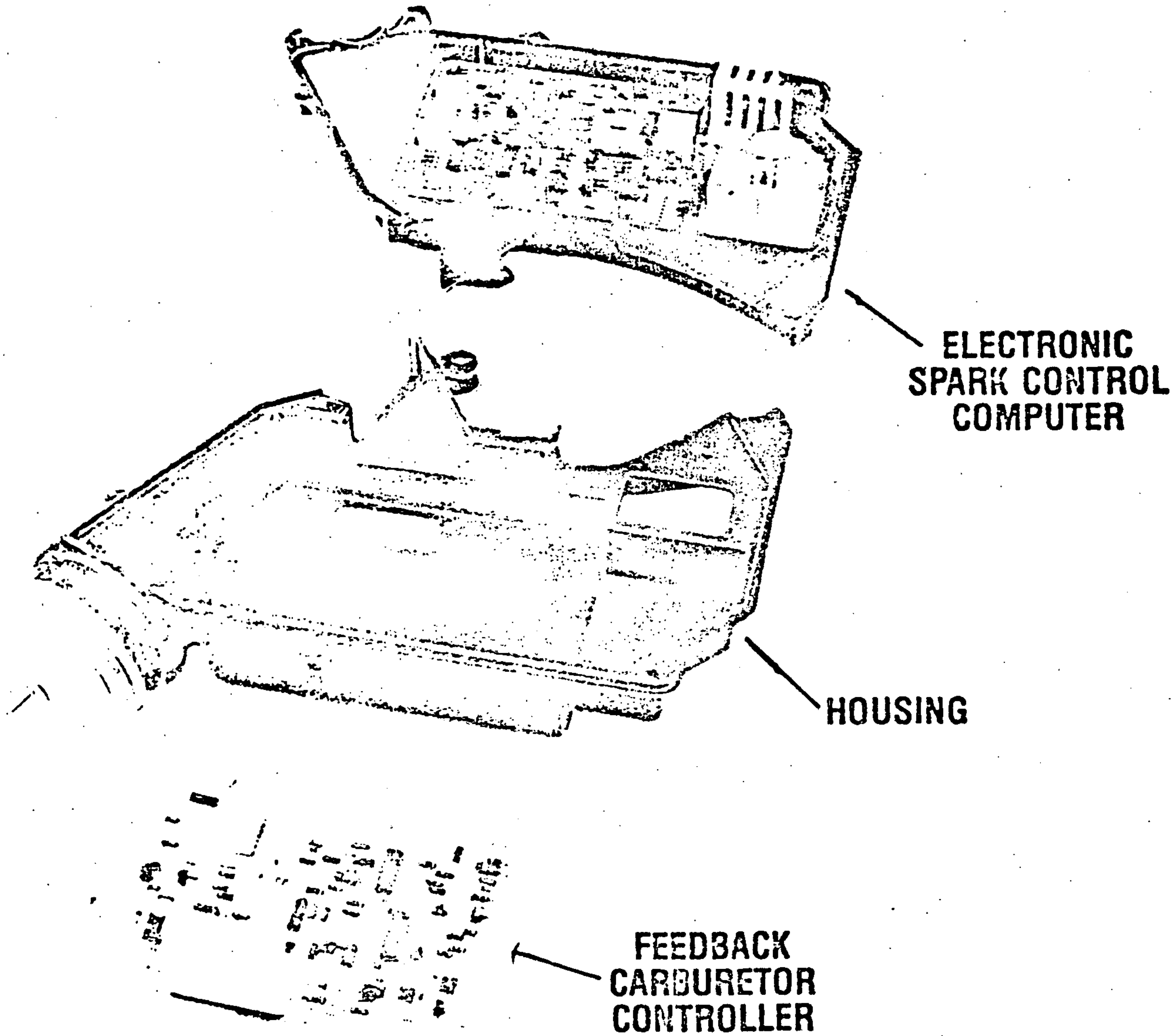
In order to ensure good air-fuel ratio control over the life of the vehicle, the sensor must be changed at 15,000 mile (24 000 km) intervals.



MILEAGE COUNTER

Mileage Counter

A mileage counter (Figure 7) in-line with the speedometer is used to indicate when to replace the oxygen sensor. When 15,000 miles (24 000 km) have elapsed, the counter will actuate an "EFC SYSTEM" instrument panel light. The counter can be reset at the time the sensor is replaced.



COMBUSTION COMPUTER

Combustion Computer with Feedback Carburetor Controller

The Combustion Computer on the air cleaner houses both the Electronic Spark Control Computer and the Feedback Carburetor Controller (Figure 8).

The electronic spark control computer interfaces with the feedback carburetor controller and provides optimum engine ignition timing through electronic control of the spark advance. The feedback carburetor controller is the information processing component of the EFC system. It monitors the voltage generated by the oxygen sensor and receives input signals from sensors reporting engine coolant temperature, manifold vacuum, engine rpm, and engine starting. The controller interprets the various inputs and then transmits the proper output signal to the solenoid-operated vacuum regulator valve, which in turn forwards a signal to the carburetor.

Feedback Carburetor

A single barrel feedback carburetor is used to maintain the air-fuel ratio within the limits required for efficient catalysis in the three-way catalyst. The vacuum signal acts simultaneously on two diaphragms (Figure 9), one for controlling the idle system and the other for controlling the main metering system. The diaphragms control tapered rods which vary the size of orifices to adjust the idle system air bleed and the main metering system fuel flow. These variable controls complement and are used in parallel with a fixed idle air bleed and main fuel metering jet.

A "lean" command from the Feedback Carburetor Controller to the vacuum regulator will result in an increasing vacuum level to the carburetor. This will cause the diaphragm to move the idle air bleed rod upward in its orifice causing increased idle air bleed. Simultaneously, the other diaphragm will move the main metering rod upward in its orifice causing reduced fuel flow. The result from both circuits is a leaner air-to-fuel ratio. On the other hand, a "rich" command will result in a lower vacuum level to the carburetor which will cause the spring-loaded rods to move in the opposite direction and furnish a richer mixture. The range of mixture control is approximately 4 air-to-fuel ratios, 2 rich and 2 lean, or 14.7 ($\pm$ 2.0) to 1. The carburetor is calibrated so that the desired nominal flow is obtained with a vacuum signal of 2.5 inches Hg (8.5 kPa).

