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Evaluation of the Applicability of Inspection/Maintenance Tests On A Chevrolet Camero Z-28

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ABSTRACT

This report presents test results which were gathered to determine the suitability of existing I/M short tests on a Chevrolet car with a computer based emission control system. This car had a microprocessor based engine control system with a dual bed catalyst . After suitable baslines were established, various components were made inoperative in the emission control system. Complete FTP, HFET and I/M tests were run for each vehicle condition. Also an on-board system diagnostic check was performed for each configuration after the initial baselines.

This report presents the measured data taken during the tests.

BACKGROUND

Beginning with the 1981 model year, 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 Inspection/Maintenance programs be capable of identifying 1981 and later model year vehicles with equipment failure and parameter maladjustment. With the advent of the use 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 and early production cars containing representative electronics of the future have been tested according to both the Federal Test Procedures and I/M test procedures. The data obtained should indicate which I/M test best suits these automobiles. This report presents the data collected on the fifth such automobile tested by EPA, a 1981 Chevrolet Camaro Z-28 with a microprocessor controlled emission control system.

HISTORY

The Chevrolet Camaro Z-28 is a 1981 production vehicle purchased by EPA from a local Chevrolet dealer. This particular vehicle, which has a Federal emission package, was delivered to EPA on 1 October 1980 with 30 miles on the odometer. Break-in mileage was accumulated utilizing repeated LA-4 and HFET cycles in a ratio of about 4 LA-4's per HFET. Since this vehicle was originally procured for use in a different long term EPA test project which was on a very tight timetable, the decision was made to accomplish the I/M test project with relatively few miles on the vehicle. At 233 accumulated miles, I/M baseline testing started.

After two baseline sequences were run, the vehicle was tested with seven different component deactivations. Two final confirmatory baseline sequences were then run. The testing was completed on 5 November 1980.

TESTING PROCEDURE

In order to test the vehicle the following test sequence was used:

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

b. 50 MPH Cruise. This test consists of a three minute steady state run at 50 MPH. HC and CO measurements are taken with a garage type analyzer. This test is performed with the hood open and fan on. The three minute 50 MPH cruise also serves as preconditioning for the highway fuel economy test.

c. Highway Fuel Economy Test (HFET). Immediately after the 50 MPH cruise.

Each of the following steps required a six minute idle preconditioning, hood open, fan on.

d. Four Mode Idle Test with raw HC/CO garage type analyzer. Emissions were tested at Idle (neutral), 2500 rpm, Idle (neutral), and Idle (drive). The hood was open and the fan was on.

e. Loaded Two Mode. Raw HC and CO measurements were taken with the dynamometer set at 9.0 A.H.P. at 30 MPH with the I.W. = 1750 pounds. Immediately afterward, measurements were taken at idle (neutral) using a garage type analyzer. The hood was open and the fan was on.

f. Propane Injection Procedure for three way catalyst vehicles. A description of this test and a sample data sheet are given in Attachment 1.

Note: This propane injection procedure is still in the development stage. Some difficulties were encountered by the technicians in applying this test to this vehicle. In some tests tachometer fluctuations mask the theoretically expected results. Bear in mind when reviewing the obtained data that this is still an experimental procedure.

g. On-Board System Diagnostic Check. This check took advantage of the on-board self-diagnostic system used on 1981 GM products. See Attachment 3 for a description of the system.

I/M test HC and CO measurements were recorded before and after the dual bed catalyst. A worksheet recording the I/M test results is shown in Attachment 2.

VEHICLE DESCRIPTION

The Chevrolet Camaero Z-28 used for this testing was a production vehicle with a Federal Emission Package. The most important components of this automobile's emission control system were the sensors, actuators, and the microprocessor unit. A complete description of these components is given in Attachment 3. Attachment 4 lists specific vehicle parameters.

BASELINE DATA

To accurately determine the effect of the various component deactivations, it was necessary to have an accurate baseline determined for each pollutant in each mode of every test type. This baseline data is displayed with the component deactivation data.

TEST CONFIGURATIONS

After the baseline testing was completed, various components of the emission control system were, one by one, deactivated prior to vehicle testing.

Configurations a, b and c were run with power to the air control solenoid interrupted in addition to the listed system disablements. Computer control of this solenoid is accomplished by switching the ground side of this solenoid.1/

This malfunction may be realized in several ways. The malfunction may be induced by deliberate tampering, by improper maintenance i.e. pulling on wires to disconnect an electrical connection may result in an open circuit, or by computer failure. The former cases will not be sensed by the computer. The latter case may be indicated in the diagnostic check dependent on the computer failure mode.

a. Mixture control solenoid disconnected - Test numbers 80-6335 and 80-6336 were run with the mixture control solenoid (MCS) disconnected. When the system is operating properly, this solenoid oscillates at the duty cycle determined by the microprocessor. The duty cycle determines the fuel/air ratio. With this device deactivated the system defaults to a full rich condition.

b. Coolant temperature sensor disconnected - Test numbers 80-6337 and 80-6338 were run with the coolant temperature sensor (CTS) disconnected. Because the oxygen sensor does not perform properly until it reaches a specified temperature, the coolant sensor informs the feedback control system to operate in open-loop mode until temperature is reached. With the CTS disconnected the system runs in an open-loop, cold mode.

c. Throttle position sensor disconnected - Test numbers 80-6339 and 80-6340 were run with the throttle position sensor (TPS) electrically disconnected. This sensor provides the microprocessor with information regarding the throttle blade angle. Disconnecting this device gives a fixed throttle input to the microprocessor.

The remaining configurations were run with power to the air control solenoid enabled. This provides normal microprocessor-controlled air routing which routes the secondary air to the air cleaner during any perceived system failure. With the secondary air system functioning normally, the ultimate destination of secondary air is the same as for other GM systems with a different air routing configuration given a similar set of computer inputs.

1/ In most GM air management system applications the air control valve routes air to the air cleaner when energized and to the air switching valve when de-energized. The air switching valve routes air to the ports when energized and to the dual bed catalytic converter when de-energized. In this particular application air is supplied to the catalytic converter when the control valve is de-energized and to the air switching valve when energized. The air switching valve routes air to the ports when de-energized and to the air cleaner when energized.

d. Mixture control solenoid disconnected - Test numbers 80-6344 and 80-6625 were run with the MCS disconnected.

e. EGO sensor lead disconnected and short circuited - Test numbers 80-6626 and 80-6627 were run with the exhaust gas oxygen (EGO) sensor disconnected with the microprocessor input lead shorted. Shorting the EGO sensor lead guaranteed a zero voltage input to the microprocessor. These tests were designated EGO shorted.

f. Throttle position sensor disconnected - Test numbers 80-6628 and 80-6629 were run with the TPS disconnected.

g. EGO disconnected lead open circuited - Test numbers 80-6630 and 80-6631 were run with the exhaust gas oxygen sensor disconnected. The EGO sensor supplies a voltage signal to the microprocessor based on the oxygen content of the exhaust stream. By disconnecting this sensor and leaving the lead open circuited the senses a near zero voltage and the closed loop systems is deactivated. These tests were designated EGO sensor disconnected.

TEST RESULTS

The test results are given in several attachments.

a. The FTP and HFET results are given in attachment 5. The HC, CO, CO_2 and NOx readings are in grams/mile while fuel economy is in miles per gallon.

b. Attachment 6 presents the standard I/M test data. Values are given for readings taken before and after the catalyst.

c. Attachment 7 presents the results of the propane injection diagnostic procedure for three-way catalyst vehicles.

d. Attachment 8 presents the results of the on-board system diagnostic check.

ATTACHMENT 1

Propane Injection Diagnostic Procedure for Three-Way Catalyst Vehicles

The purpose of this procedure is to identify a failed feedback control system. If a running engine with a functioning feedback control system is suddenly given a volume of propane gas, the engine should give a characteristic response: the CO emission levels, and engine speed, should first increase, but then return to normal as the carburetor compensates for the richer mixture. If the feedback system is not functioning, the carburetor will be unable to compensate (i.e. lean out the mixture) for the presence of the programs. In this case the CO levels and engine speed will simply rise (or possibly fall) without returning to normal.

For this experimental procedure, four propane gas flow rates were used for each vehicle: 1, 2, 3, and 4 cubic feet per hour (cfh). Each rate was pre-set with a flowmeter, and then suddenly presented to the carburetor through an inlet to the air cleaner. A large bottle of propane was purchased for this project, and a system of regulators was attached to easily set the flow rates.

The vehicle was at curb idle in Neutral or Park gear, fully warmed-up, and all accessories off. Before each measurement the engine speed was increased to approximately 2500 rpm in neutral gear for 30 seconds. The propane was admitted within 30 seconds after the engine was returned to idle. Readings were taken within 60 seconds after the propane was flowing. The propane flow was then shut off to the vehicle and further readings were taken and recorded.

One data sheet was filled out for each flow rate. If a flow rate caused the engine to stall, notation of that was made at step 3 of the data sheet and the procedure stopped for that vehicle.

Propane Injection Diagnostic Procedure for Advanced Technology Vehicles

Vehicle # ____________________
Make/Model ____________________

Date ____________________
CID ____________________

1. Preset Flow Rate. Record Flow Rate ________________________ cfh ____
   Operate engine at 2500 RPM for 30 seconds, then return to idle.

2. Record: Idle RPM ____________ (Neutral/Park gear, no propane flowing)
   ICO ____________

3. Induce propane quickly, observe vehicle behavior over a period not larger than 60 seconds.

Codes Check one:
1 ___ RPM rises smoothly
2 ___ RPM decreases smoothly
3 ___ RPM rises smoothly to ____________ (record RPM), then falls.
4 ___ RPM falls smoothly to ____________ (record RPM), then rises.
5 ___ Engine runs rough, then stabilizes
6 ___ Engine dies (stop procedure here)
7 ___ No Change

4. When engine stabilizes (maximum 60 seconds) record: RPM ____________
   ICO ____________

5. Withdraw propane quickly, observe vehicle behavior

Codes Check one:
1 ___ RPM rises smoothly
2 ___ RPM decreases smoothly
3 ___ RPM rises smoothly to ____________ (record RPM), then falls.
4 ___ RPM falls smoothly to ____________ (record RPM), then rises.
5 ___ Engine runs rough, then stabilizes
6 ___ Engine dies
7 ___ No Change

6. When engine stabilizes record: RPM ____________
   ICO ____________

ATTACHMENT 2

DISABLEMENT TESTING - SHORT TEST DATA SHEET

DATE ______________ TEST NO. ______________ VEHICLE ______________

DISABLEMENT ______________________ OPERATOR ______________________

	Before Catalysts		After Catalysts	
	HC	CO	HC	CO
50 MPH Cruise				
<u>4 Speed Idle</u>				
Idle (N)				
2500 RPM				
Idle (N)				
Idle (M)				
<u>2 Mode Loaded</u>				
Loaded* (Pendant Mode)				
Idle (N)				

* The loaded mode is a 30 mph cruise @ 9.0 AHP.

