EPA-AA-IMS/80-9

Evaluation of the Applicability of Inspection/Maintenance Tests On A Toyota Celica Supra

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NOTICE

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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 Toyota car with a computer based emission control system. This car had a microprocessor based fuel injection system and a small light-off catalyst followed by a three-way catalyst. After suitable baselines 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.

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 procedures used by Inspection/Maintenance programs be capable of identifying vehicles with equipment failure and parameter maladjustment which result in excessive in-use emissions. With the advent of the use of advanced electronics on 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 most advanced and representative electronics of the future have been tested according to both the Federal Test Procedure and various 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 fourth such automobile tested by EPA, a 1980 Toyota Celica Supra with a microprocessor controlled emission control system.

HISTORY

The Toyota Celica Supra is a 1980 production vehicle rented from a local Toyota dealer. This particular vehicle, which has a 50-state emission package, was delivered to EPA on 15 May 1980. The vehicle was delivered with over 3000 miles and used briefly in another test program. At 3351 miles, I/M baseline testing started.

After two baseline sequences were run, the vehicle was tested with eight different component deactivations. Two final confirmatory baseline sequences were then run. The testing was completed on 15 October 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.

The propane injection procedure is still in the development stage. Some difficulties were encountered by the technicians in applying the 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.

I/M test HC and CO measurements were recorded before, between and after the catalysts. A worksheet recording the I/M test results is shown in Attachment 2.

VEHICLE DESCRIPTION

The Toyota Celica Supra used for this testing was a production vehicle with a 50-state 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, several components of the emission control system were, one by one, deactivated prior to vehicle testing.

a. Idle Adjust Connector Shorted - Test numbers 80-5387 and 80-5388 were run with the idle adjust connector shorted. Shorting the idle adjust connector causes the feedback control circuit to be in an open loop configuration.

b. O_2 Sensor Disconnected and Grounded - Tests Numbers 80-5389 and 80-5390 were run with the exhaust gas oxygen sensor disconnected and grounded. This unit supplies a voltage signal to the feedback control circuit based on the oxygen content of the exhaust stream. By disconnecting and grounding the sensor lead the voltage sensed by the computer is insured to be zero and the closed loop system goes to full rich.

c. O_2 Sensor Disconnected and Open - Test numbers 80-5391 and 80-5392 were run with the exhaust gas oxygen sensor disconnected and the lead left open-circuited. This test is similar to the previous test except that the voltage sensed by the computer is not necessarily zero. In this case the feedback system is cut off and the vehicle operates in open loop mode.

d. One Injector Disconnected - Test numbers 80-5393 and 80-5394 were run with the number 5 fuel injector electrically disconnected. The deactivated cylinder continues to draw air and some residual fuel from the intake manifold resulting in a leaner then normal exhaust.

e. Throttle Position Sensor Disconnected - Test numbers 80-6291 and 80-6292 were run with the throttle position sensor electrically disconnected. This device informs the microprocessor when the throttle is in idle or full load positions. Disconnecting this device eliminates idle and full load enrichment.

f. EGR Disconnected - Test numbers 80-6293 and 80-6294 were run with the signal vacuum sources to EGR valves A and B disconnected and plugged. When properly operating this device resubmits a portion of the burned exhaust gas into the combustion chamber. This exhaust gas lowers the peak combustion chamber temperature resulting in reduced NOx formation.

g. Baseline - Test numbers 80-6328 and 80-6329 were in a baseline configuration.

h. Spark Control BVSV Closed - Test numbers 80-6355 and 80-6356 were run with the vacuum lines to the spark control Bimetalic Vacuum Switching Valve (BVSV) disconnected and plugged to simulate a closed BVSV. The BVSV is a thermally operated vacuum routing switch. The BVSV is closed during cold engine operation resulting in advanced ignition timing.

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 I/M test data. Since there are two catalytic converters on this vehicle, values are given for readings taken before, between and after the catalysts.

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

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 possibly engine speed, should first increase, but then return to normal as the carburetor compensates for the richer mixture.

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 accesories 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 bahavior

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		Between Catalysts		After Catalysts	
	HC	CO	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.
  For D208 this is equivalent to IHP = 7.3.

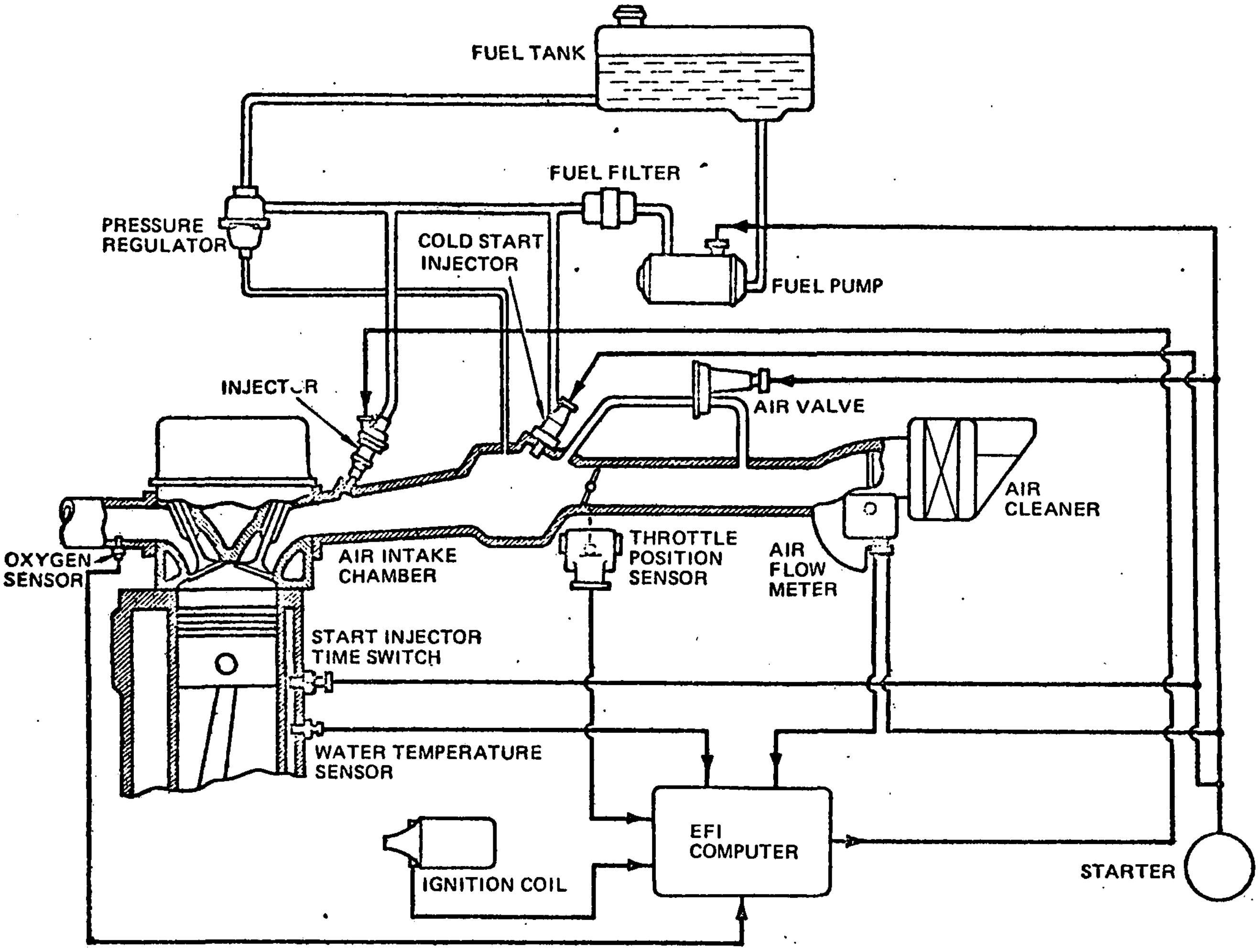
ELECTRONIC CONTROL SYSTEM

The EFI computer receives signals from various sensors indicating changing engine operating conditions such as:

Intake air volume
Intake air temperature
Coolant temperature
Engine load
Acceleration/deceleration
Exhaust oxygen content ete.

These signals are utilized by the EFI computer to determine the injection duration necessary for an optimum air-fuel ratio.