Other features of the feedback carburetor include .....

- o A throttle-actuated wide-open-throttle enrichment valve (not shown)
- o An idle mixture screw, concealed within the throttle body to prevent tampering
- o A separate nipple on the throttle body to serve as a source for the air pump diverter valve vacuum signal.

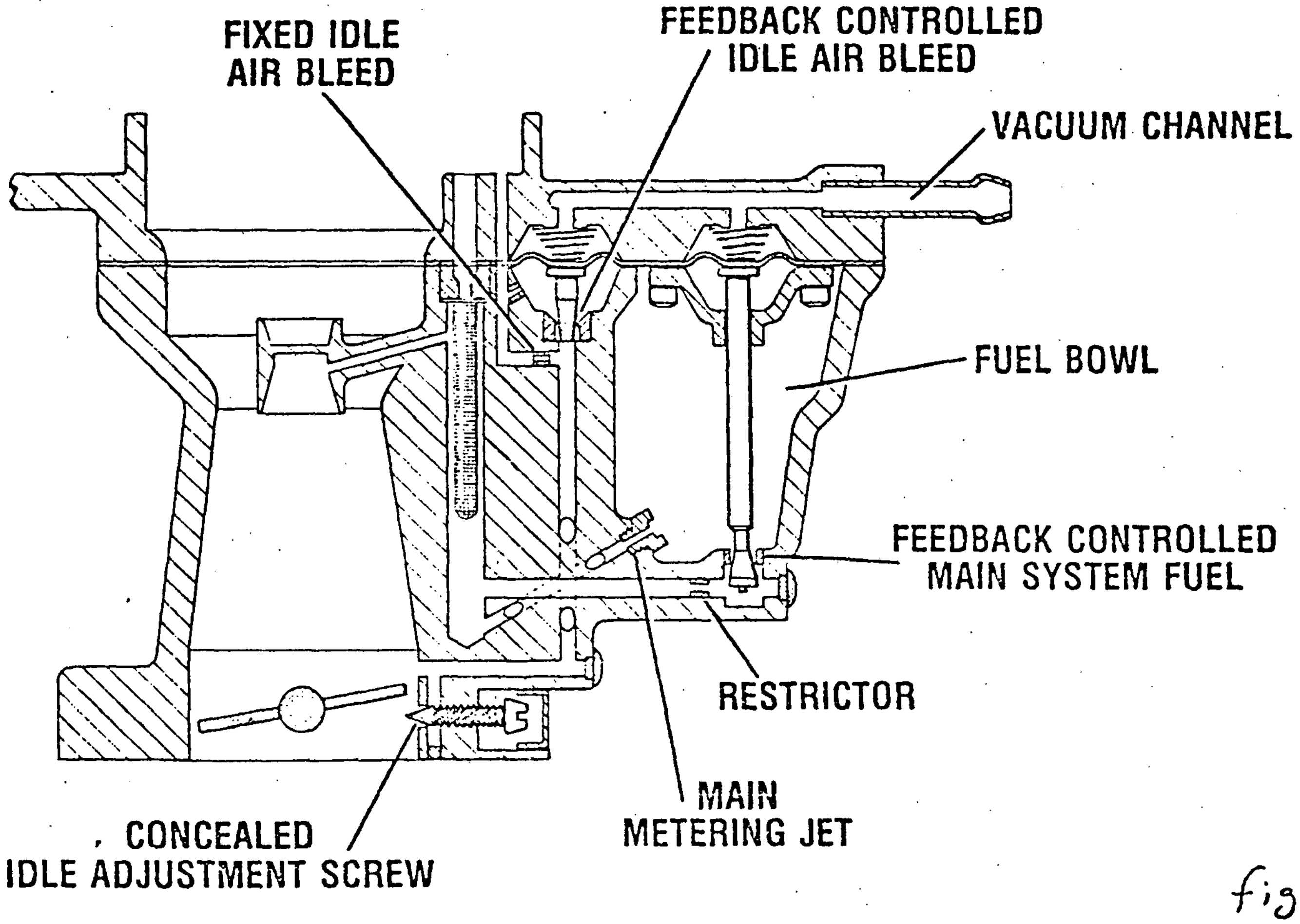
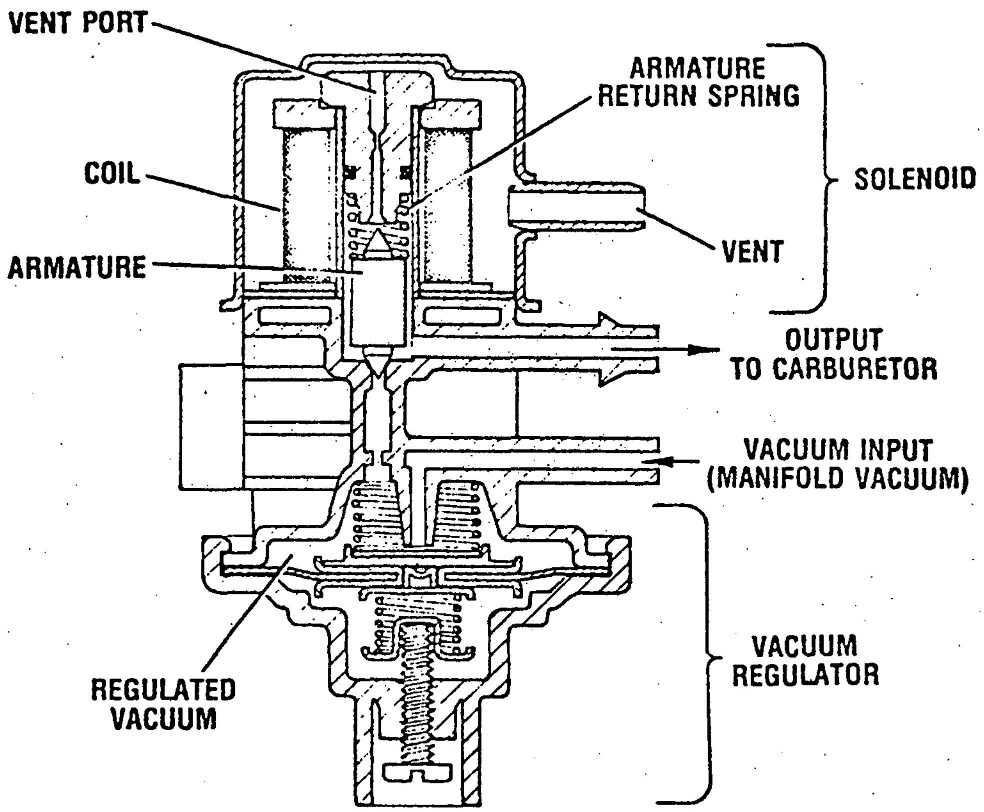