ATTACHMENT 3

SECTION 6E1

COMPUTER COMMAND CONTROL SYSTEM

CONTENTS

GENERAL DESCRIPTION

SYSTEM DESCRIPTION

The Computer Command Control system (Fig. 6E1-1) is an electronically controlled exhaust emission system that monitors up to fifteen (15) different engine/vehicle functions and can control as many as nine (9) different operations including the transmission converter clutch (Fig. 6E1-1A). The system has back-up programs in the event of a failure to alert or instruct the operator through a "CHECK ENGINE" lamp on the instrument panel. This lamp will light indicating a fault in the system and will remain "on" until problem is corrected. This same lamp through an integral diagnostic system, will aid the technician in locating the cause of the problem area.

The system helps to lower exhaust emissions while maintaining good fuel economy and driveability. The system controls the following operations:

- Fuel Control System
- Electronic Spark Timing (EST)
- Electronic Spark Control and EST
- Air Management
- Exhaust Gas Recirculation System
- Evaporative Emission Control System
- Early Fuel Evaporation
- Transmission Converter Clutch

Electronic Control Module (ECM)

The electronic control module (ECM) located in the passenger compartment, is the control center of the Computer Command Control system. The ECM controls the Computer Command Control system by constantly monitoring engine function. Information regarding cooling system temperature, crankshaft rpm, throttle blade position, manifold pressure and the amount of oxygen in exhaust

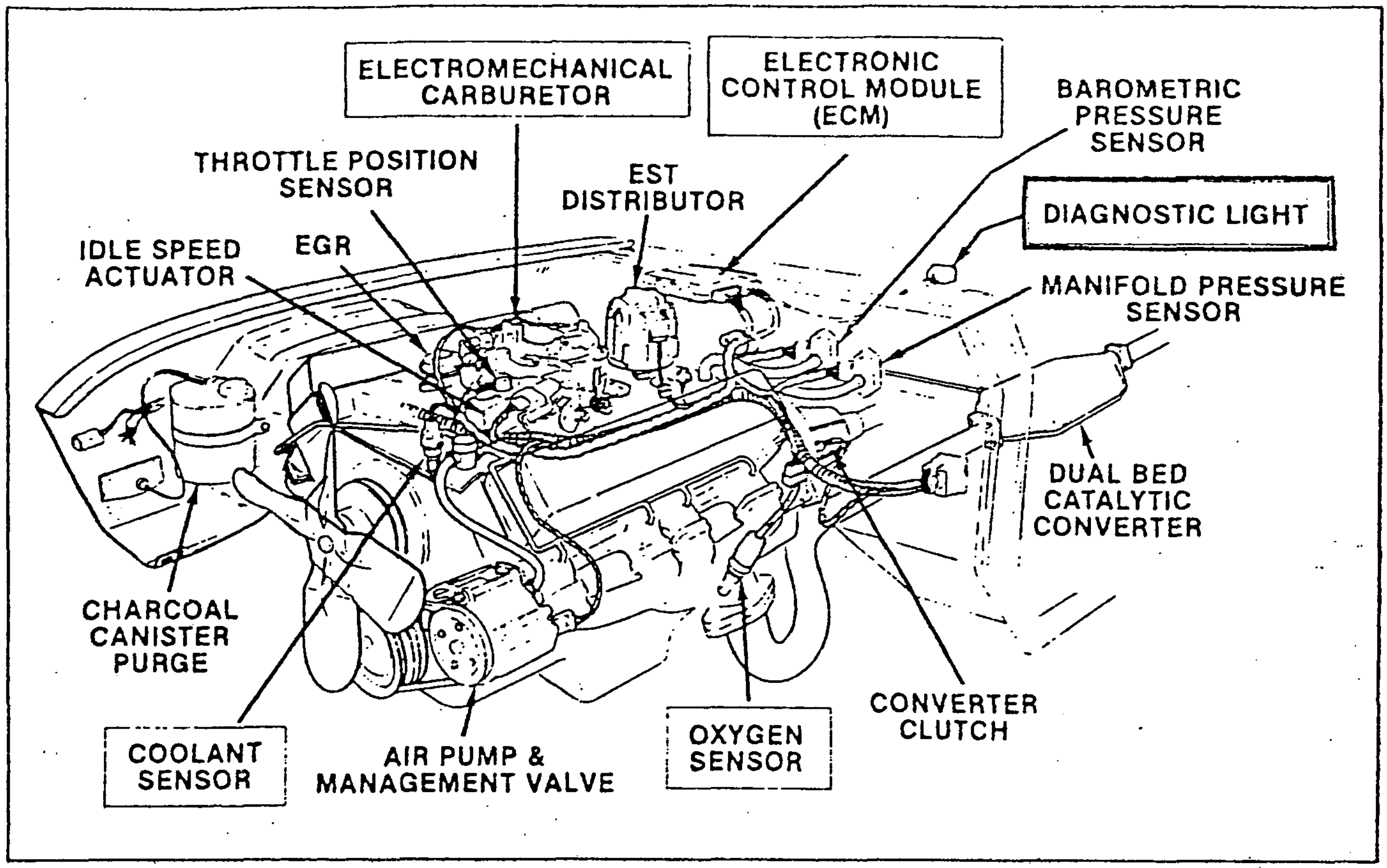

Fig. 6E1-1—Computer Command Control System-Typical

MONITORED PARAMETERS

- Exhaust Oxygen Concentration
- Engine Coolant Temperature
- Throttle Position
- Barometric Pressure
- Manifold Pressure (Absolute or Differential)
- Engine Crankshaft Position
- Battery Voltage
- Vehicle Speed
- Transmission Gear Indication and/or Carburetor Air Inlet Temperature
- Park/Neutral Mode
- Brake Pedal Engagement
- A/C Clutch Engagement
- Throttle Actuator Contact Switch Engagement
- Time (Internally Generated within ECM)
- Cold Start Program Modifier Condition

ELECTRONIC CONTROL MODULE (ECM)

CONTROLLED PARAMETERS

- Carburetor M/C Solenoid Signal
- AIR Control Valve Signal
- AIR Switching Valve Signal
- Electronic Spark Timing Signal
- Canister Purge Valve Signal
- Torque Converter Clutch Signal
- EGR Control Valve Signal
- EFE Control Valve Signal
- Idle Speed Control Signal

Not all features are used on all engines.

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Fig. 6E1-1A—System Parameters

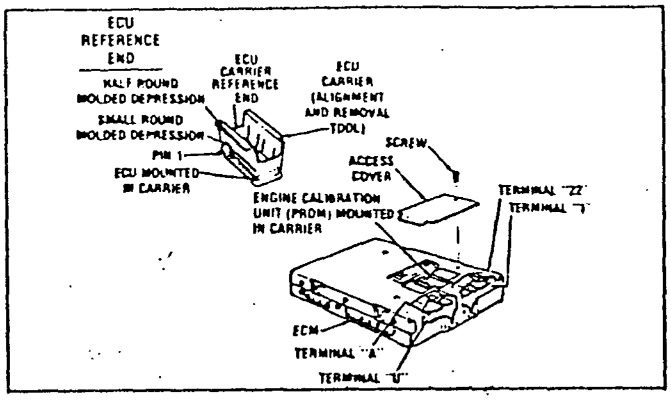

Fig. 6E1-2—ECM-PROM Identification

gases is continuously fed into the ECM while the engine is running. The ECM is designed to process this information and programmed to send the necessary electrical responses to control the Computer Command Control system. The ECM contains a engine calibration unit called a PROM (Fig. 6E1-2) which is located under an access cover. The PROM contains specific instructions to tailor each ECM to each car design such as:

- Car size and weight
- Engine
- Transmission
- Final Drive Ratio

When a PROM has been programmed for a particular car, it cannot be used on another car that does not have the same standards.

The ECM also monitors the engine crankshaft posiiion signal in order to determine engine RPM.

Coolant Sensor (Fig. 6E1-3)

The coolant sensor is mounted in the engine coolant stream. It has a high resistance (around 100,000 ohms) when the coolant is cold and a low resistance (under 1,000 ohms) when the coolant is warm. The sensor sends information on engine temperature to the ECM which is used for the following:

- To vary the air-fuel ratio as the engine coolant temperature varies with time during a cold start.

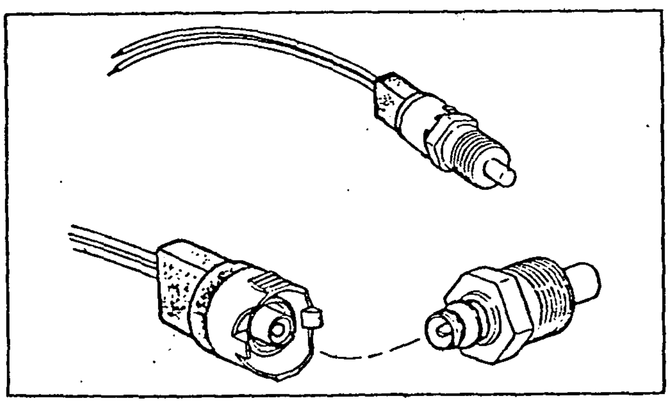

Fig. 6E1-3—Coolant Temperature Sensor

- To accomplish various switching functions at different temperatures on EGR, EFE, AIR Management Systems and transmission converter clutch.
- To provide a switch point for hot temperature light indication.
- To vary spark advance.

Pressure Sensors

All engine families use various types of pressure sensors except 3.8L (RPO LC3). The ECM uses sensor voltage information to adjust air/fuel ratio and/or spark timing or transmission converter clutch.

Barometric Pressure (BARO) Sensor

The BARO sensor is located in the engine compartment. It produces a voltage of 3 to 4.5 volts to indicate the ambient (barometric) air pressure. The BARO sensor is not used on all engine applications. The output varies with altitude.

Manifold Absolute Pressure (MAP) Sensor or Vacuum Sensor

The MAP Sensor or Vacuum Sensor is mounted in the engine compartment. This sensor measures changes in manifold pressure and provides this information (electrical signal) to the ECM. The pressure changes reflect need for adjustment in air/fuel mixture and spark timing (EST) that are required to maintain good vehicle performance under various driving conditions.