ATTACHMENT 3



SYSTEM DESCRIPTION

The EFI used on Toyotas has three basic systems:

FUEL SYSTEM

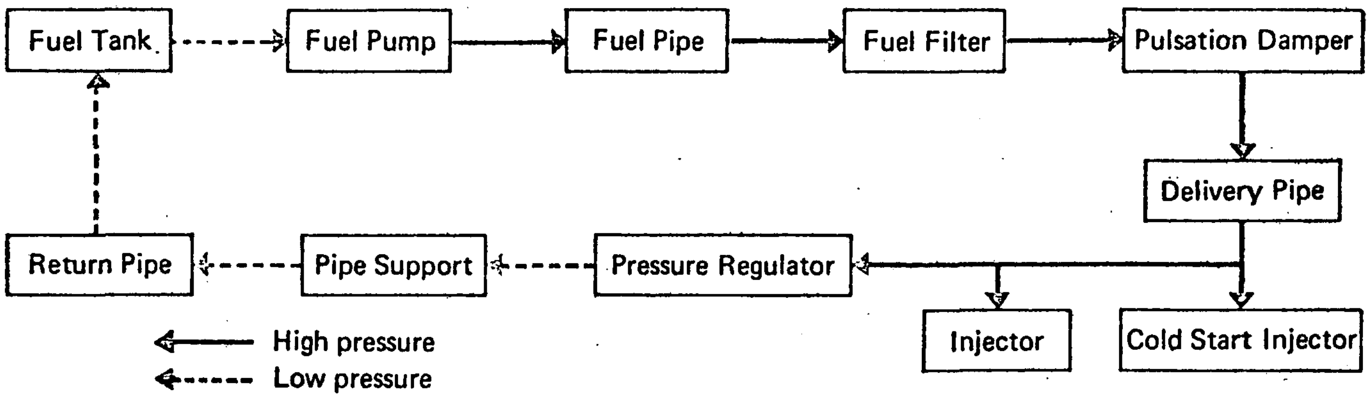
An electric fuel pump supplies sufficient fuel, under a constant pressure, to the EFI injectors. These injectors inject a metered quantity of fuel into the intake manifold in accordance with signals from the EFI computer. Each injector injects, at the same time, one half of the fuel required for ideal combustion with each engine revolution.

AIR INDUCTION SYSTEM

The air induction system provides sufficient air for engine operation.

FUEL SYSTEM

FUEL FLOW



Fuel is drawn from the fuel tank by the fuel pump and distributed through the fuel filter, under pressure, to the injectors and cold start injector respectively.

The pressure regulator controls the pressure of the fuel line (high pressure side). Excess fuel is returned to the fuel tank through the return pipe.

The pulsation damper acts to absorb the slight fuel pressure fluctuations due to fuel injection.

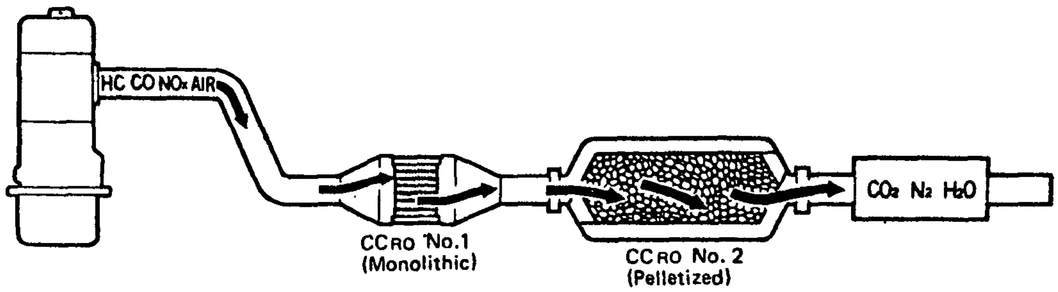
The injector performs the injection of fuel into the intake manifold in accordance with the computer-calculated injection signals.

The cold start injector is provided to improve starting by injecting fuel into the air intake chamber only when the coolant temperature is low.

CATALYTIC CONVERTER (CCRO) SYSTEM

OPERATION

Fig. 3-51



To reduce CO, HC and NOx emission, they are oxidized, reduced and converted to dinitrogen (N_2), carbon dioxide (CO_2) and water (H_2O) in the catalytic converters, No. 1 and No. 2.

Exhaust port		Converter No.1 and No.2		Exhaust gas
Unburnt HC, CO, NOx air and proper temp.	⇒	OXIDATION AND REDUCTION (Temperature is increased.)	⇒	CO_2 H_2O N_2

INSPECTION

1. Inspect exhaust pipe assembly.

(1) **Inspect connections.**
Look for looseness or damage.

(2) **Inspect clamps.**
Look for weakness, cracks or damage.

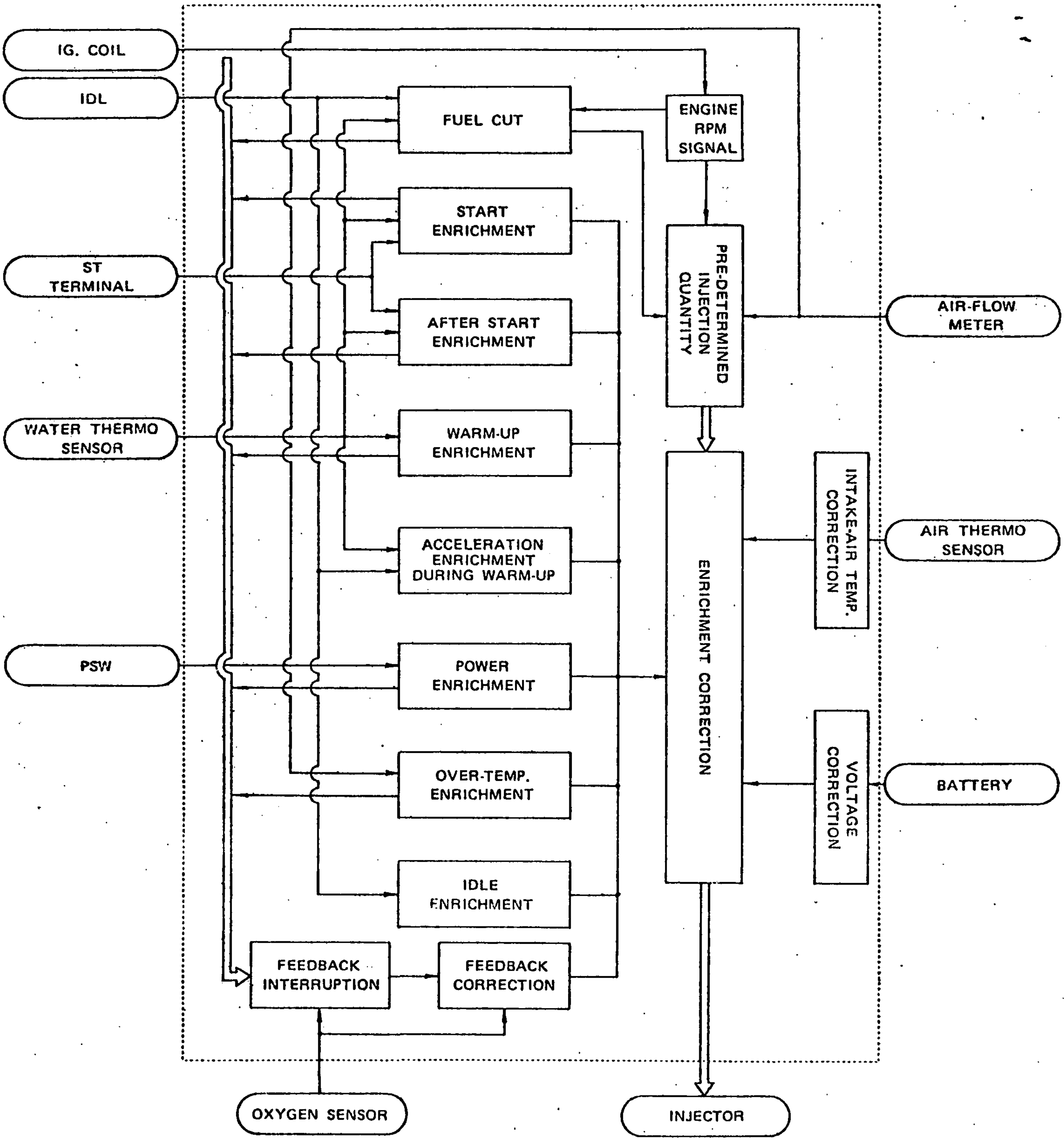
ELECTRONIC CONTROL SYSTEM

The electronic control system contains sensors which detect various engine conditions as electrical signals, and a computer, which determines the duration of injection according to the electrical signals from these sensors.

SENSORS AND FUNCTIONS

SENSOR	FUNCTION
Air Flow Meter	Detects intake air volume as a voltage ratio using a potentiometer.
Throttle Position Sensor	Detects the heavy load and idle conditions according to the throttle valve opening.
Water Thermo Sensor	Detects coolant temperature.
Air Thermo Sensor	Detects the intake air temperature.
O_2 Sensor	Detects the oxygen density inside the exhaust pipe.
Start Injector Time Switch	Is activated when the coolant temperature is low and signals the computer operate to the cold start injector during starting.
Ignition Primary Signal	Detects injection timing and engine rpm by means of an ignition primary signal.
Starter Signal	Detects engine cranking.