fig. 9

FEEDBACK CARBURETOR



SOLENOID-VACUUM REGULATOR VALVE

Solenoid-Operated Vacuum Regulator Valve

A solenoid-operated vacuum regulator valve (Figure 10) converts the electrical signal from the Feedback Carburetor Controller to a vacuum signal to control the carburetor in maintaining the air-fuel ratio at stoichiometric (14.7:1). Intake manifold vacuum is supplied to the regulator at the lower port, and a regulated 5 inches of mercury (Hg) (17 kPa) is generated within the device. The armature in the electric solenoid at the top of the unit is fitted with a conical tip at each end and functions as a valve. When there is no electrical signal to the solenoid, the spring-loaded armature is held downward as shown to block off the port to the regulated vacuum and open the vent port to atmosphere. When the solenoid is energized, the armature rises off its seat allowing the regulated vacuum signal to pass to the carburetor while simultaneously closing the vent port. The carburetor control vacuum signal can be regulated between 0 and 5 inches Hg by varying the length of time the armature rests in the on (full 5 inches Hg (17 kPa) vacuum) or off (0 inches Hg (0 kPa) vacuum) position. The rapid up-down motion of the armature determines the average vacuum supplied to the carburetor. Control of the ratio of time "on" to time "off" is determined by the feedback carburetor controller through the electrical signal to the solenoid.

SYSTEM OPERATION

Purpose

As was seen earlier (Figure 3), a three-way catalyst is most efficient in controlling HC and CO when the air-to fuel ratio is leanest and there is an excess of oxygen; however, under this condition, control of NOx is poor. On the other hand, when the air-to-fuel ratio is rich and there is a deficiency of oxygen, the control of NOx is good but control of HC and CO is poor. At the chemically correct mixture, a narrow "window" exists about the stoichiometric region (14.7:1 air-to-fuel ratio) where the control of all three pollutants is quite good. Maintaining the exhaust constituents at this precise value at which the three-way catalytic converter is most effective is the purpose of the EFC system.

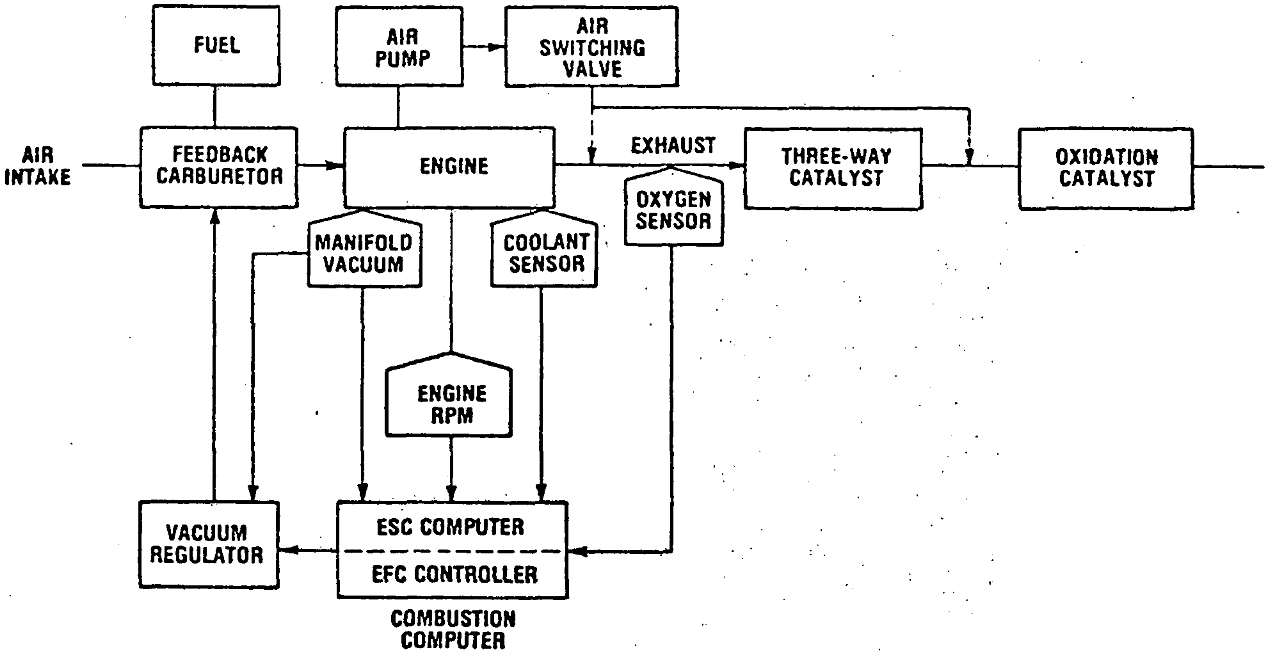
Operating Modes

The EFC system can operate in two distinct modes, open loop and closed loop. During closed loop operation, the system is responsive to exhaust gas oxygen levels as indicated by the oxygen sensor. In the open loop mode, the system operates in response to preprogrammed electronic commands and signals other than those from the oxygen sensor.

Closed Loop Operation

In the closed loop mode, the feedback system is operational and continuously corrects the air-to-fuel ratio toward a stoichiometric mixture. Figure 11 shows a block diagram of sensing and actuating elements that interact to form a loop. Each component is sensitive to the performance of the upstream component and responds by communicating to the down-stream component.