FUEL CONTROL SYSTEM (FIG. 6E1-4)

Mixture Control Solenoid (Figs. 6E1-5 and 6)

The fuel flow through the carburetor idle main metering circuits is controlled by a mixture control (M/C) solenoid located in the carburetor. The M/C solenoid changes the air/fuel mixture to the engine by allowing more or less fuel to flow through the carburetor. The ECM controls the M/C solenoid by providing a ground for the solnoid. When the solenoid is energized, the fuel flow through the carburetor is reduced, providing a leaner fuel mixture. When the ECM removes the ground path, the solenoid de-energizes and allows more fuel flow and thus a richer mixture. The solenoid is turned on and off at a rate of 10 times per second.

Oxygen Sensor (Fig. 6E1—7)

The oxygen sensor is mounted in the engine stream. It supplies a low voltage (under 1.2 volt) when the fuel mixture is lean and a higher voltage (up to 1 volt) when the fuel mixture is rich. The oxygen sensor supplies a voltage when the exhaust stream has reached 360°C (600°F). On some installations, it may cool off at idle and the system will then go to open loop. Running at fast idle will warm up the sensor.

The oxygen sensor requires the use of unleaded fuel only.

System Operation

The ECM determines the proper fuel mixture by monitoring the signal sent by the oxygen sensor. When mixture is lean to oxygen sensor, a low voltage signal is sent to the ECM and the ECM commands (dwell output signal) a richer mixture to the M/C solenoid. When the mixture

FUEL CONTROL SYSTEM OPERATION

ENGINE CONDITION	INPUTS TO ECM	M/C SOLENOID OPERATION	DWELLMETER READING
STARTING (CRANKING)	• TACHOMETER LESS THAN 200 RPM	M/C SOLENOID OFF (RICH MIXTURE)	0°
WARM-UP	• TACH ABOVE 200 RPM (ENGINE RUNNING) • O_2 SENSOR LESS THAN 1030°C (600°F) • COOLANT LESS THAN 150°F (66°F) • LESS THAN 10 SECONDS ELAPSED SINCE STARTING	FIXED COMMAND FROM ECM TO M/C SOLENOID	FIXED READING BETWEEN 10° AND 50°
WARM OPERATION IDLE AND CRUISING ("CONSTANT" ENGINE SPEED)	• O_2 SENSOR ABOVE 1030°C (600°C) • COOLANT ABOVE 150°C (66°F) • MAP SENSOR	M/C SOLENOID SIGNAL DETERMINED BY OXYGEN SENSOR INFORMATION TO ECM	VARING ANYWHERE BETWEEN 10° AND 50° (NOMINAL 35°) (FASTER WITH HIGHER RPM)
ACCELERATION AND DECELERATION ("CHANGING" ENGINE SPEEDS)	• THROTTLE POSITION SENSOR (TPS) • MAP SENSOR • O_2 SENSOR	MOMENTARY PROGRAMMED SIGNAL FROM ECM DURING PERIOD AFTER THROTTLE CHANGE UNTIL OXYGEN SENSOR RESUMES CONTROL OF M/C SOLENOID	MOMENTARY CHANGE, CAN'T BE READ ON DWELLMETER. WILL BE VARYING, BUT HIGH OR LOW ON SCALE DEPENDING UPON OPERATING CONDITION(S)
WIDE-OPEN THROTTLE	• TPS FULLY OPEN • MAP SENSOR	VERY RICH COMMAND TO M/C SOLENOID	6°

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Fig. 6E1-4—Fuel Control System

is rich to the oxygen sensor, a high voltage signal is sent to the ECM and the ECM commands a leaner mixture to the M/C solenoid.

When car is started, there is a short delay which sends a rich only signal from the ECM to the M/C solenoid. The delay time is dependant upon coolant temperature. During engine warm-up and before oxygen sensor has reached operating temperature, the ECM sends a fixed mixture command to the M/C solenoid. This is called Open Loop.

When engine and oxygen sensor have reached operating temperature and a predetermined time has elapsed in the ECM, the ECM monitors the voltage output of the oxygen sensor and generates a dwell output signal (also called duty cycle) to the M/C solenoid. This is called Closed Loop. (Fig. 6E1-8). When the system in open or closed loop modes and the throttle is opened to near W.O.T., the ECM sends a steady power enrichment command to the M/C solenoid.

Most all of the following components are used on a given engine:

THROTTLE POSITION SENSOR (TPS)

The TPS (Fig. 6E1-9) is mounted in the carburetor body. It is moved by the accelerator pump linkage. It provides a low voltage (under 1 volt) when the throttle blades are closed and up to 5 volts as the throttle blades are opened to wide open throttle. The ECM needs this voltage to indicate throttle position.

IDLE SPEED CONTROL (ISC)

An Idle Speed Control (ISC) system (Fig. 6E1-10) is used on some engines to control idle speed. ISC maintains low idle speeds while preventing stalls due to engine load changes. A motor assembly mounted on the carburetor moves the throttle lever to open or close the throttle blades.

The ECM monitors engine load to determine proper idle speed. To prevent stalling, the ECM monitors the air conditioning compressor switch, transmission, part/neutral switch, and the ISC throttle switch. With this information, the ECM will control the ISC motor and vary the engine idle RPM as necessary.

ISC THROTTLE SWITCH

The ISC switch is mounted in the ISC motor housing. It is closed when the throttle lever contacts the ISC plunger and opens as the throttle lever moves away from the plunger.

AIR CONDITIONING "ON" SWITCH

When A/C is turned "on", a switch in the compressor is supplied 12 volts to engage the compressor. At the same time, the ECM, because of changes in engine load, adjusts ISC to maintain idle speed.

ELECTRONIC SPARK TIMING (EST)

Electronic Spark Timing (EST) is used on all engines except 3.8L (RPO LC3). The EST distributor (Fig. 6E1-11) contains no vacuum or centrifugal advance and uses a

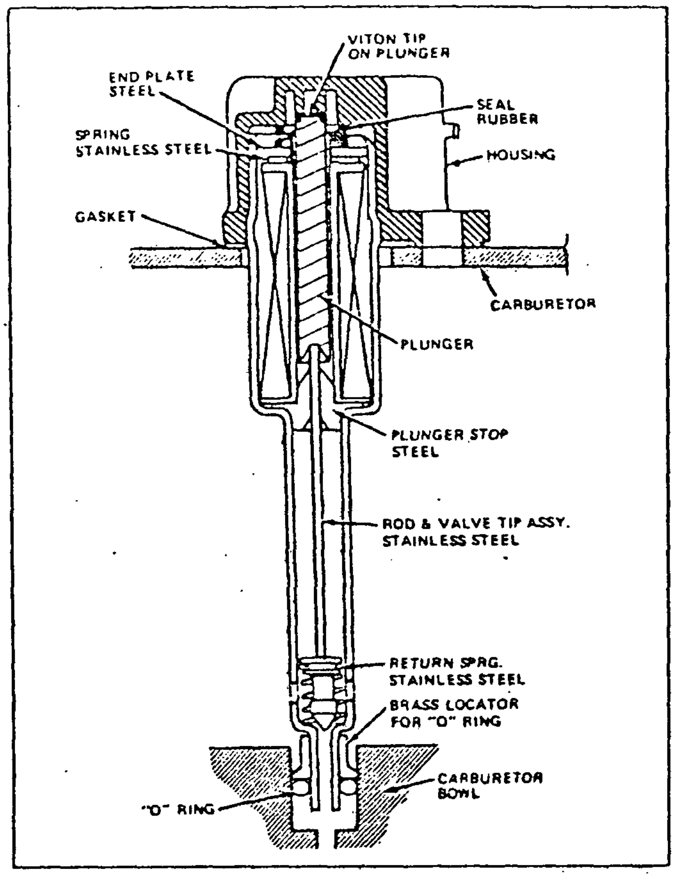


Fig. 6E1-5—M/C Solenoid-E2SE

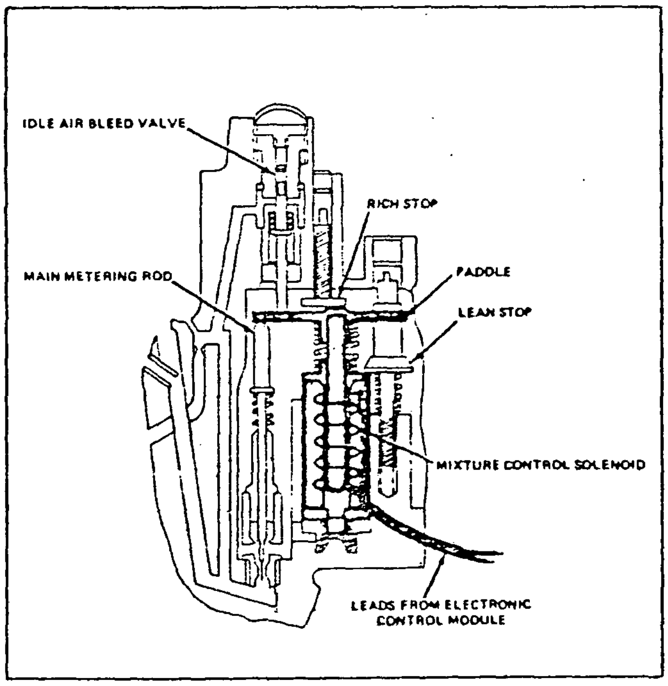


Fig. 6E1-6—M/C Solenoid-E2ME and E4ME

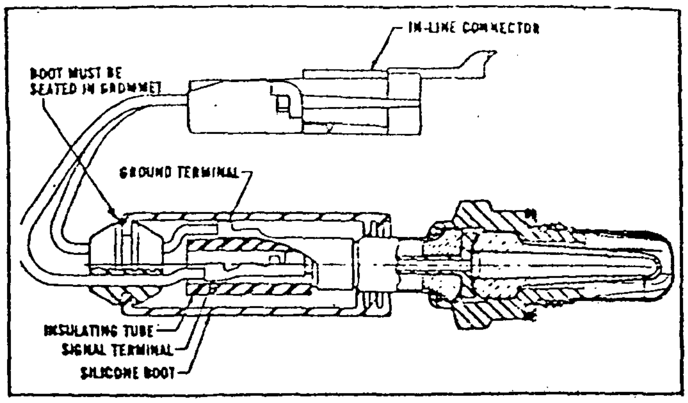


Fig. 6E1-7—Oxygen Sensor

seven-terminal HEI module. It has four wires going to a four terminal connector in addition to the connectors normally found on HEI distributors. A reference pulse, indicating both engine RPM and crankshaft position, is sent to the ECM. The ECM determines the proper spark advance for the engine operating conditions and sends an "EST" pulse to the distributor.