4M-E ELECTRONIC CONTROL UNIT (COMPUTER)



COMPUTER FUNCTIONS

Based on the signal from the air flow meter, the computer determines the necessary fuel injection quantity making corrections in accordance with the signals from the other sensors.

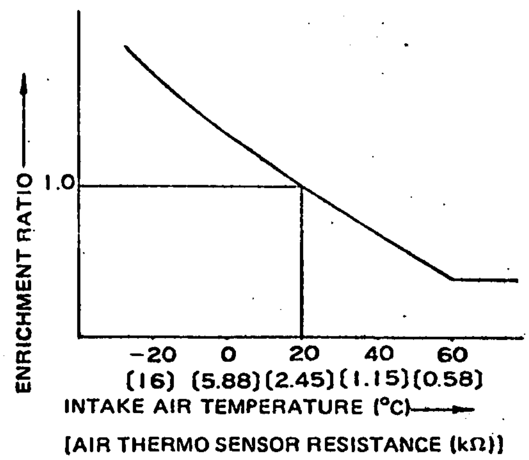
PRE-DETERMINED INJECTION QUANTITY CHARACTERISTIC

This is determined by both the intake air volume detected by the air flow meter and the engine rpm detected by the primary ignition signal.

$$\text{Injection Quantity} = K \frac{\text{Intake Air Volume}}{\text{Engine rpm}}$$

$$K = \text{a coefficient}$$

1. INTAKE AIR TEMPERATURE CORRECTION



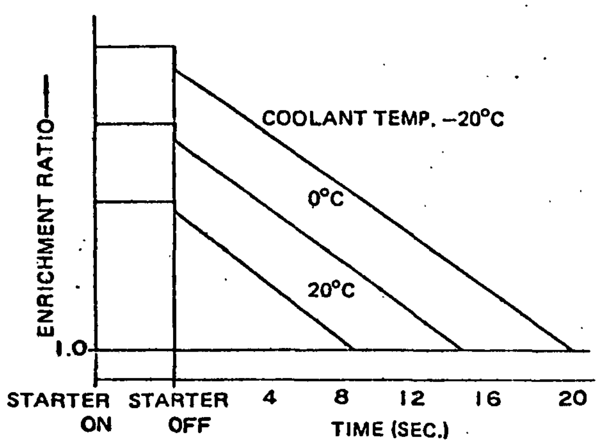
This is accomplished by a signal from the air thermo sensor and prevents an air-fuel ratio discrepancy due to air density fluctuations occuring because of temperature changes. With 20°C as the standard, injection quantity will be increased if the air temperature goes lower and decreased if the air temperature goes higher.

When the intake air temperature is low, the air will be contracted resulting in more weight per volume. Therefore, the air-fuel mixture will be learner. Thus, the correction is accomplished by increasing fuel injection quantity during low temperature.

2. START ENRICHMENT

To improve the startability, the injection quantity during starting is increased.

3. AFTER START ENRICHMENT



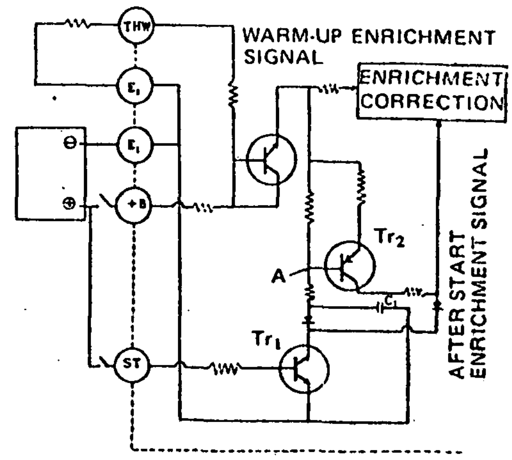
After the engine has started (the starter motor no longer cranking), injection pulse duration will be increased for a limited time. The quantity increase will be at maximum while cranking and will gradually decrease with time. The enrichment ratio will vary with the water temperature.

– Reference only –

As for the after start enrichment, a condensor is utilized for correction of the enrichment ratio variation.

EX.

The reason the after start enrichement ratio varies according to the coolant temperature is because the coolant temperature enrichment signal is utilized as the power source of the after start enrichment.



AFTER START ENRICHMENT THEORY

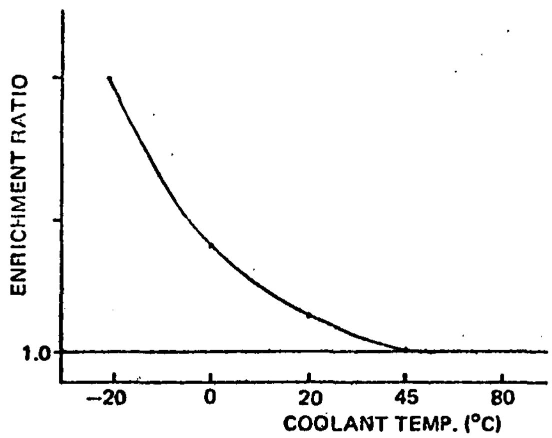
(1) When the starter switch is closed (ON), both transistor Tr1 and Tr2 are turned "ON" However, the current from Tr2 to the enrichment correction circuit is grounded by Tr1, so there is no current flow to the after start enrichment circuit and there is no enrichment. In this state, condensor C1 is in a discharged condition.

(2) When the engine is started, the starter switch will open and, accordingly, so will Tr1. The base current of Tr2 becomes the charging current for C1 and Tr2 remains on. Thus, an after start enrichment signal is sent to the enrichment correction circuit.

(3) As C1 is gradually charged, the voltage at point "A" becomes higher, base current of Tr2 decreases and the current to the enrichment correction circuit is also decreased. In other words, the after start enrichment signal voltage drops as the condensor is charged (the voltage at point "A" rises).

(4) After a limited time (time varies in accordance with the warm-up enrichment signal voltage) C1 will become fully charged, Tr2 is cut off and after start enrichment is terminated.

4. WARM-UP ENRICHMENT

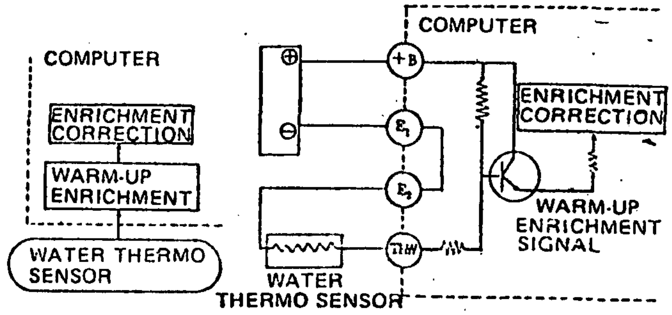


This enrichment is for the purpose of maintaining drivability before the engine is completely warmed up. When the coolant temperature is low, the water thermo sensor will send a signal to increase injection pulse duration. Using 80°C as the standard operating temperature, enrichment will stabilize above 45°C.

— *Reference only* —

The various correction to the pre-determined injection quantity is performed by either increasing or decreasing the current flow. In other words, when there is more current flow to the enrichment correction circuit, the fuel quantity is increased accordingly. Conversely, if there is less current flow to the circuit, the fuel quantity decreases accordingly.

EX.

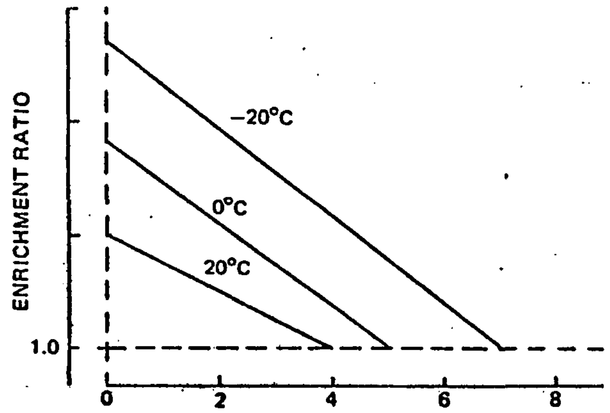


WARM-UP ENRICHMENT THEORY

There is more water thermo sensor resistance when the coolant temperature is low. Thus, there is high voltage in the warm-up enrichment signal flowing from the transistor to the enrichment correction circuit.

As the voltage rises, there is more current flow to the circuit and there is more enrichment. Conversely, as the coolant temperature rises there is less water thermo sensor resistance, the voltage drops, there is less current flow and there is less enrichment.