Closed loop operation will not begin until the engine coolant temperature reaches 150°F (66°C). This permits the oxygen sensor and three-way catalyst to warm to operating temperatures.



EFC SYSTEM BLOCK DIAGRAM

At exhaust temperatures over 660°F (350°C), the zirconium dioxide electrolyte allows the passage of oxygen ions from one electrode to the other while blocking the passage of others. The resulting oxygen pressure differential produces a voltage output signal that varies in strength depending on the relative availability of oxygen.

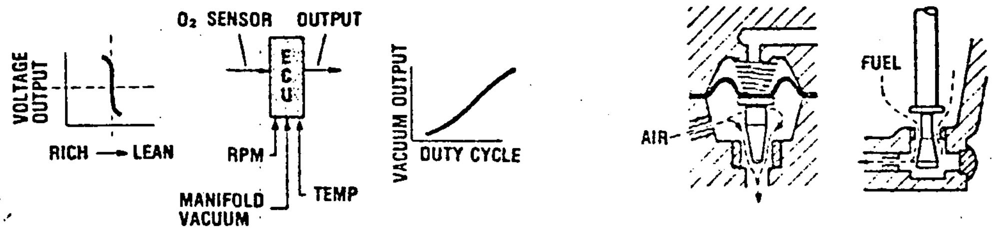
The sensor has the unique property of producing an abrupt change in voltage output precisely when the supply of exhaust gas oxygen departs from the stoichiometric (14.7 tol) air-to-fuel ratio necessary for optimum three-way catalyst efficiency (Figure 6). Because of this characteristic, the sensor output voltage can be used as an indication of when the system is operating richer or leaner than desired.

When the exhaust gas oxygen content is low, as it would be with a rich mixture, the voltage output will be high, indicating a leaner mixture is required. Similarly, a voltage output that is low means the oxygen content is too high and that a richer mixture is needed. Thus, the EFC system does not run at a constant 14.7 to 1 air-to-fuel ratio, but fluctuates closely about it. It constantly corrects to stoichiometric by monitoring sensor voltage signals and issuing "rich" or "lean" commands to drive the system to stoichiometry.

The output voltages from the sensor are evaluated by the controller along with signals from the other system sensors. This processing results in an electrical output signal to the solenoid-vacuum regulator valve. By rapid switching of the solenoid and control of the relative "on" to "off" time, vacuum levels between 0 and 5 inches Hg (17 kPa) can be provided as control vacuum to the carburetor. Figure 12 provides two examples of the chain of events that occurs continuously to drive the air-to-fuel ratio toward a stoichiometric mixture.

An added benefit of the EFC system is its built-in ability to maintain mixture constant at varying altitudes, eliminating the mixture enrichment which normally occurs when a car is driven to higher altitudes.

ENGINE OPERATING CONDITION →	EXHAUST GAS OXYGEN SENSOR OUTPUT →	FEEDBACK CARBURETOR CONTROLLER →	SOLENOID VACUUM REGULATOR VALVE →	VACUUM SIGNAL TO FEEDBACK CARBURETOR →	POSITION OF IDLE DIAPHRAGM →	POSITION OF MAIN SYSTEM DIAPHRAGM →	RESULTANT CORRECTIONS
RICH OF STOICHIOMETRY	HIGH OUTPUT VOLTAGE (>.4 VOLT)	DIRECTS VAC. SOL.-REG. TO GREATER "ON" TIME	INCREASED DUTY CYCLE RESULTS IN HIGHER OUTPUT VACUUM	INCREASING SIGNAL PULLS DIAPHRAGMS UPWARD	HIGHER POSITION FOR INCREASE IN AIR BLEED (INCREASES ORIFICE)	HIGHER POSITION FOR DECREASE IN FUEL FLOW (DECREASES ORIFICE)	TOWARD LEAN
LEAN OF STOICHIOMETRY	LOW OUTPUT VOLTAGE (<.4 VOLT)	DIRECTS VAC. SOL.-REG. TO LESS "ON" TIME	DECREASED DUTY CYCLE RESULTS IN LOWER OUTPUT VACUUM	DECREASING SIGNAL ALLOWS DIAPHRAGM SPRINGS TO MOVE DIAPHRAGMS DOWNWARD	LOWER POSITION FOR DECREASE IN AIR BLEED (DECREASES ORIFICE)	LOWER POSITION FOR INCREASE IN FUEL FLOW (INCREASES ORIFICE)	TOWARD RICH



CLOSED LOOP OPERATING SEQUENCE

Open Loop Operation

The Feedback Carburetor Controller also directs operation of the EFC system during periods when the air-fuel ratio information from the oxygen sensor is interrupted (open loop modes). This occurs under any of the following conditions, as explained below.

- o Coolant temperature below 150°F (66°C)
- o Oxygen sensor temperature below 660°F (350°C)
- o Low manifold vacuum
- o Oxygen sensor default
- o Hot engine starting

During start-up and acceleration, the controller is programmed to ignore signals from the oxygen sensor, allowing the carburetor to produce temporarily richer mixtures for good performance. When the engine is warming up, the air injection system supplies air to the exhaust manifold -- upstream of both catalytic converters -- to provide extra oxygen for more complete burning within the catalytic converter of hydrocarbons and carbon monoxide emissions that tend to develop at lower operating temperatures. (NOx is not a problem at this time since oxides of nitrogen develop only at higher combustion temperatures). This extra burning raises temperatures within the exhaust system and causes the oxygen sensor and three-way catalyst to warm up faster. During this period, the three-way catalytic converter functions as an oxidation catalyst. After the engine is warmed up and oxygen sensor and catalyst operating temperatures are reached, an air switching valve diverts air flow from the exhaust ports to enter the exhaust downstream from the three-way catalyst and just ahead of the oxidation catalyst. At this point, the exhaust is hot enough to oxidize the unburned HC and CO. Again, the addition of injected air is required in the oxidation process.