Under normal operating conditions, the ECM will control the spark advance. However, under certain operating conditions such as cranking or when setting base timing, the distributor can operate without ECM control. This condition is called BYPASS and is determined by the bypass lead from the ECM to the distributor. When the bypass lead is at 5 volts. the ECM will control the spark. When the bypass line is at ground or open circuited, the HEI module will control the spark. Disconnecting the 4-terminal EST connector causes the engine to operate in the bypass mode.

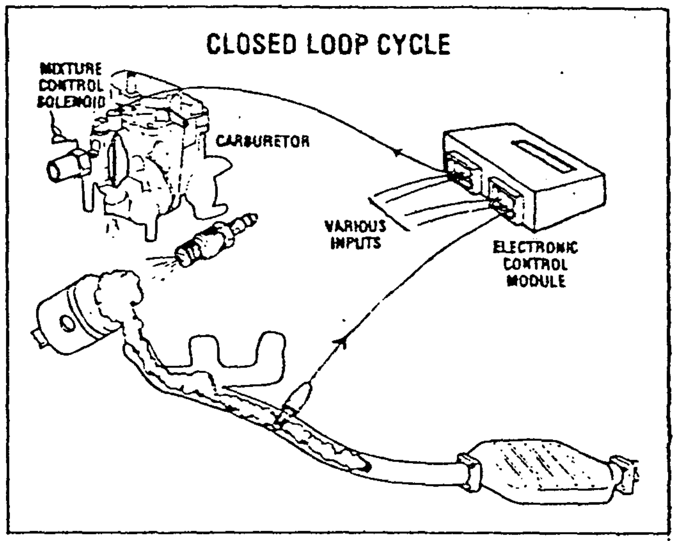


Fig. 6E1-8—Closed Loop Cycle

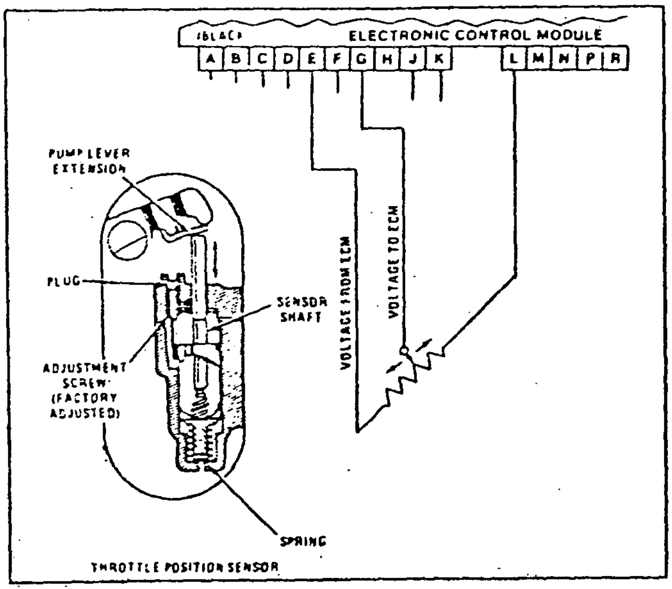


Fig. 6E1-9—Throttle Position Sensor

Electronic Spark Control (ESC) and EST

Electronic Spark Control, used with a turbocharged engine, receives the EST signal from the ECM and remodifies it when the Electronic Spark Control (ESC) senses detonation in the engine through its detonation sensor.

AIR MANAGEMENT

The AIR system helps reduce hydrocarbon (HC) and carbon monoxide (CO) content in the exhaust gases. It does this by injecting air into the exhaust ports of each cylinder during cold engine operation. This air injection also helps to heat up the catalytic converter. When the engine is warm or is in closed loop, the AIR system injects air into the catalytic converter. This helps lower HC and CO in the exhaust.

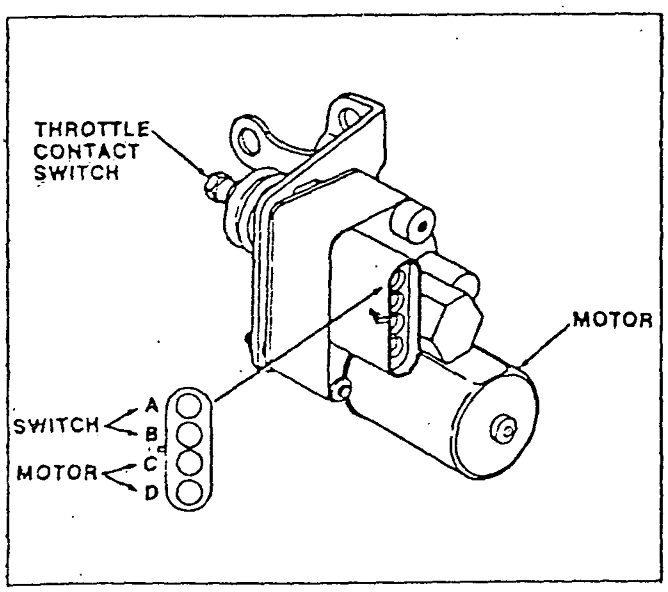


Fig. 6E1-10—Idle Speed Control Motor

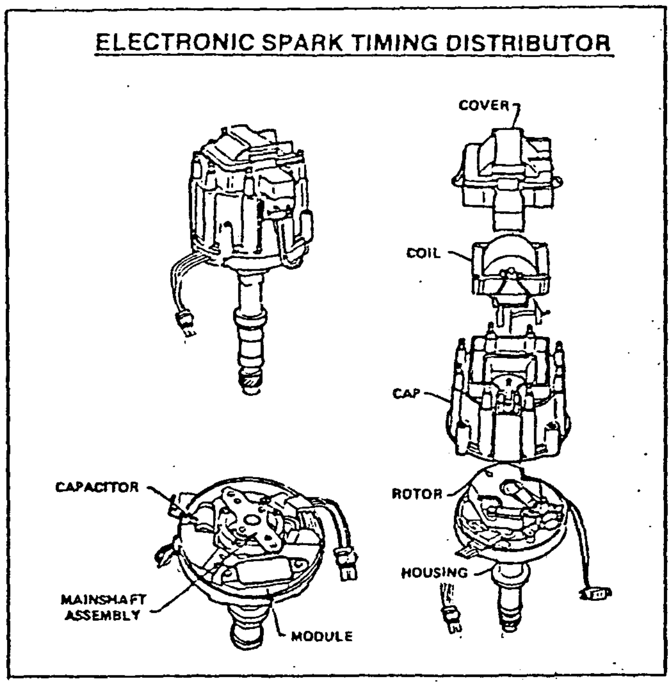


Fig. 6E1-11—EST Distributor

When the engine is cold, the ECM energizes an AIR CONTROL solenoid. This allows air to flow to an AIR SWITCHING valve. The air switching valve is energized to direct air to the exhaust ports.

On a warm engine or when in closed loop, the ECM de-energizes the air switching valve, directing air to the converter.

If the air control valve detects a rapid increase in manifold vacuum (as under a decel), certain operating modes, or the ECM self-diagnostic system detects any failure in the system, air is diverted to the air cleaner.

EXHAUST GAS RECIRCULATION (EGR)

The ECM controls the ported vacuum to the EGR valve with a solenoid valve. When the engine is cold, the solenoid valve is energized and blocks vacuum to the EGR valve. When the engine is warm, the solenoid valve is de-energized and EGR is allowed.

EVAPORATIVE EMISSION CONTROL SYSTEM

The ECM controls the vacuum to the purge valve in the charcoal canister with a solenoid valve. When the system is in open loop, the solenoid valve is energized and blocks vacuum to the purge valve. When the system is in closed loop, above specified RPM, the solenoid valve is de-energized and vacuum can be applied to the purge valve. This releases the collected vapors into the intake manifold.

EARLY FUEL EVAPORATION (EFE)

Two types of EFE systems are controlled by the ECM:

One EFE system uses a valve and actuator motor that controls a valve assembly and has an ECM controlled solenoid located in the vacuum source to the valve motor. The function of the solenoid is to control the shut off of the system by an electrical signal supplied by the ECM.

The other EFE system, used in a 1.6L engine, has a ceramic heater grid located underneath the primary bore of the carburetor which is part of the insulator. When the ignition switch is turned "on" and engine coolant temperature is low, voltage is applied to the EFE relay through the ECM. With the EFE relay energized, voltage is applied to the EFE heater. When coolant temperature increases, the ECM de-energizes the relay which shuts "off" EFE heater.

TRANSMISSION CONVERTER CLUTCH (TCC)

The ECM controls a solenoid mounted in the automatic transmission. When the vehicle speed is high enough, the ECM energizes the solenoid and allows the torque converter to mechanically couple the engine to the transmission. When operating conditions indicate the transmission should operate as a normal fluid coupled transmission, the solenoid is de-energized. The transmission also returns to normal automatic operation when the brake is depressed.

Vehicle Speed Sensor (VSS)

The VSS is mounted behind the speedometer in the instrument cluster. It provides a series of 8-volt pulse used to determine vehicle speed.

High Gear Switch

The high gear switch is mounted in the transmission. It opens when the transmission has shifted into high gear and closes under any other condition.

Park/Neutral (P/N) Switch

The P/N switch is connected to the transmission gear selector. It is closed when the selector is in park or neutral, and is open when the selector is in gear.

WIRING HARNESS AND CONNECTORS

The wiring harnesses for the system electrically connects the ECM to the various switches and sensors within the system. The wiring is an additional harness in the engine compartment and connects to the ECM located inside the car.

There are many new components required for the system. This includes new terminals, connectors, cables and seals. All of the connectors will have positive locks and and secondary terminal locks.

All system connections in the engine compartment will be environmentally protected. The reasons for using this type of connection are low voltage and current levels, and the environment to which the connectors are exposed. In many cases in the system, the voltage is limited to 5V and as low as 500 MV for the oxygen sensor connections. In nearly all cases, the current is below 250 MA.

Environmental protection protects the terminations from the harsh corrosive engine compartment environment. This is especially important when the voltage and current levels are too low to break down oxidation and film growth on the terminals, as in the case for the Computer Command Control system.

DIAGNOSIS

GENERAL

The Computer Command Control system has a self-diagnostic system which will cause the "CHECK ENGINE" lamp on the instrument panel to remain "on" when engine is running. This is an indication that there is a fault in the system. If this is the problem, refer to the Diagnostic Circuit Check chart (Fig. 6E1-14).