5. ACCELERATION ENRICHMENT DURING WARM-UP

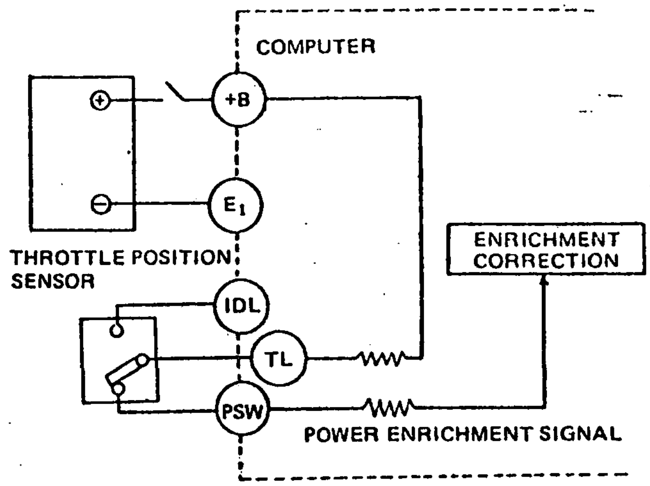


Fuel quantity is increased for acceleration during engine warm-up in order to improve drivability when the engine is still cold. Fuel quantity is increased when the idle contact point of the throttle position sensor is opened. The enrichment ratio will change in relation to the coolant temperature.

6. POWER ENRICHMENT

When the throttle valve is open 60° or more (from closed position), the engine output power range will be detected from the throttle position sensor and, by this signal, the fuel injection will be enriched by 1.19 over the pre-determined injection quantity.

— Reference only —
The power enrichment ratio remains constant because the current flows through a non-variable resistance circuit.



POWER ENRICHMENT THEORY

7. OVER TEMPERATURE ENRICHMENT

To prevent the catalyst converter from overheating, the fuel injection will be enriched when the intake air exceeds certain amount (More than 165 m^3/h).

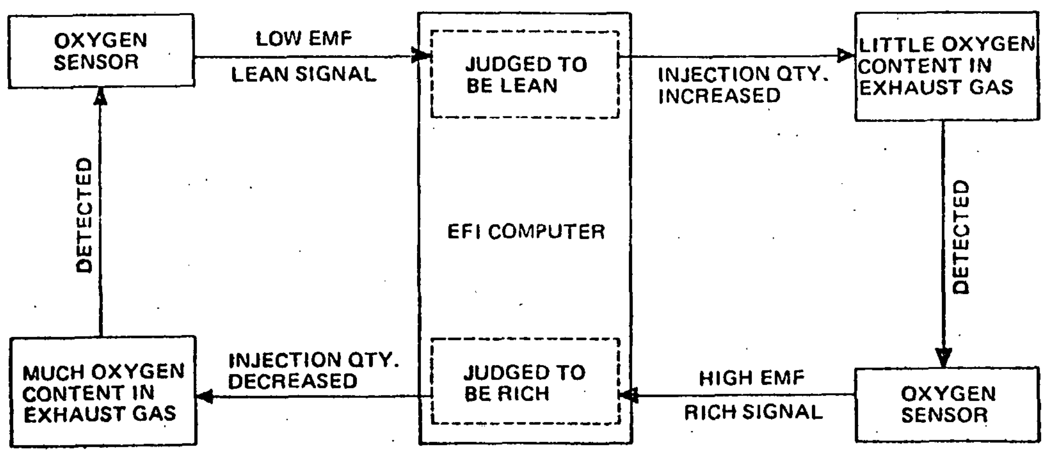
Enrichment Ratio 1.14

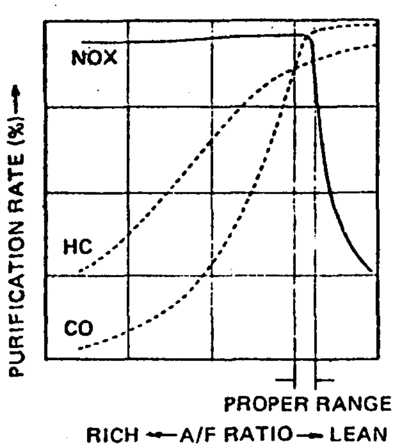
This is detected by the air flow meter output U_S/U_B.

8. IDLING ENRICHMENT

The enrichment is supplied for a stable idling condition by a signal from the throttle position switch which is transmitted to the electronic control unit.

9. AIR-FUEL RATIO COMPENSATION (FEEDBACK CORRECTION)





RELATION BETWEEN AIR-FUEL RATIO AND 3-WAY CATALYTIC CONVERTER PURIFICATION RATE

When the air-fuel ratio is greater (leaner) than the theoritical air-fuel ratio, there will be more air than is required for combustion and, as a result, the exhaust gas will contain oxygen. Conversely, if the ratio is less (richer) than the theoritical ratio, the exhaust gas will contain no oxygen. The O2 sensor will detect oxygen density in the exhaust gas and determine whether the air-fuel ratio is richer or leaner than the theoritical ratio. The signal (either rich or lean) from the O2 sensor is compared within the computer, and if it is higher, the air-fuel ratio is judged to be richer (rich signal) than the theoretical ratio and the fuel injection quantity will be decreased. Conversely, if it is lower, the ratio will be computed as being leaner (lean signal) and injection quantity will be increased. Normally, the quantity is maintained near the theoretical ratio range and the 3-way catalytic converter purification performance will be maintained at high efficiency.

In the illustration above, the cycle is continuous and the air-fuel mixture is controlled to within a fraction of the theoritical ratio.

There is no feedback during the following conditions:

1. When the coolant temperature is below 40°C.
2. When the start and after start enrichment is in operation.
3. When the amount of intake air is increased more than 165 m³/h.