Low-Vacuum Sensor: Upon acceleration with a cold engine, if the throttle is open sufficiently so that manifold vacuum drops below 4.5 inches Hg (15 kPa), a vacuum signal will be supplied to the Feedback Carburetor Controller which will enrich the air-fuel mixture even further to prevent engine stalls, sags, or stumbling and enhance driveability. After the engine has warmed up and the system is under the control of the oxygen sensor (closed loop mode), the system will revert to the open loop mode whenever the manifold vacuum drops below 3 inches Hg (10 kPa). This signal is to assure a sufficiently-rich mixture for power and performance when accelerating from cruising speeds. After acceleration, manifold vacuum will return to a higher level and closed loop operation will resume. Different vacuum signal values are used during open and closed loop modes because less enrichment is required for acceleration when fully warmed up than for acceleration during warm-up.

Coolant Temperature Sensing Switch: A coolant temperature sensing switch, located in the cylinder head, electrical circuit to the Feedback Carburetor Controller when engine coolant reaches a temperature of $150^{\circ}F$ ($66^{\circ}C$). At this point, the oxygen sensor is sufficiently warm to start functioning. When this occurs, operation begins in response to signals from the sensor.

Open loop operation terminates when there is sufficient vacuum and the engine coolant and oxygen sensor are at their proper operating temperatures. It may happen, however, under prolonged idle at low ambient temperatures that the oxygen sensor may cool off enough so that it will not function properly. This condition will be detected electronically from the sensor and the system will compensate accordingly until the sensor is again warm. The sensor will warm up very quickly once the car is accelerated away from idle.

DIAGNOSTICS

The following test equipment is needed for diagnosis of the EFC system:

- o Vacuum gauge - 0-5" Hg (accurate within ± 1/2" in that range)
- o Vacuum gauge - 0-30" Hg
- o Hand pump with vacuum gauge
- o Two short length of 3/16" I.D. vacuum tubing
- o Two 3/16" tee
- o Jumper wire (approximately 5 feet)

In general a malfunction of the EFC system can be diagnosed by observing the action of a vacuum gauge connected so as to observe the control vacuum from the solenoid-regulator to the carburetor.

A malfunction of the EFC system can cause such problems as:

- o Surge
- o Hesitation
- o Rough Idle
- o Poor Fuel Economy

The following checks should be made prior to performing any diagnostic tests:

- o Check all vacuum hoses for proper hook up. (Refer to hose routing label located underhood) and for kinks or other damage.
- o Check all electrical connections and for frayed, cracked or broken wiring. Refer to wiring diagram.
- o Check the intake and exhaust manifolds for leakage.

Determining the Problem

With the vehicle fully warmed-up, the 0-5" Hg vacuum gauge is teed into the control vacuum signal to the carburetor. The vehicle is started and allowed to idle while the vacuum gauge is observed. The gauge should indicate a steady 2.5" Hg reading for approximately 100 seconds after starting, drop to 0", and then gradually rise to between 1.0 and 4.0" Hg average. The reading will oscillate about ± 0.5" Hg.

If the gauge does not indicate in the above area, the engine speed should be raised to approximately 2000 rpm and the reading observed again. If the reading is between 1.0 and 4.0" Hg, the engine should be returned to idle to determine if the reading there is now between 1.0 and 4.0" Hg. If the reading at idle is within the proper range, it indicates the oxygen sensor was not fully warmed originally and the system is operating properly and other areas should be checked to resolve the complaint.

If the gauge reads in the proper range at 2000 rpm and does not at idle, it means the idle mixture is out of adjustment and the carburetor must be replaced.

The following procedures should be undertaken to determine the cause of the problem if the control vacuum is above 4" Hg or below 1.0" Hg. It should be noted that for most system malfunction conditions the control vacuum is typically at either 0" Hg or 5" Hg.

CONTROL VACUUM ABOVE 4" Hg

If in the previous tests the control vacuum was consistently above 4" Hg, the problem could be found in the following components:

- o Carburetor
- o Carburetor Heat Shield
- o Solenoid - Regulator
- o Combustion Computer
- o Oxygen Sensor

The engine is started and with the transmission in Neutral, the throttle is placed on the next to the lowest step of the fast idle cam. The following steps are then taken to determine the cause of the problem.

STEP 1

Carburetor

Since a high control vacuum indicates that the system is trying to correct for a rich mixture, the following test should be made to determine if the mixture is in fact too rich. Remove the PCV hose from the PCV valve and cover the end with your thumb. Gradually uncover the end of the hose until the engine begins running roughly indicating a very lean mixture. If the control vacuum to the carburetor gradually gets lower as more of the PCV hose is uncovered, it indicates the carburetor was too rich and the carburetor should be replaced; however, step 2 should be completed before the carburetor is replaced. If the control vacuum remains high, the problem is in another area of the system.

STEP 2

Carburetor Heat Shield

Prior to replacing the carburetor as indicated by Step 1, an inspection should be made to determine if an interference exists between the carburetor heat shield and the mechanical power enrichment valve actuating lever at the rear of the carburetor. If there is an interference, it will cause the carburetor to be too rich.

> A new heat shield has been released for 1979 model year. This was done to provide clearance for the mechanical power enrichment lever and the throttle position transducer actuating lever. The earlier heat shield is not recommended but could be used if modified for clearance.

STEP 3

Solenoid - Regulator

Disconnect the electrical connector to the device. The control vacuum to the carburetor should drop to zero. If it does not, replace the solenoid - regulator.

STEP 4

Combustion Computer

Disconnect the oxygen sensor wire and with a jumper wire connect the harness lead to the battery negative terminal.

CAUTION: DO NOT CONNECT THE WIRE FROM THE OXYGEN SENSOR TO BATTERY OR GROUND.

The control vacuum should gradually lower to 0" in about 15 seconds. If it does not, replace the computer. If it does, replace the oxygen sensor.

NOTE: Prior to replacing computer or sensor, make sure wire between the two is okay.

CONTROL VACUUM BELOW 1.0" Hg

If in the preliminary tests the control vacuum was consistently below 1.0" Hg, the problem could be found in the following areas:

- Lack of vacuum to the computer vacuum transducer
- Carburetor
- Air switching system
- Solenoid - Regulator
- Wiring Harness
- Combustion Computer
- Oxygen Sensor

STEP 1

Lack of Vacuum to Computer Vacuum Transducer

With engine at idle Neutral, disconnect the vacuum hose at the computer transducer and connect the hose to a vacuum (0-30" Hg) gauge. The gauge should read manifold vacuum (in excess of 12" Hg). If it does not, trace the hose to its source and then connect it properly (to a source of manifold vacuum).