Before suspecting a problem in the Computer Command Control system and it is not "CHECK ENGINE" lamp related, refer to Section 6 "Engine Performance Diagnosis" in companion manual.

The Computer Command Control system diagnosis starts in sequence with the following charts:

1. Diagnostic Circuit Check chart
2. Driver Complaint
3. System Performance Check chart

It is important that these charts be followed in a step-by-step sequential procedure without leaving out a step or assuming the solution to the problem. If charts are not followed, the system will be improperly diagnosed.

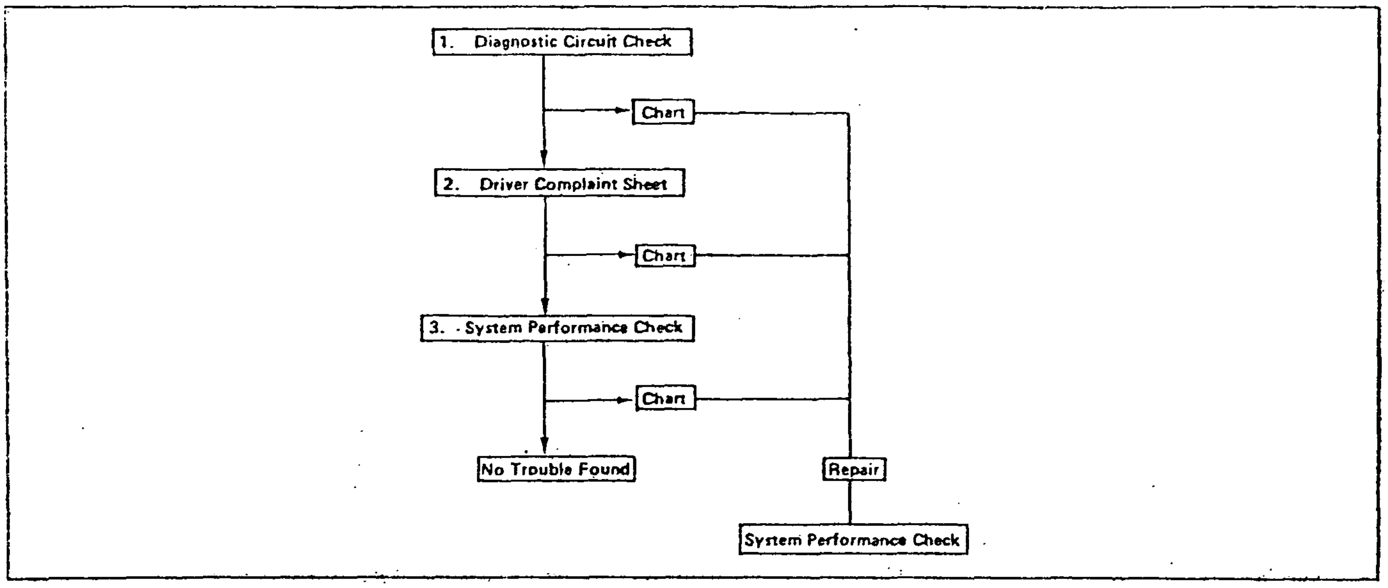


Fig. 6E1-12—Computer Command Control Diagnostic Procedure

Although there are many charts and trouble codes connected with the system diagnostics, only two charts are needed to prove the system is properly operating. Normally, only three charts are needed to diagnose and repair a problem.

Figure 6E1-12 summarizes the system diagnosis procedure.

TOOLS AND EQUIPMENT

The Computer Command Control system requires the following tools and equipment (Fig. 6E1-13) to properly diagnose a complete system:

1. System Performance Checking

- Tachometer-Either a harmonic balance revolution pickup type or electronic coil trigger signal pickup type tachometers can be used for diagnosis.
- Dwellmeter – Used to indicate the performance conditions of the M/C solenoid circuit. Connect the positive lead of dwellmeter to the bright green connector in the wiring harness near the M/C solenoid. Place meter on 6-cylinder scale. The scale on the meter will show the condition of the M/C solenoid circuit. When needle is on 10° scale, this indicates a rich mixture. A lean mixiture will read near 54° scale. A varying needle indicates that the system is in closed loop.
- Vacuum Gage -to monitor manifold engine vacuum
- Vacuum Pump - to check pressure or vacuum sensors and vacuum operated valves (EGR, AIR, etc.)

2. Circuit Checking

- Voltmeter and Ohmmeter – use digital volt-ohmmeter J-29125 to measure voltage and ohm for Computer Command Control circuits
- Jumper Wires – to by-pass a circuit and to insert between special connectors to permit access to the connector terminals for circuit checking.
- Test light
- Connector Tools – Use tool J-28742 for removal of terminals on Weather Pack connectors. Refer to Figure 6E1-13 for tool to extract terminal from connectors at the ECM.

DIAGNOSTIC CIRCUIT CHECK

The Diagnostic Circuit Check (Fig. 6E1-14) makes sure that the self-diagnostic system works, determines that the trouble codes will display and guides diagnosis to other problem areas.

With the engine running and a problem developes in the system, the "CHECK ENGINE," lamp will come "on" and a trouble code will be stored in the ECM "Trouble Code Memory." The lamp will remain "on" with engine running as long as there is a problem. If the problem is intermittent, the "CHECK ENGINE" lamp will go out but the trouble code will be stored in the ECM trouble code memory.

With ignition turned "ON" and engine stopped, the "CHECK ENGINE" lamp should be "ON". This is a bulb check to indicate that the lamp is working.

The trouble code "test" terminal (Fig. 6E1-14) is located in a five (5) terminal connector, located under the dash. A ground terminal is located next to the test terminal. With the ignition "ON", ground the test terminal.

The "CHECK ENGINE" light will begin to flash a Trouble Code "12". Code 12 consists of one flash, a short pause, then two flashes. There will be a longer pause and Code 12 will repeat two more times. This check indicates that the self-diagnostic system is working. The cycle will then repeat itself until the engine is started or the ignition is turned "OFF." If more than one fault is stored in memory, the lowest number code will flash three times followed by the next highest code number, until all faults have been flashed. The faults will then repeat in the same order. Remove ground from test terminal before starting engine.

A trouble code indicates a problem in a given circuit i.e., trouble code 14 indicates a problem in the coolant sensor circuit. This includes the coolant sensor, connector, harness, and Electronic Control Module (ECM). The procedure for finding the problem can be found in Diagnosis Trouble Code Chart 14. Charts are provided for each trouble code.

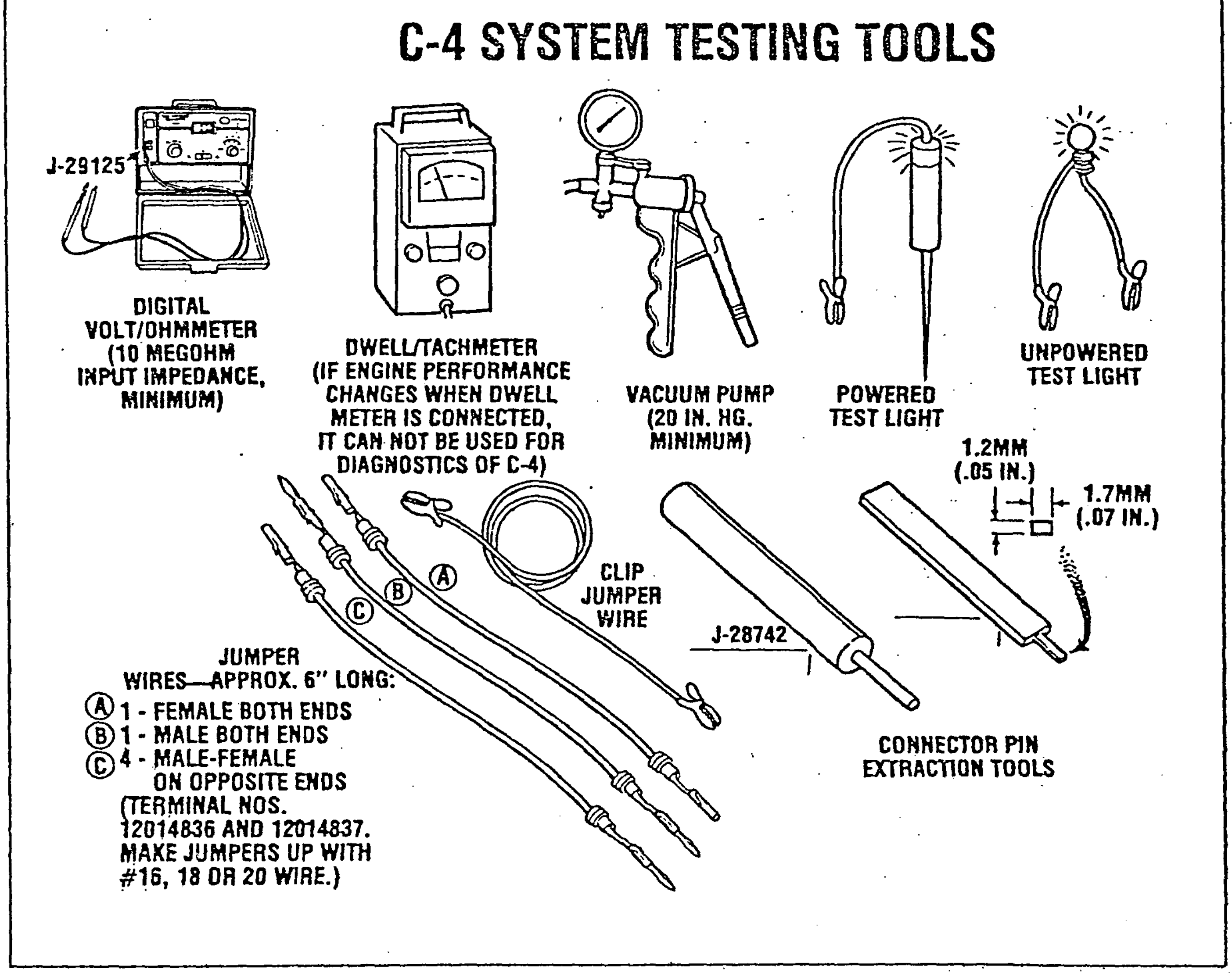


Fig. 6E1-13—Tools and Equipment

When the engine is started, the "CHECK ENGINE" light will remain "ON" for 1 to 4 seconds and then go "OFF". If the "CHECK ENGINE" light remains ON, the self-diagnostic system has detected a fault.