COMPONENT LAYOUT & SCHEMATIC DRAWING

Fig. 3-1

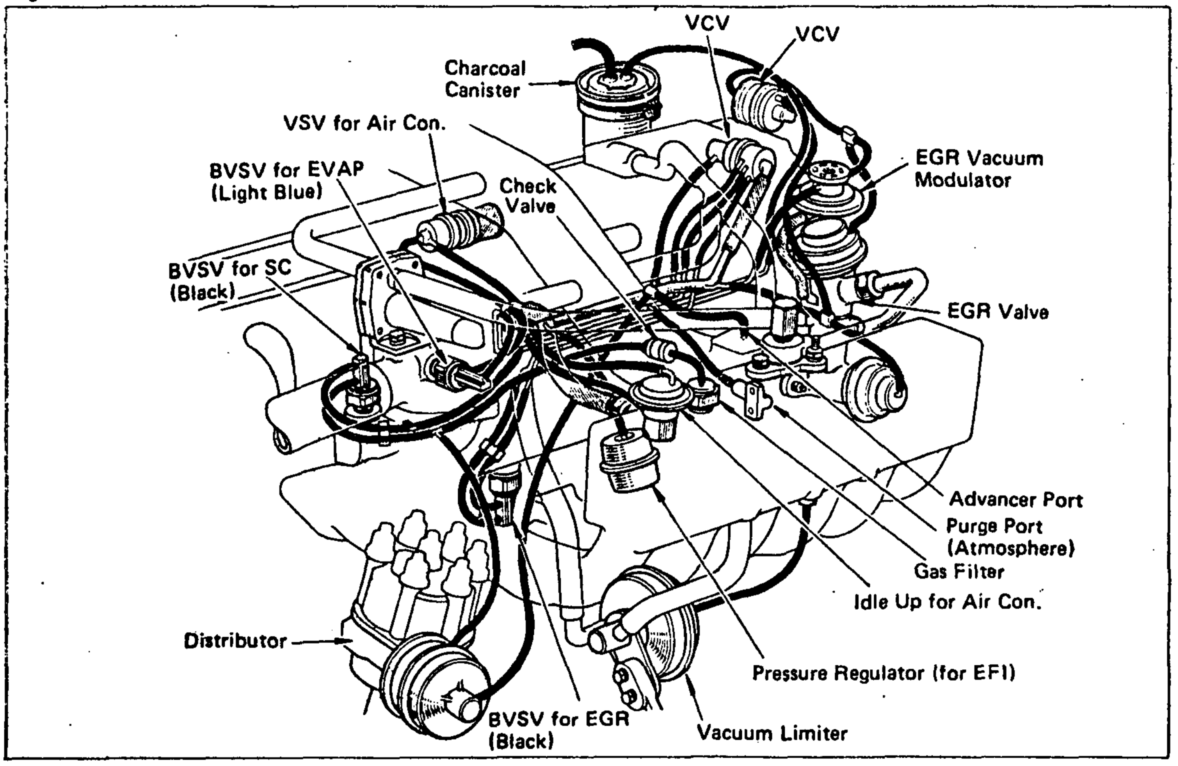


Fig. 3-2

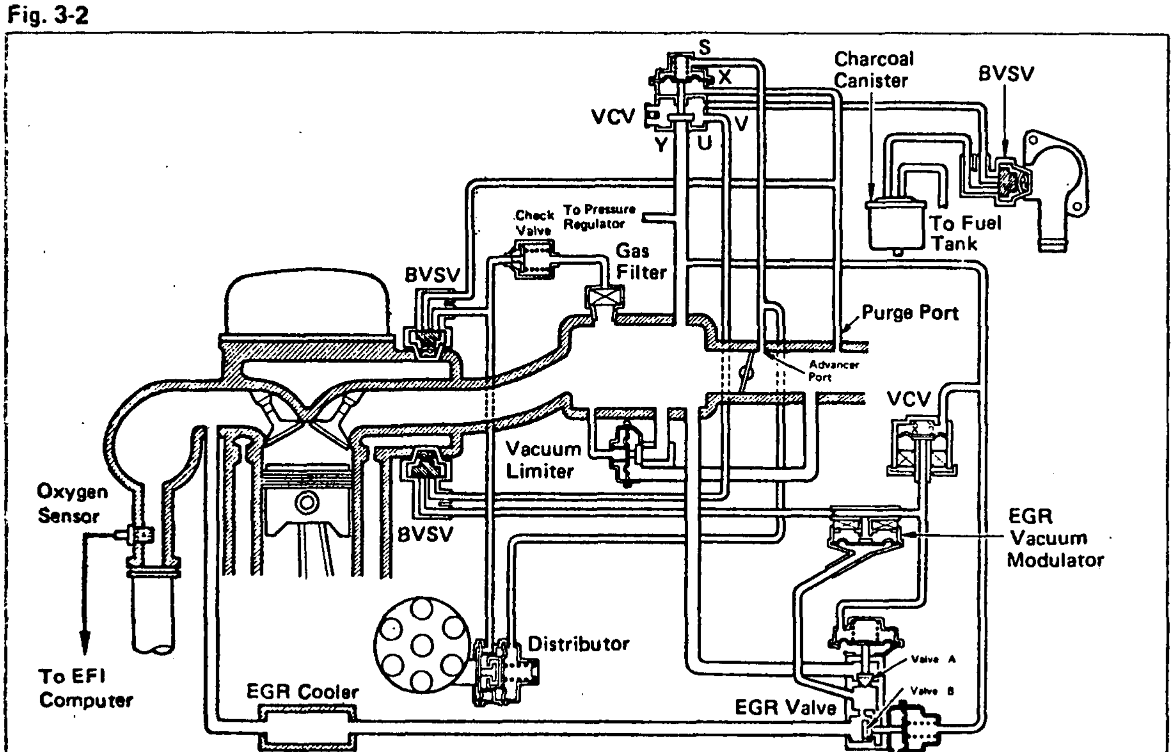
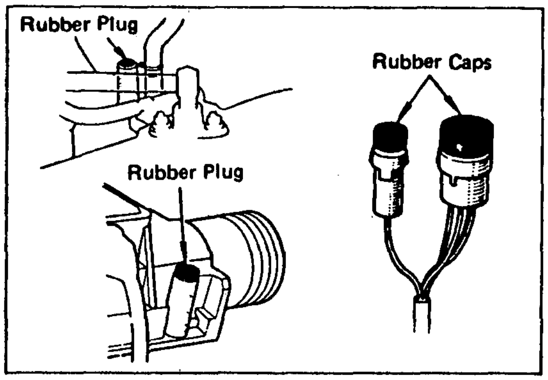


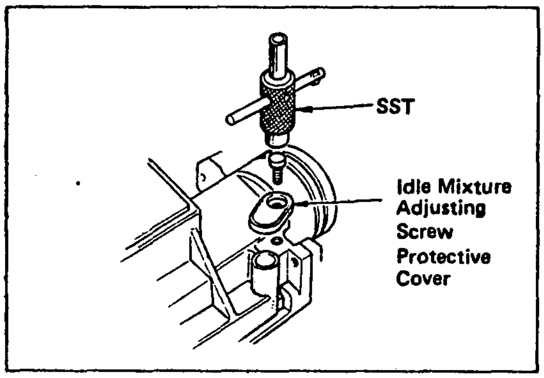
Fig. 4-10



f. Put the rubber plugs into the holes of the idle mixture adjusting screw and idle speed adjusting screw.

g. Remove the EFI checker and install the rubber caps on to the service connectors.

Fig. 4-11



h. (California only)
Install the idle mixture adjusting screw protective cover using SST [09243-00020].

B: (ALTERNATE METHOD)
Adjust idle speed and idle mixture with a voltmeter.

a. Remove the rubber cap from service connector and connect an EFI idle adjusting wiring harness (SST No. 09842-14010) to it.
Service connector location: on the left fender apron as illustrated.

— Warning —
Do not connect the testing probes of the voltmeter to the service connector directly.

b. Connect (+) testing probe to the red wire of the SST and (—) testing probe to the black wire.

Fig. 4-12

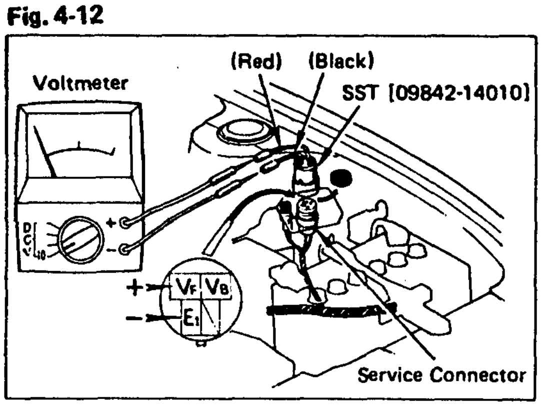
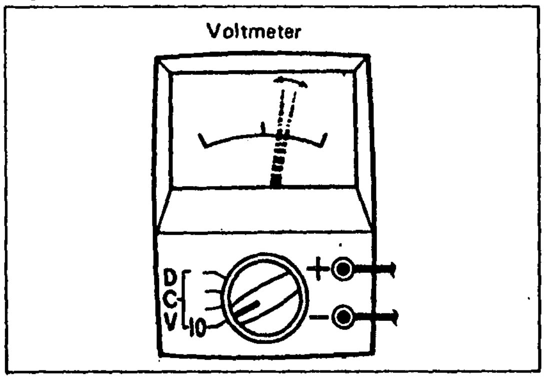
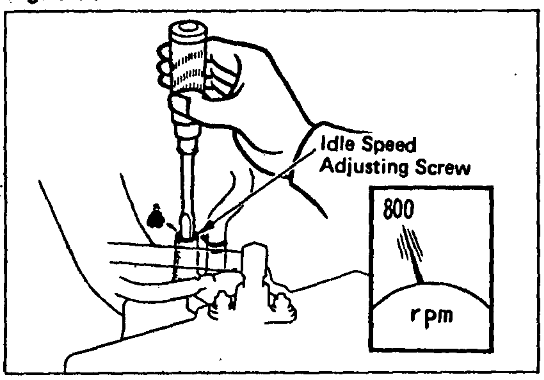


Fig. 4-13



c. Warm-up the oxygen sensor with the engine at 2,500 rpm for about 2 minutes.
d. Verify that needle of the voltmeter is fluctuating at this time.
e. If the needle does not fluctuate, adjust the idle mixture adjusting screw until needle fluctuation is obtained.

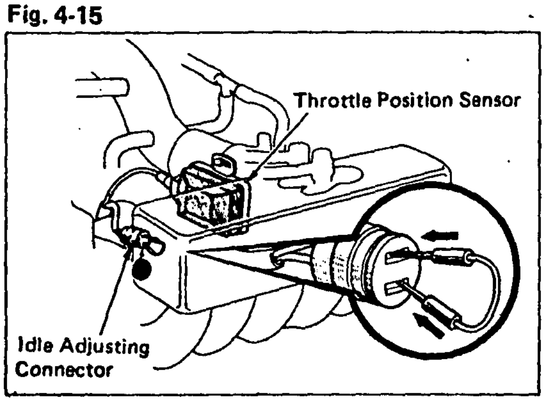
Fig. 4-14



f. Set the idle speed with the IDLE SPEED ADJUSTING SCREW.
Idle speed: 800 rpm

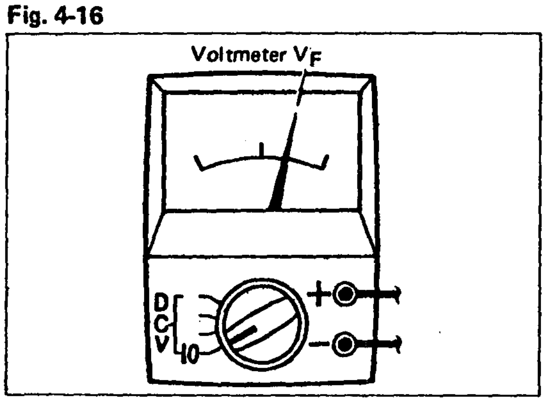
– Note –
Set the idle speed immediately after warming. The needle of the voltmeter should be fluctuating at this time.