The remaining steps should be performed with the transmission in Neutral and the throttle on the next to the lowest step of the fast idle cam, parking brake applied.

STEP 2

Carburetor

Since a low control vacuum is indicative of the system trying to correct for a lean mixture, the following test should be made to determine if the mixture is in fact too lean. The air cleaner cover is removed and the choke blade is gradually closed until the engine begins running roughly thus indicating a very rich mixture. If the control vacuum to the carburetor gradually increases to 5" Hg as the choke is closed, it indicates either the carburetor was too lean or the air switching system was not functioning properly (go to Step 3). If the control vacuum remains low, it indicates the problem is in another area of the system (go to Step 4).

STEP 3

Air Switching System

Disconnect the air injection hose at the metal tube that leads to the rear of the cylinder head and plug the tube. If the control vacuum remains below 1.0" Hg, replace the carburetor. If the control vacuum returns to the proper range, reconnect the air injection hose and disconnect the 3/16" vacuum hose from the air switching valve. If the control vacuum remains below 1.0" Hg, replace the air switching valve. If the control vacuum returns to the proper range, check the vacuum hose routings for proper connections and if the connections are correct, replace the vacuum coolant switch (CCVES).

STEP 4

Solenoid - Regulator

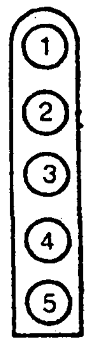
> Before testing the solenoid - regulator, verify that the bottom nipple is connected to the manifold vacuum.

Disconnect the electrical connector to the solenoid - regulator. Connect a jumper wire from the positive terminal of the battery to one terminal of the solenoid - regulator lead. Connect the other terminal of the solenoid - regulator lead to ground. The control vacuum should go above 5" Hg. If it does not, replace the solenoid - regulator. If it does, go to Step 5.

STEP 5

Wiring Harness

Disconnect the 5-way connector at the computer. Connect a jumper wire from terminal 2 in harness to ground. The control vacuum should go to 5" Hg. If it does not, trace the wire back to the battery to find where the voltage is lost. If it does, go to Step 6.



NOTE: Almost all problems associated with the wiring harness will be caused by the connectors. Make sure connectors are firmly snapped in place and there is no corrosion or frayed wires causing poor contact.

STEP 6

Combustion Computer

Disconnect the oxygen sensor wire and with a jumper wire, connect the harness lead to the battery positive terminal.

CAUTION: Do not connect the wire from the oxygen sensor to battery or ground.

The control vacuum should gradually rise to 5" Hg in about 15 seconds. If it does not, replace the computer. If it does, replace the oxygen sensor.

OXYGEN SENSOR - Removal and Installation

Removal

Disconnect battery cable, remove air cleaner. Disconnect oxygen sensor connector. Remove sensor using Special Tool C-4589.

Inspection

Inspect wire and connector for signs of degradation. If insulation is frayed to extent that connector or terminal is visible, replace sensor. Inspect water splash shield which is a metal band running around the upper portion (sleeve) of the sensor and covers the vent holes. If splash shield is not intact, replace sensor.

Installation

Coat threads of sensor with a nickel base anti-sieze compound such as Loctite LO-607 or Never Seez NSN, or equivalent. Do not use graphite or other type compounds as these could electrically insulate the sensor from the manifold. Start sensor by hand and torque to (35 $\pm$ 5 foot-pounds) using Special Tool C-4589. Install air cleaner assembly. Reconnect battery cable.

CARBURETOR SPECIFICATIONS

Accelerator Pump	1-3/4"
Dry Float Setting (± 1/32")	Flush with top of bowl cover gasket
Bowl Vent	1/16"
Vacuum Kick	.150"
Fast Idle Cam	.080"
Choke Unloader	.250"
Basic Timing	15° BTDC
Idle set speed	750
Fast Idle Speed	1800

IGNITION TIMING PROCEDURE

1. Ground the carburetor switch with a jumper wire.

2. Connect a suitable timing light to ignition system.

3. Start the engine.

4. Wait one minute after step 3.

5. With the engine running at a rpm not greater than the specified curb idle rpm, adjust timing to specifications.

6. Remove ground wire and timing light.

CURB IDLE SET PROCEDURE*

1. Start and run engine in Neutral on the second step of the fast idle cam until thermostat is open (engine fully warmed up) and the radiator becomes hot. This may take 5-10 minutes.