If a trouble code can be obtained when the "CHECK ENGINE" light is OFF with the engine running, the trouble code must be evaluated. A determination must be made to see if the fault is intermittent or if the engine must be at certain operating conditions to turn the "CHECK ENGINE" light ON.

Faults indicated by trouble codes 13, 24, 44 and 45 require engine operation at part throttle for up to five minutes before the "CHECK ENGINE" light will come on and store a trouble code.

The fault indicated by trouble code 15 takes five minutes of engine operation before it will display. The diagnostic charts for trouble codes 13, 15, 24, 44 and 45 should be used if any of these trouble codes can be obtained.

Clearing Trouble Code Memory

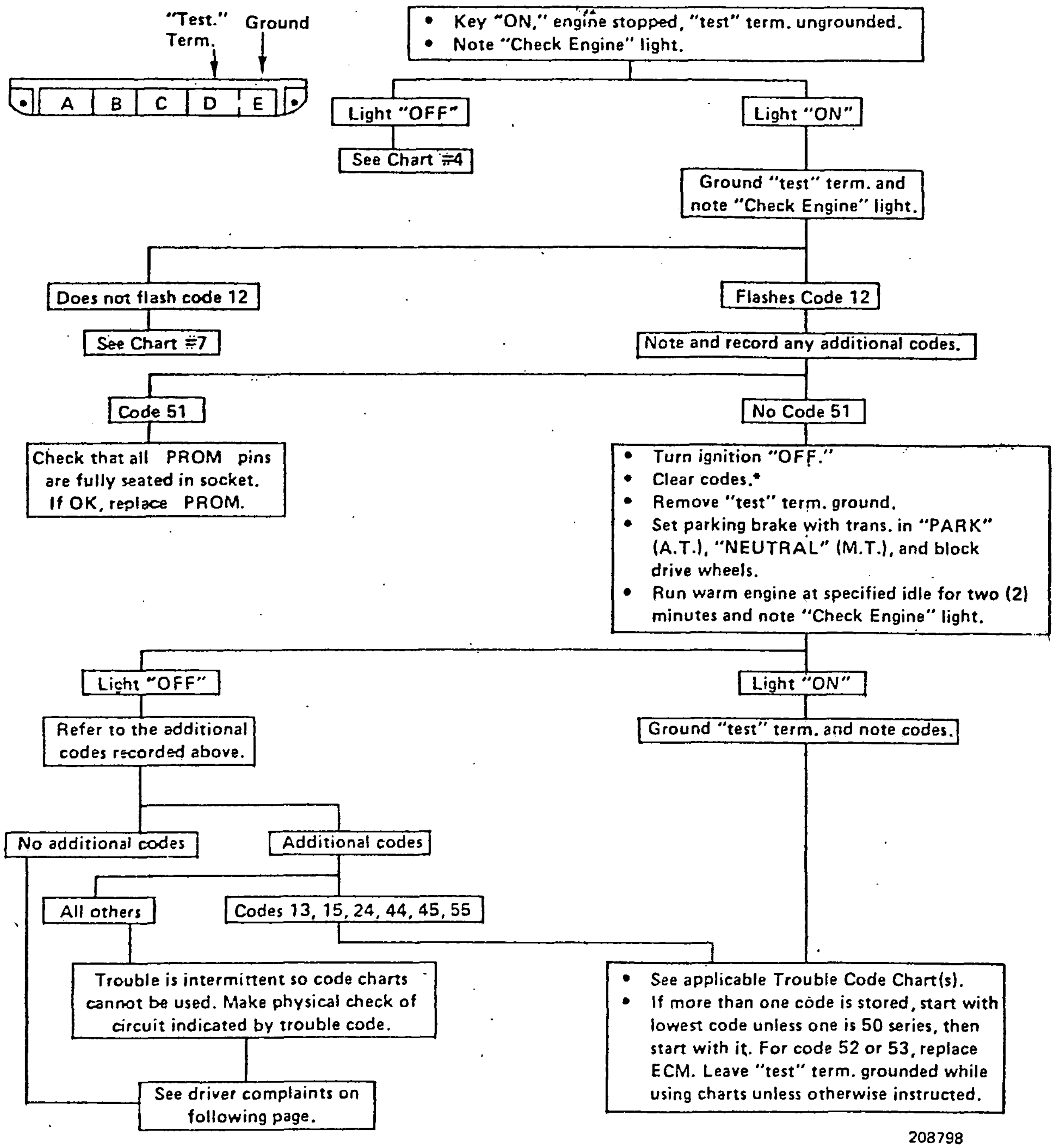
The trouble code memory is fed a continuous 12 volts even with key in "OFF" position. After a fault has been corrected, it will be necessary to remove this voltage for 10 seconds to clear any stored codes. Voltage can be removed by removing "ECM" fuse, removing voltage at battery or disconnecting lettered connector at the ECM.

DRIVER COMPLAINT

After performing the Diagnostic Circuit Check and there is no "CHECK ENGINE" light with a warm running engine, then refer to Driver Complaint (Fig. 6E1-15) for an emission non-compliance problem or an engine performance problem (odor, surge, fuel economy...).

DIAGNOSTIC CIRCUIT CHECK

Always check "PROM" for correct application before replacing an "ECM."



*See Code(s) Clearing Procedure

The system performance check should be performed after any repairs to the "System" have been made.

Fig. 6E1-14—Diagnostic Circuit Check

TROUBLE CODE IDENTIFICATION

The "CHECK ENGINE" light will only be "ON" if the malfunction exists under the conditions listed below. It takes up to five seconds minimum for the light to come on when a problem occurs. If the malfunction clears, the light will go out and a trouble code will be set in the ECM. Code 12 does not store in memory. If the light comes "on" intermittently, but no code is stored, go to the "Driver Comments" section. Any codes stored will be erased if no problem reoccurs within 50 engine starts.

The trouble codes indicate problems as follows:

TROUBLE CODE 12	No reference pulses to the ECM. This code is not stored in memory and will only flash while the fault is present.
TROUBLE CODE 13	Oxygen Sensor Circuit - The engine must run up to five minutes at part throttle, under road load, before this code will set.
TROUBLE CODE 14	Shorted coolant sensor circuit - The engine must run up to two minutes before this code will set.
TROUBLE CODE 15	Open coolant sensor circuit - The engine must run up to five minutes before this code will set.
TROUBLE CODE 21	Throttle position sensor circuit - The engine must run up to 25 seconds, below 800 RPM, before this code will set.
TROUBLE CODE 23	Open or grounded M/C solenoid circuit.
TROUBLE CODE 24	Vehicle speed sensor (VSS) circuit - The car must operate up to five minutes at road speed before this code will set.
TROUBLE CODE 32	Barometric pressure sensor (BARO) circuit low.
TROUBLE CODE 34	Manifold absolute pressure (MAP) or vacuum sensor circuit - The engine must run up to five minutes, below 800 RPM, before this code will set.
TROUBLE CODE 35	Idle speed control (ISC) switch circuit shorted. (Over 50% throttle for over 2 sec.)
TROUBLE CODE 42	Electronic spark timing (EST) bypass circuit grounded.
TROUBLE CODE 44	Lean oxygen sensor indication - The engine must run up to five minutes, in closed loop, at part throttle and road load before this code will set.
TROUBLE CODE 44 & 45	(At same time) - Faulty oxygen sensor circuit.
TROUBLE CODE 45	Rich System indication - The engine must run up to five minutes, in closed loop, at part throttle and road load before this code will set.
TROUBLE CODE 51	Faulty calibration unit (PROM) or installation. It takes up to 30 seconds before this code will set.
TROUBLE CODE 52	Faulty ECM
TROUBLE CODE 53	Faulty ECM
TROUBLE CODE 54	Shorted M/C solenoid circuit.
TROUBLE CODE 55	Grounded +8 volts, Vref, faulty oxygen sensor or ECM.

Fig. 6E1-24—Trouble Code Identification

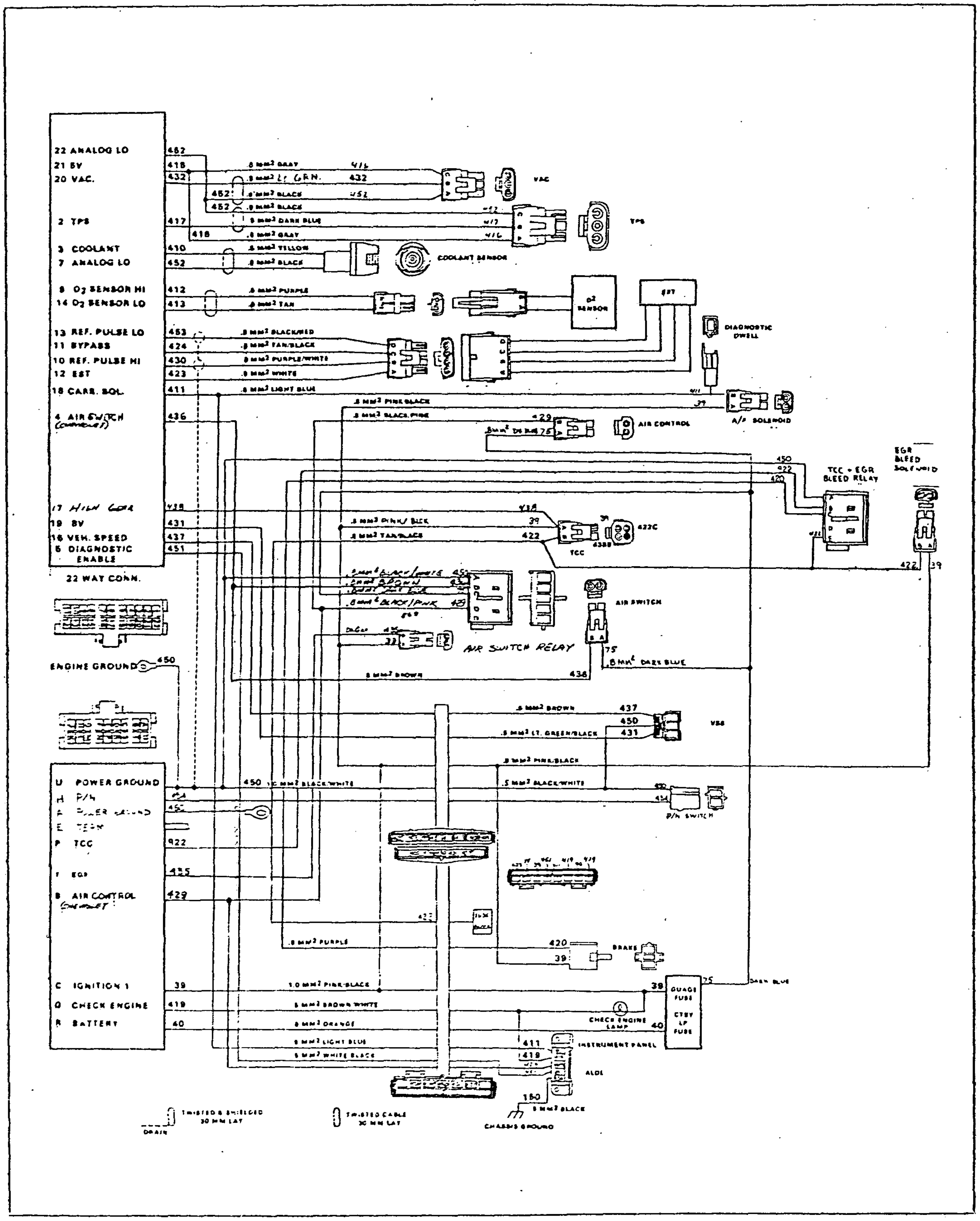


Fig. 6E1-89—Wiring Diagram-5.0L/5.7L Engine

GLOSSARY OF TERMS

A F — Air fuel

AIR — Air injection Reactor

AIR INJECTION REACTOR (AIR) SYSTEM — air flow from pump is directed by system controlled solenoids to reduce exhaust emissions.