Fig. 4-15



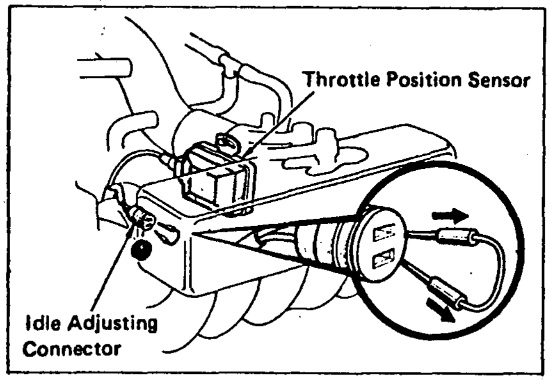
g. Remove the rubber cap from the idle adjusting connector and short both terminals of the connector with a wire.
Idle adjusting connector location:
near the throttle position sensor.
h. Rewarm-up the oxygen sensor with the engine at 2,500 rpm for about 2 minutes.

Fig. 4-16



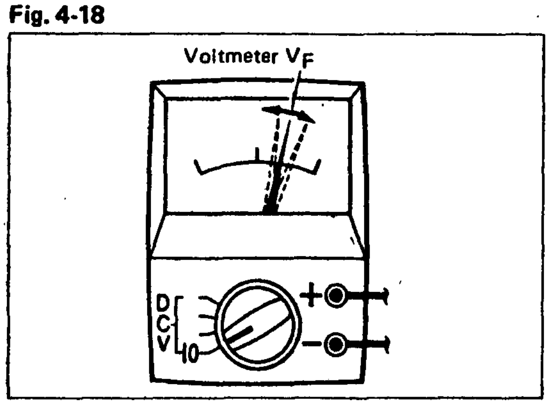
i. Note the indicated voltage (VF) of the voltmeter at idle.

Fig. 4-17



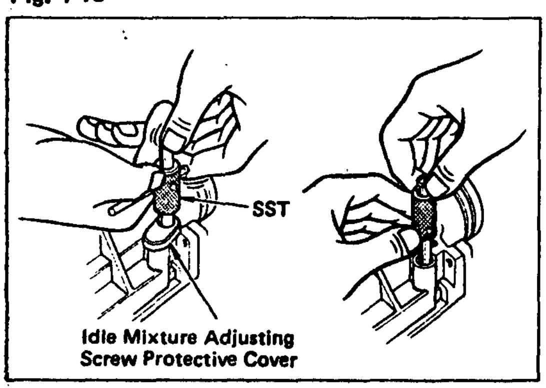
j. Remove the short-circuit wire from the idle adjusting connector.
k. Race the engine to 2,500 rpm once.

Fig. 4-18



l. Adjust the IDLE MIXTURE ADJUSTING SCREW until the median of the indicated voltage range is the same as the VF voltage indicated in item (i).

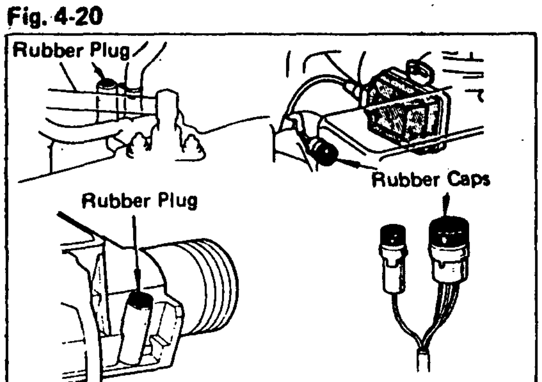
Fig. 4-19



– Note –

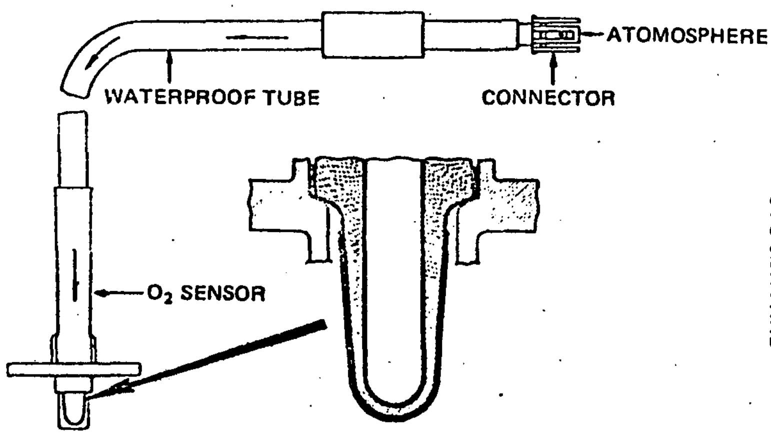
For California, remove the idle mixture adjusting screw protective cover and adjust the idle mixture adjusting screw using SST [09243-00020].

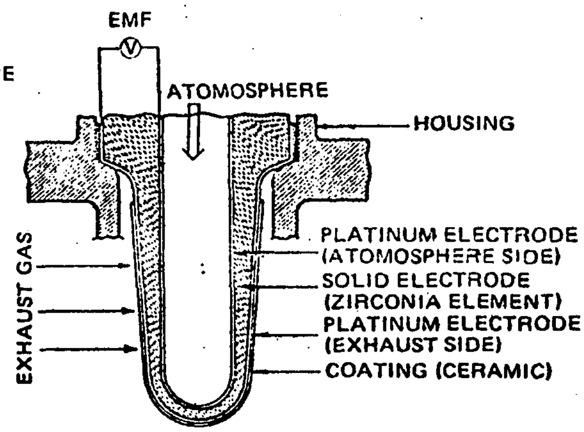
Fig. 4-20



m. Put the rubber plugs into the holes of the idle mixture adjusting screw and idle speed adjusting screw.
n. Remove the voltmeter and SST [09842-14010].
o. Install the rubber caps to the service connectors.

OXYGEN SENSOR



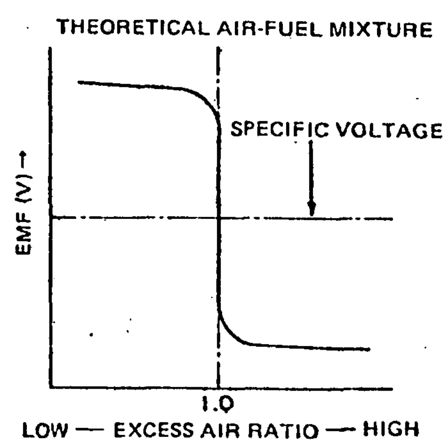


(1) This solid electrolyte type oxygen sensor, installed in the exhaust manifold, utilizes the oxygen concentration cell principle to produce electromotive force (emf) by means of the oxygen density difference in the exhaust gas. A thin layer of platinum is bonded to both surfaces of the test tube-shaped zirconia element. Atmospheric air is directed to the inner surface while the outer surface is exposed to the exhaust gas. The electromotive force (signal) is sent to the computer.

(2) If there is an oxygen density difference on both surfaces of the zirconia element, it will produce electromotive power. If the air-fuel ratio is leaner than the theoretical air-fuel ratio, the electromotive power will be low; if it is richer, the electromotive force will be high. Also, the emf indicates the characteristic of the theoretical air-fuel mixture surrounding when it suddenly changes toward the boundary.

(3) Characteristics of the oxygen sensor generating power.

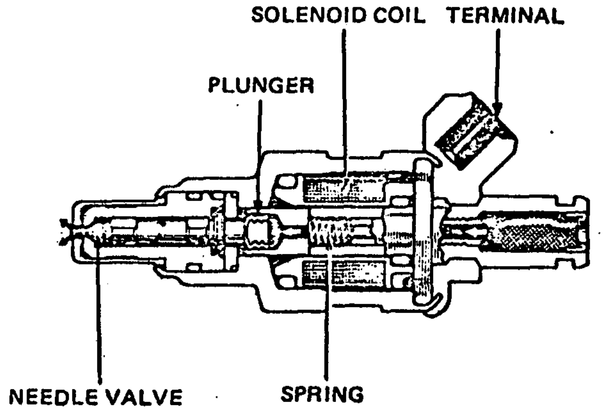
$$\text{Excess air ratio} = \frac{\text{actual air-fuel ratio}}{\text{theoretical air fuel ratio}}$$



FUEL SYSTEM

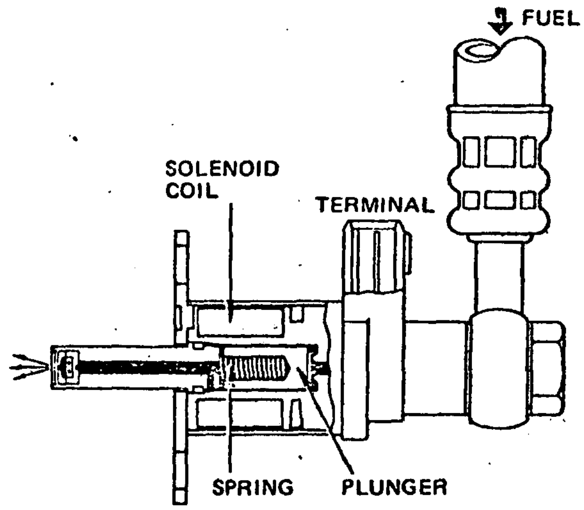
○ INJECTOR ○ COLD START INJECTOR

INJECTOR



The injector performs the injection of fuel in accordance with a computer-calculated injection signal. When a pulse from the computer is received by the solenoid coil, the plunger is pulled against spring tension. Since the needle valve and plunger are a single unit, the valve is also pulled off of the seat and fuel is injected as shown by the arrows. Because the needle valve stroke is fixed, injection continues as long as the needle valve is open and fuel volume is controlled by the duration of the electrical pulse.