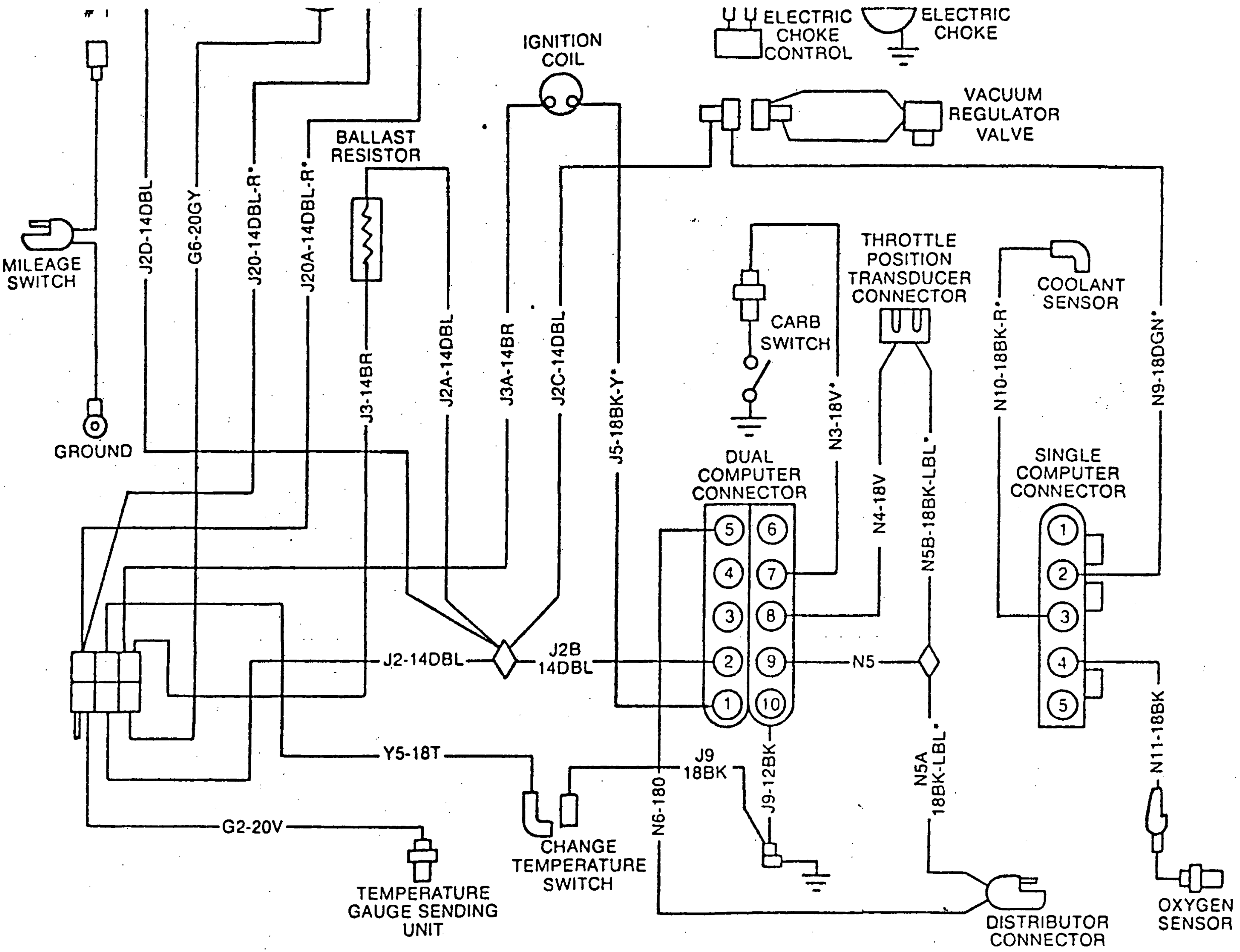
2. Disconnect and plug the EGR hose at the EGR valve.

3. Ground carburetor switch with a jumper wire.

4. Adjust the idle rpm in Neutral to the curb idle rpm specification located on the Vehicle Emission Control Information Label.

5. Reconnect the EGR hose and remove jumper wire from the ground switch.

*Only after timing is known to be within specification.


IGNITION COIL
ELECTRIC CHOKE CONTROL
ELECTRIC CHOKE
VACUUM REGULATOR VALVE
BALLAST RESISTOR
MILEAGE SWITCH
GROUND
J2D-14DBL
G6-20GY
J20-14DBL-R*
J20A-14DBL-R*
J3-14BR
J2A-14DBL
J3A-14BR
J2C-14DBL
J5-18BK-Y*
CARB SWITCH
N3-18V*
THROTTLE POSITION TRANSDUCER CONNECTOR
N4-18V
N5B-18BK-LBL*
COOLANT SENSOR
N10-18BK-R*
N9-18DGN*
DUAL COMPUTER CONNECTOR
SINGLE COMPUTER CONNECTOR
J2-14DBL
J2B 14DBL
N5
Y5-18T
J9 18BK
J9-12BK
N6-180
N5A 18BK-LBL*
N11-18BK
G2-20V
TEMPERATURE GAUGE SENDING UNIT
CHANGE TEMPERATURE SWITCH
DISTRIBUTOR CONNECTOR
OXYGEN SENSOR

No. 14-05-79

COMPONENT IDENTIFICATION
(EMISSION RELATED)

ITEM	IDENTIFICATION NUMBER*
Air Pump Pulley	
with Chrysler A/C	4173221
with Sankyo A/C	4071720
without A/C	4071720
Air Switching/Diverter Valve	4105053
Carburetor (Holley R-8286A)	4095909
CCEVS Switch	4006587
Choke Assembly	4095336
Charge Temperature Switch	4111482
Distributor	4091490
EGR Vacuum Amplifier	4041732
EGR Valve	
All except wagons	4104009
Wagons	4104008
Electric Choke Control	4091036
Emission Control Information Label	4173883
Combustion Computer	4111373
Coolant Switch	4091719
Spark Plugs	4091678 (RBL-16Y)
EGR Timer	4111481
Vacuum Hose Routing Label	4173258
Vacuum Solenoid	3874027
Vapor Canister	3577595

*This number is located on either a label or stamped into part. It does not represent a service replacement number. Refer to the appropriate Parts Catalog for this information.

		FTP (gms/mile)					Raw (ppm/%)		HFET (gms/mile)					Raw (ppm/%)		NYCC (gms/mile)					Raw ppm/%		
Date	Test Number	HC	CO	CO_2	NOx	F.E.	HC	CO	HC	CO	CO_2	NOx	F.E.	HC	CO	HC	CO	CO_2	NOx	F.E.	HC	CO	Test Comments
6-29-79	79-8148,49	.40	4.5	527	.91	16.6	65	.02	.067	.276	415.3	1.848	21.3	55	.025	.907	4.111	831.6	.550	10.5	49	.16	B/L
7-2-79	79-8150,51	.41	3.7	518	.89	16.9	60	.02	.070	.286	414.6	1.967	21.4	40	.02	.898	3.745	829.2	.630	10.6	90	.022	B/L
7-3-79	79-8152,53	.34	3.3	507	1.39	17.3	28	.03	.079	.121	404.6	3.566	21.9	25	.02	1.090	8.340	817.25	.533	10.6	43	.016	EGO Sen. Disc.
7-9-79	79-8154,55	.40	1.9	494	1.15	17.8	85	.03	.066	.199	408.7	2.059	21.7	35	.02	.889	2.996	829.17	.726	10.6	75	.02	CTS Disc.
7-10-79	79-8156,57	.62	7.6	551	.60	15.7	33	.04	.050	2.134	490.5	.725	18.0	18	.02	1.084	21.013	927.65	.511	9.2	42	.06	Sol. Vac. Reg. Disc.
7-11-79	79-8158,59	1.03	29.8	473	.40	17.0	230	.09	.082	5.543	396.8	1.185	21.9	120	.7	1.838	33.818	784.3	.664	10.5	250	.65	A.I. Bypassed
7-13-79	79-8160,61	.40	3.7	504	1.81	17.4	50	.03	.057	.136	419.9	5.834	21.1	20	.03	.691	2.572	830.4	1.378	10.6	50	.04	EGR Disc.
7-16-79	79-8162,63	.43	3.7	521	.89	16.8	30	.03	.063	.174	405.5	2.021	21.8	15	.02	.644	2.959	860.6	.748	10.2	60	.04	B/L