BAROMETRIC ABSOLUTE PRESSURE SENSOR (BARO) — Reads atmospheric pressure. May be called BARO, or barometric absolute pressure sensor.

CAR INERTIA WEIGHT CLASS — Weight of car; used in exhaust emission tests to determine inertia weight settings for the chassis dynamometer. This information is used to calibrate the engine calibration unit (PROM).

CARBON MONOXIDE (CO) — One of the pollutants found in engine exhaust.

CATALYTIC CONVERTER, THREE-WAY — Exhaust converter containing platinum and palladium to speed up conversions of HC and CO, and rhodium to accelerate conversion of NOx.

CONTROLLED CANISTER PURGE (CCP) — ECM controlled solenoid valve that permits manifold vacuum to purge the evaporative emissions from the charcoal canister.

CLOSED LOOP CARBURETOR CONTROL — Used to describe oxygen sensor to ECM to M/C solenoid circuit operation.

COOLANT TEMPERATURE SENSOR — Device that senses the engine coolant temperature, and passes that information to the electronic control module through a coaxial connector.

DIAGNOSTIC CODE — Pair of numbers obtained from flashing "CHECK ENGINE" light. This code can be used to determine area in the system where a malfunction may be located.

DWELL — The amount of time (recorded on a dwellmeter in degrees of crankshaft rotation) that voltage passes through a closed switch; for example, ignition contact points or internal switch in an electronic control module.

EARLY FUEL EVAPORATION (EFE) — Method of warming the intake manifold during cold engine operation. Provides efficient air/fuel mixing.

EXHAUST GAS RECIRCULATION (EGR) — Method of reducing NOx emission levels.

ELECTRONIC CONTROL MODULE (ECM) — A metal cased box (located in passenger compartment) containing electronic circuitry which operates the system and turns on the "CHECK ENGINE" light when a malfunction occurs in the system. Service replacement name is engine control module assembly, or "controller, carb."

EMR — Electronic Module Retard. Controls spark retard.

ENERGIZE DE-ENERGIZE — When voltage is passed through the M C solenoid, the metering control armature is pulled into the solenoid (energized). When the voltage to the solenoid is turned off, a spring raises the metering control armature (de-energized).

ENGINE CALIBRATION UNIT (ECU) — An electronic component which can be specifically programmed to the design of each car model to control the M C solenoid. The ECU plugs into the electronic control module (ECM). The ECU may be called a PROM.

ELECTRONIC SPARK TIMING (EST) — ECM controlled timing of ignition spark.

FEDERAL — Car engine available in all states except California.

HIGH IMPEDANCE VOLTMETER — Has high opposition to the flow of electrical current. Good for reading circuits with low current flow, such as, found in the system.

HYDROCARBONS (HC) — One of the pollutants found in engine exhaust.

IDEAL MIXTURE — The air/fuel ratio which provides the best performance, while maintaining maximum conversion of exhaust emissions, typically 14.7/1.

IDLE AIR BLEED VALVE — Controls the amount of air let into the idle fuel mixture prior to the mixture entering the idle system, when the M/C solenoid is energized.

IDLE SPEED CONTROL MOTOR (ISC) — Regulates throttle valve position. Is controlled by the ECM.

INPUTS — Information from sources (coolant temperature sensors, exhaust oxygen sensor, etc.) that tells the ECM how the engine is performing.

INTERMITTENT — Occurs now and then; not continuously. In electrical circuits, refers to occasional open, short, or ground.

MALFUNCTION — A problem that causes the system to operate incorrectly. Typical malfunctions are: wiring harness opens or shorts, failed sensors or, M/C solenoid or ECU failure.

MANIFOLD PRESSURE SENSOR (MAP) — Reads pressure changes in intake manifold. May be called MAP, or manifold absolute pressure sensor.

MANIFOLD VACUUM SENSOR — Reads pressure changes in intake manifold in relation to barometric pressure. May be called manifold barometric pressure sensor, or differential sensor.

MIXTURE CONTROL (M/C) SOLENOID — Device, installed in carburetor, which regulates the air/fuel ratio.

MODE — A particular state of operation.

NATIONAL — Car/engine available in all states.

NITROGEN, OXIDES OF (NOx) — One of the pollutants found in engine exhaust.

OPEN LOOP — Describes ECM control of the M/C solenoid without use of the oxygen sensor information.

OUTPUT — Functions, typically solenoids, that are controlled by the ECM.

OXYGEN SENSOR, EXHAUST — Device that detects the amount of oxygen (O_2) in the exhaust stream, and sends that information to the ECM.

PROM — Programmable Read Only Memory; an electronic term used to describe the engine calibration unit (ECU).

SELF-DIAGNOSTIC CODE — The ECM can detect malfunctions in the system. If a malfunction occurs, the ECM turns on the "CHECK ENGINE" light. A diagnostic code can be obtained from the ECM through the "Check Engine" light. This code will indicate the area of the malfunction.

TORQUE CONVERTER CLUTCH (TCC) — ECM controlled solenoids in transmission which positively couples the transmission to the engine.

THROTTLE POSITION SENSOR (TPS) — Device that tells the ECM when the throttle position changes.

TVS — Thermal Vacuum Switch. Used to control vacuum in relationship to engine temperature.

VACUUM, MANIFOLD — Vacuum source in manifold below throttle plate.

VACUUM, PORTED — Vacuum source in carburetor above closed throttle plate.

VEHICLE SPEED SENSOR (VSS) — Sensor in speedometer cluster which sends vehicle speed information to the electronic control module.

Fig. 6E1-90—Glossary of Terms

ATTACHMENT 4

Test Vehicle Description

Model/Year	1981
Make	Chevrolet Camero Z-28
Emission Control System	EGR, air injection, closed loop, dual bed catalytic converter
Engine Configuration	V-8
Bore x Stroke	4.00 inches x 3.48 inches
Displacement	350.0 cubic inches
Rated Horsepower	155
Transmission	A-3 lock-up
Chassis Type	Sedan
Tire Size	P 225/70 R 15
Inertial Weight	4000 lbs.
Vin	P87LX BL 103466
AHP	8.2
Engine Family	AVA 5.7L 11L4AC
Fuel Type	Unleaded - IND HO
Compression Ratio	8.2:1

ATTACHMENT 5

DILUTE SAMPLE TESTING

		FTP					HFET					
Date	**Test Numbers**	**HC**	**CO**	**CO_2**	**NOx**	**FE**	**HC**	**CO**	**CO_2**	**NOx**	**FE**	**Comments**
8 Oct. 80	80-6331-32	0.206	1.40	618.	0.69	14.3	0.64	0.02	422.	0.52	21.0	Baseline
9 Oct. 80	80-6333-34	0.257	1.89	618.	0.66	14.3	0.056	0.03	424.	0.51	20.9	Baseline
15 Oct. 80	80-6335-36	1.083	31.58	666.	0.22	12.3	0.111	18.20	458.	0.26	18.2	MCS disconnected*
16 Oct. 80	80-6337-38	1.120	51.96	729.	0.29	10.9	0.248	41.74	521.	0.20	15.1	CTS disconnected*
21 Oct. 80	80-6339-40	1.020	50.24	692.	0.33	11.5	0.123	20.23	470.	0.29	17.7	TPS disconnected*
28 Oct. 80	80-6344-6625	6.289	209.06	432.	0.24	11.5	2.578	112.59	312.	0.15	17.8	MCS disconnected
29 Oct. 80	80-6626-27	0.566	37.13	671.	0.34	12.1	1.105	65.53	390.	0.16	17.9	EGO sensor shorted
30 Oct. 80	80-6628-29	6.203	213.46	445.	0.29	11.1	2.717	119.07	313.	0.16	17.4	TPS disconnected
31 Oct. 80	80-6630-31	0.220	1.75	589.	2.57	15.0	0.267	7.52	400.	1.14	21.5	EGO disconnected
4 Nov. 80	80-6632-33	0.200	1.64	594.	0.90	14.8	0.054	0.01	412.	0.59	21.5	Baseline
5 Nov. 80	80-6634-35	0.174	1.18	586.	0.90	15.6	0.053	0.02	418.	0.62	21.2	Baseline

* These three test sequences were run with an open circuit in the air switching solenoid in addition to the listed disablements. This causes air to be supplied to the catalyst continuously.