COLD START INJECTOR



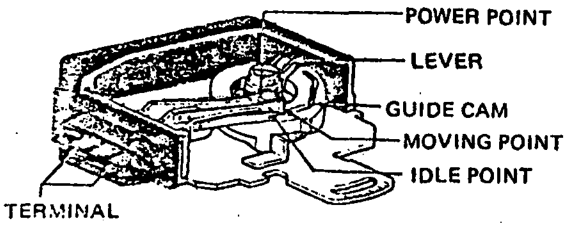
A cold start injector, installed in the center area of the air distribution chamber, is provided to improve starting when the engine is cold.

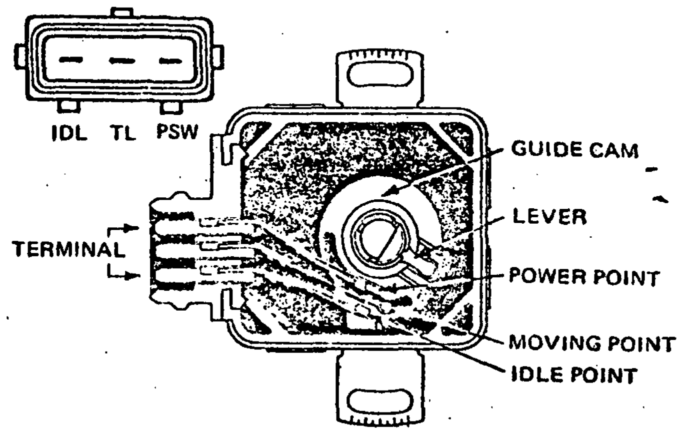
This injector functions in accordance with directions from the start injector time switch and only during engine cranking when the coolant temperature is below 35° C.

The injector tip employs a special design to improve mist spray.

When the start injector time switch signal is applied to the solenoid coil, the plunger is pulled against spring tension. Thus, the valve will open and fuel will flow over the plunger and through the injector tip. Once the engine has been started, current to the start injector is cut off and injection is terminated.

THROTTLE POSITION SENSOR





The throttle position sensor is attached to the throttle body.
It senses the throttle valve opening (degree) to detect a heavy load condition. Using this signal, the computer determines whether to increase or decrease fuel quantity.

CONSTRUCTION

(1) Lever (secured to the same axis as the throttle valve)
(2) Guide Cam (functions by the lever (1))
(3) Moving Contact Point (this moves along the guide cam groove)
(4) Idle Contact Point } output power terminals
(5) Power Contact Point }

OPERATION

(1) When the throttle valve is in the closed position, the moving point and idle point will make contact, and idle condition will be detected. This signal is also utilized to cut off fuel when declerating.

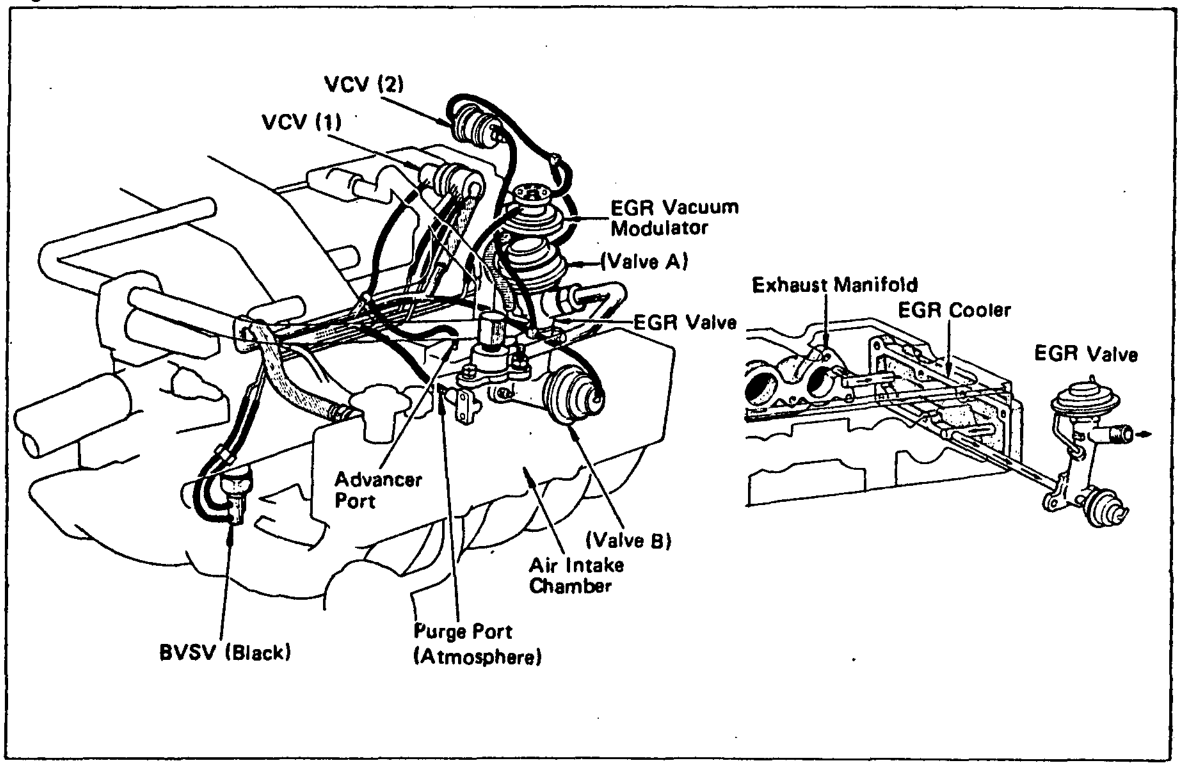
(2) When the throttle valve is open about 60° (from closed position), the moving point and power point make contact and full load condition is detected.

(3) At other times, the moving contact point is in a neutral state and no points are making contact.

Idle condition	Throttle valve opening ...... less than 15°
Full load condition	Throttle valve opening ...... more than 60°