		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 Numbers	52 mph		25 mph		Idle (Drive)		Idle (Neutral)		30 mph		Idle (Neutral)		Test Comments
6-29-79	79-8148, 49	10/.02	10/.02	15/.02	15/.018	20/.01	20/.011	30/.01	28/.016	10/.02	10/.02	15/.02	30/.011	B/L
7-2-79	79-8150, 51	10/.018	10/.018	15/.02	12/.02	25/.018	20/.011	43/.018	30/.01	11/.016	10/.017	25/.015	28/.014	B/L
7-3-79	79-8152, 53	12/.025	22/.035	18/.05	22/.055	22/.04	22/.055	22/.04	33/.055	25/.05	22/.055	20/.02	22/.055	EGO Sen. Disc.
7-9-79	79-8154, 55	10/.02	10/.02	10/.02	10/.02	15/.02	25/.02	60/.02	30/.02	10/.02	10/.02	35/.02	25/.015	CTS Disc.
7-10-79	79-8156, 57	10/.15	12/.15	10/.06	12/.06	30/.04	25/.02	35/.02	30/.02	18/.07	18/.07	25/.02	30/.02	Sol. Vac. Reg. Disc.
7-11-79	79-8158, 59	15/.25	12/.17	13/.45	12/.35	85/.60	175/.70	200/.80	250/.75	18/.33	12/.25	110/.55	70/.50	A.I. Bypassed
7-13-79	79-8160, 61	10/.05	10/.03	10/.04	10/.04	50/.05	25/.03	80/.05	70/.04	10/.04	10/.04	70/.04	35/.03	EGR Disc.
7-16-79	79-8162, 63	10/.04	10/.03	10/.03	10/.03	20/.03	18/.025	35/.03	35/.03	10/.03	10/.03	35/.03	25/.02	B/L

Note: HC values in ppm Hexane.
CO values in percent.

Attachment 4

Date	Test Number	Two Speed Idle Cycle						Abbreviated I/M Idle Cycle				Test Comments
		HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	
		Neutral		2500 rpm		Idle (Neutral)		Idle (Neutral)		Idle (Neutral)		
6-29-79	79-8148, 49	40/.016	40/.018	10/.02	15/.02	55/.13	45/.016	35/.02	50/.02	45/.10	30/.02	B/L
7-2-79	79-8150, 51	28/.015	27/.016	12/.017	12/.020	22/.017	20/.012	30/.018	22/.010	22/.018	24/.010	B/L
7-3-79	79-8152, 53	28/.02	38/.05	22/.025	18/.04	90/.03	38/.04	30/.03	42/.04	35/.03	50/.05	EGO Sen. Disc.
7-9-79	79-8154, 55	30/.1	25/.02	10/.02	10/.02	45/.02	25/.02	50/.02	35/.02	35/.02	30/.02	CTS Dis.
7-10-79	79-8156, 57	30/.02	30/.02	25/.09	20/.9	40/.03	40/.02	40/.03	40/.02	40/.03	40/.02	Sol. Vac. Reg. Disc.
7-11-79	79-8158, 59	130/.55	150/.60	15/.45	15/.35	140/.80	80/.45	140/.80	80/.45	150/.77	90/.50	A.I. Bypassed
7-13-79	79-8160, 61	60/.04	55/.04	10/.04	10/.04	40/.03	30/.03	40/.03	30/.03	40/.04	30/.03	EGR Disc.
7-16-79	79-8162, 63	30/.03	30/.025	10/.03	10/.03	25/.02	30/.02	25/.02	30/.02	30/.03	30/.025	B/L

Note: HC values in ppm Hexane.
CO values in percent.

Prolonged Idle Cycle HC/CO

Date	Test Number	Int.	1	2	3	4	5	6	7	8	9	10	Test Comments
6-29-79	79-8148, 49	20/.02	30/.02	35/.02	50/.02	55/.02	60/.02	85/.02	80/.02	70/.02	80/.02	65/.02	B/L
7-2-79	79-8150, 51	20/.011	22/.017	25/.017	35/.018	30/.018	50/.018	45/.018	50/.012	50/.016	50/.015	50/.015	B/L
7-3-79	79-8152, 53	50/.05	38/.03	44/.03	44/.03	40/.02	58/.02	58/.02	45/.02	50/.02	53/.02	70/.02	EGO Sen. Disc.
7-9-79	79-8154, 55	40/.02	50/.02	60/.02	70/.02	75/.02	100/.02	85/.02	110/.02	80/.02	110/.02	95/.02	CTS Disc.
7-10-79	79-8156, 57	40/.02	35/.02	38/.005	40/.05	40/.07	40/.07	45/.07	45/.07	40/.08	42/.09	42/.09	Sol. Vac. Reg. Disc.
7-11-79	79-8158, 59	100/.60	200/.65	175/.60	225/.60	240/.55	185/.55	230/.65	250/.50	250/.60	250/.60	250/.60	A.I. Bypassed
7-13-79	79-8160, 61	30/.03	55/.04	60/.04	70/.04	80/.04	80/.04	100/.05	110/.05	95/.04	100/.05	90/.04	EGR Disc.
7-16-79	79-8162, 63	30/.025	30/.03	40/.04	45/.04	65/.04	60/.04	60/.04	75/.04	90/.05	100/.045	100/.045	B/L

Attachment 5

☆ U.S. GOVERNMENT PRINTING OFFICE: 1979- 651-112/0070