ATTACHMENT 6

I/M Testing Before Catalysts

Date	Test Numbers	50 Cruise	4 Mode Idle				Two Mode Loaded		Comments
			Idle	2500	Idle	Drive	30 MPH	Idle	
		HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	HC/CO	
8 Oct. 80	80-6331-32	90/.45	100/.10	70/.60	160/.45	190/.70	140/.90	170/.50	Baseline
9 Oct. 80	80-6333-34	90/.45	160/.45	80/.45	150/.40	200/.45	130/.80	175/.50	Baseline
15 Oct. 80	80-6335-36	160/5.20	300/5.60	195/6.40	400/6.00	325/6.20	200/4.60	310/6.0	MCS disconnected*
16 Oct. 80	80-6337-38	110/5.20	200/4.40	110/5.40	200/4.80	230/4.60	125/5.60	195/4.30	CTS disconnected*
21 Oct. 80	80-6339-40	180/6.00	300/5.80	180/5.80	340/6.20	340/6.20	200/5.60	360/6.80	TPS disconnected*
28 Oct. 80	80-6344-6625	185/6.50	340/6.2	240/7.70	370/6.70	350/6.70	210/5.60	380/6.90	MCS disconnected
29 Oct. 80	80-6626-27	200/6.50	340/6.40	240/8.00	440/6.50	340/6.10	240/6.80	320/6.10	EGO sensor shorted
30 Oct. 80	80-6628-29	200/6.50	330/5.80	210/6.80	340/6.50	360/6.60	220/5.70	380/6.70	TPS disconnected
31 Oct. 80	80-6630-31	95/.75	65/.13	20/.35	90/.13	100/.18	80/.80	80/.15	EGO disconnected
4 Nov. 80	80-6632-33	90/.48	150/.42	60/.58	140/.60	180/.60	120/.85	150/.43	Baseline
5 Nov. 80	80-6634-35	95/.60	170/.42	70/.50	145/.40	190/.50	140/.80	160/.41	Baseline

* These three test sequences were run with an open circuit in the air switching solenoid in addition to the listed disablements. This causes air to be supplied to the catalyst continuously.

I/M Testing After Catalysts

			4 Mode Idle				Two Mode Loaded		
Date	Test Numbers	50 Cruise HC/CO	Idle HC/CO	2500 HC/CO	Idle HC/CO	Drive HC/CO	30 MPH HC/CO	Idle HC/CO	Comments
8 Oct. 80	80-6331-32	30/.02	30/.02	30/.02	30/.02	30/.02	40/.02	30/.02	Baseline
9 Oct. 80	80-6333-34	20/.02	30/.02	30/.02	30/.02	30/.02	30/.02	40/.05	Baseline
15 Oct. 80	80-6335-36	35/.80	20/.15	25/.75	20/.18	25/.18	30.55	40/.18	MCS disconnected*
16 Oct. 80	80-6337-38	20/1.60	30/.20	20/.80	30/.15	20/.15	30/1.0	20/.15	CTS disconnected*
21 Oct. 80	80-6339-40	30/1.00	20/.05	20/.30	30/.06	20/.20	40/.30	20/.08	TPS disconnected*
28 Oct. 80	80-6344-6625	180/5.70	365/6.30	270/7.70	390/6.80	360/6.60	210/5.60	390/6.90	MCS disconnected
29 Oct. 80	80-6626-27	190/6.30	30/.08	230/8.50	50/.05	40/.35	210/6.20	50/.07	EGO sensor shorted
30 Oct. 80	80-6628-29	200/6.30	370/6.00	260/7.00	430/6.50	370/6.60	220/5.00	390/6.50	TPS disconnected
31 Oct. 80	80-6630-31	40/.15	20/.02	20/.02	20/.02	20/.02	20/.02	20/.05	EGO disconnected
4 Nov. 80	80-6632-33	20/.02	30/.02	22/.02	18/.02	16/.02	20/.02	19/.02	Baseline
5 Nov. 80	80-6634-35	18/.02	30/.02	28/.02	19/.02	28/.02	30/.02	30/.02	Baseline

* These three test sequences were run with an open circuit in the air switching solenoid in addition to the listed disablements. This causes air to be supplied to the catalyst continuously.

ATTACHMENT 7

Results of Propane Injection Diagnostic Procedure

1 CFH Propane

Date	Test Numbers	RPM	ICO	Code	RPM	RPM	ICO	Code	RPM	RPM	ICO	Comments
8 Oct. 80	80-6331-32	850	.02	7		850	.02	7		850	.02	Baseline
9 Oct. 80	80-6333-34	760	.02	2		700	.02	2		700	.02	Baseline
15 Oct. 80	80-6335-36	800	.12	7		790	.17	7		790	.17	MCS disconnected*
16 Oct. 80	80-6337-38	630	.15	7		620	.20	7		620	.15	CTS disconnected*
21 Oct. 80	80-6339-40	960	.05	7		960	.08	7		960	.05	TPS disconnected*
23 Oct. 80	80-6344-6625	870	6.3	7		870	7.3	7		870	6.4	MCS disconnected
29 Oct. 80	80-6626-27	950	.05	1		1030	.10	2		950	.05	EGO sensor shorted
30 Oct. 80	80-6628-29	775	6.3	2		765	7.0	1		775	6.2	TPS disconnected
31 Oct. 80	80-6630-31	680	.05	1		700	.05	2		670	.05	EGO disconnected
4 Nov. 80	80-6632-33	720	.02	3	730	725	.02	7		715	.02	Baseline
5 Nov. 80	80-6634-35	760	.02	3	760	740	.02	2		725	.02	Baseline

* These three test sequences were run with an open circuit in the air switching solenoid in addition to the listed disablements. This causes air to be supplied to the catalyst continuously.

2 CFH Propane

Date	Test Numbers	RPM	%CO	Code	RPM	RPM	%CO	Code	RPM	RPM	%CO	Comments
8 Oct. 80	80-6331-32	850	.02	7		850	.02	7		850	.02	Baseline
9 Oct. 80	80-6333-34	720	.02	4	600	720	.02	4	680	720	.02	Baseline
15 Oct. 80	80-6335-36	800	.13	7		790	.20	7		790	.15	MCS disconnected*
16 Oct. 80	80-6337-38	630	.12	7		620	.20	7		620	.14	CTS disconnected*
21 Oct. 80	80-6339-40	960	.05	4	700	960	.08	4	760	960	.05	TPS disconnected*
23 Oct. 80	80-6344-6625	870	6.4	7		870	7.7	7		870	6.6	MCS disconnected
29 Oct. 80	80-6626-27	950	-	1		980	.20	7		980	.04	EGO sensor shorted
30 Oct. 80	80-6628-29	835	6.7	2		760	7.4	1		770	6.5	TPS disconnected
31 Oct. 80	80-6630-31	680	.04	1		710	.04	2		675	.04	EGO disconnected
4 Nov. 80	80-6632-33	730	.02	3	750	730	.02	4	715	720	.02	Baseline
5 Nov. 80	80-6634-35	740	.02	3	750	715	.02	4	700	720	.02	Baseline

* These three test sequences were run with an open circuit in the air switching solenoid in addition to the listed disablements. This causes air to be supplied to the catalyst continuously.

3 CFH Propane

Date	Test Numbers	RPM	ICO	Code	RPM	RPM	ICO	Code	RPM	RPM	ICO	Comments
8 Oct. 80	80-6331-32	850	.02	7		850	.02	7		850	.02	Baseline
9 Oct. 80	80-6333-34	720	.02	4	680	700	.02	4	640	700	.02	Baseline
15 Oct. 80	80-6335-36	860	.12	2		790	.25	7		790	.15	MCS disconnected*
16 Oct. 80	80-6337-38	640	.12	7		620	.20	7		620	.15	CTS disconnected*
21 Oct. 80	80-6339-40	960	.05	4	740	940	.09	7		960	.05	TPS disconnected*
23 Oct. 80	80-6344-6625	870	6.7	2		850	8.0	1		870	6.7	MCS disconnected
29 Oct. 80	80-6626-27	980	.04	-	-	-	-	-	-	-	-	EGO sensor shorted
30 Oct. 80	80-6628-29	830	6.7	2		745	7.5	1		775	6.7	TPS disconnected
31 Oct. 80	80-6630-31	685	.04	1		740	.04	2		675	.04	EGO disconnected
4 Nov. 80	80-6632-33	740	.02	3	745	725	.02	4	720	725	.02	Baseline
5 Nov. 80	80-6634-35	740	.02	3	770	730	.02	4	710	730	.02	Baseline

Note: Propane test was aborted for test numbers 80-6626-27 at 3 CFH due to equipment failure.

* These three test sequences were run with an open circuit in the air switching solenoid in addition to the listed disablements. This causes air to be supplied to the catalyst continuously.

4 CFH Propane

Date	Test Numbers	RPM	ICO	Code	RPM	RPM	ICO	Code	RPM	RPM	ICO	Comments
8 Oct. 80	80-6331-32	850	.02	7		850	.02	7		850	.02	Baseline
9 Oct. 80	80-6333-34	720	.02	4	580	720	.02	4	680	700	.02	Baseline
15 Oct. 80	80-6335-36	790	.13	2		750	.20	1		790	.15	MCS disconnected*
16 Oct. 80	80-6337-38	640	.12	7		620	.18	7		620	.15	CTS disconnected*
21 Oct. 80	80-6339-40	960	.05	4	540	900	.09	4	760	940	.05	TPS disconnected*
23 Oct. 80	80-6344-6625	870	6.7	2		840	8.2	1		870	6.7	MCS disconnected
29 Oct. 80	80-6626-27	-	-	-	-	-	-	-	-	-	-	EGO sensor shorted
30 Oct. 80	80-6628-29	765	6.8	2		720	8.2	1		755	6.5	TPS disconnected
31 Oct. 80	80-6630-31	675	.04	1		740	.04	2		675	.04	EGO disconnected
4 Nov. 80	80-6632-33	735	.02	3	775	715	.02	4	670	720	.02	Baseline
5 Nov. 80	80-6634-35	735	.02	3	770	735	.02	4	690	720	.02	Baseline

* These three test sequences were run with an open circuit in the air switching solenoid in addition to the listed disablements. This causes air to be supplied to the catalyst continuously.

ATTACHMENT 8

Results of On-Board Diagnostic Check

Date	Test Numbers	Trouble Codes Output	Trouble Code Identification	Comments
8 Oct. 80	80-6331-32	No test	12 = System operational verification	Baseline
9 Oct. 80	80-6333-34	No test	23 = M/C solenoid, 45 = rich system	Baseline
15 Oct. 80	80-6335-36	12-23-45	15 = Open coolant sensor circuit	MCS disconnected*
16 Oct. 80	80-6337-38	12-15	21 = Throttle position sensor circuit	CTS disconnected*
21 Oct. 80	80-6339-40	12-21	23 = M/C solenoid, 45 = rich system	TPS disconnected*
23 Oct. 80	80-6344-6625	12-23-45	44 = Lean oxygen sensor	MCS disconnected
29 Oct. 80	80-6626-27	12-44	21 = Throttle position sensor	ECO sensor shorted
30 Oct. 80	80-6628-29	12-21	13 = Oxygen sensor circuit	TPS disconnected
31 Oct. 80	80-6630-31	12-13		ECO disconnected
4 Nov. 80	80-6632-33	12		Baseline
5 Nov. 80	80-6634-35	12		Baseline

* These three test sequences were run with an open circuit in the air switching solenoid in addition to the listed disablements. This causes air to be supplied to the catalyst continuously.