EXHAUST GAS RECIRCULATION (EGR) SYSTEM

Fig. 3-33



OPERATION

Fig. 3-34

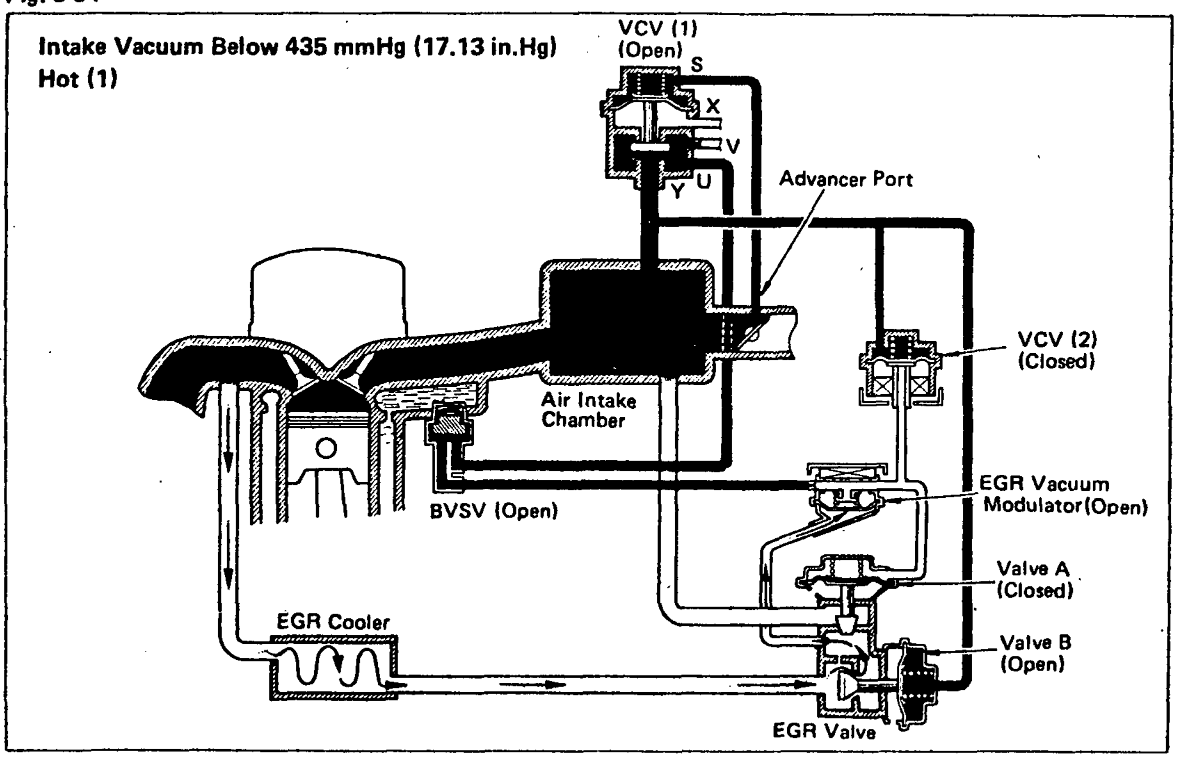
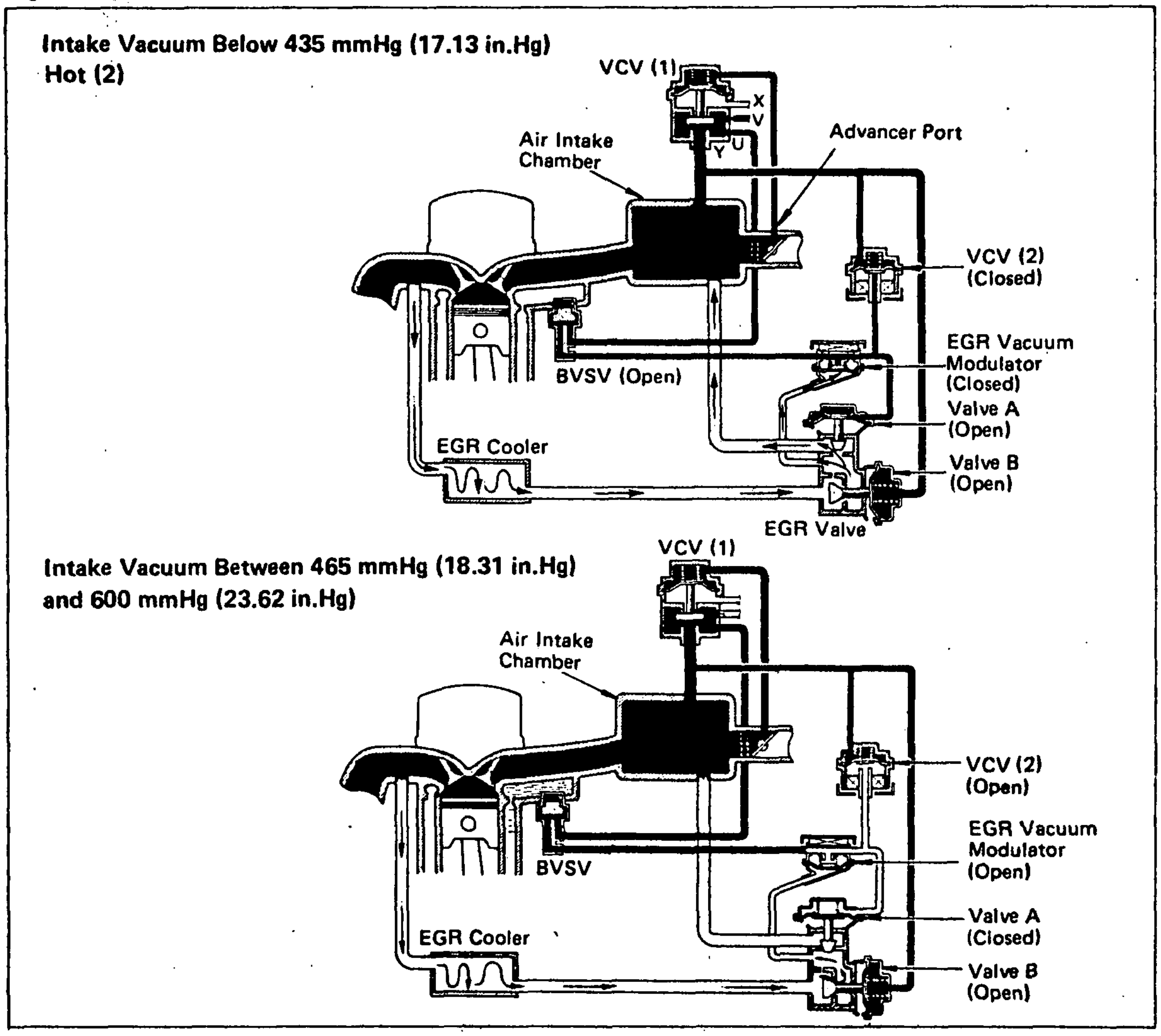


Fig. 3-35

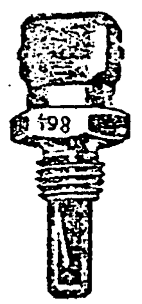


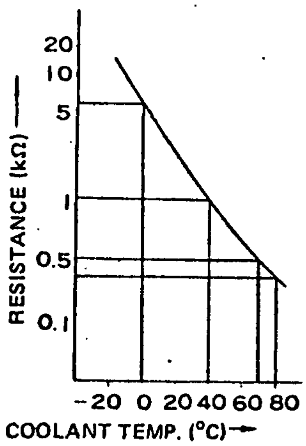
To reduce NOx emission, part of the exhaust gas is recirculated through the EGR valve to the intake manifold in order to lower the maximum combustion temperature.

Coolant Temp.	BVSV	Throttle Valve Opening Angle	VCV (1)	Intake Manifold vacuum	VCV (2)	Pressure in the EGR Pressure Chamber		EGR Vacuum Modulator	EGR Valve		Exhaust Gas
									Valve A	Valve B	
Below 50°C (122°F)	Closed	–	–	–	–	–		–	Closed	–	Not recirculated
Above 64°C (147°F)	Open	Positioned below advancer port	Closed	–	–	–		–	Closed	Open	Not recirculated
		Positioned above advancer port	Open	Below 435 mmHg (17.13 in.Hg)	Closed	Low	*Pressure constantly alternating between Low and high	Opens passage to atmosphere	Closed	Open	Not recirculated
						High		Closes passage to atmosphere	Open	Open	Recirculated
				Between 465 mmHg (18.31 in.Hg) and 600 mmHg (23.62 in.Hg)	Open	–		–	Closed	Open	Not recirculated
		–	–	Above 600 mmHg (23.62 in.Hg)	Open	–		–	Closed	Closed	Not recirculated

Remarks * Pressure increase ⟶ Modulator closes ⟶ EGR valve opens ⟶ Pressure drops ⟶ Modulator opens ⟶ EGR valve closes ⟶ (Pressure increase)

WATER THERMO SENSOR



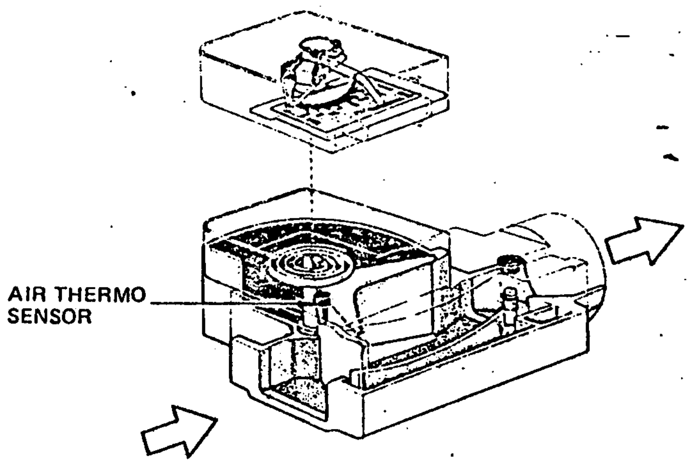


This sensor detects coolant temperature using an internal thermistor.

In accordance with the signal from this sensor, fuel quantity is increased in proportion to the coolant temperature.

Thermistor resistance increases when the coolant temperature is low, and gradually decreases as the coolant temperature rises.

AIR THERMO SENSOR



In order to detect the intake air temperature, this sensor is built into the air flow meter and, like the water temperature sensor, employs an internal thermistor.

In accordance with the signal from this sensor, fuel quantity is increased in proportion to the intake air temperature.

The thermistor characteristics are the same as for the water themo sensor.

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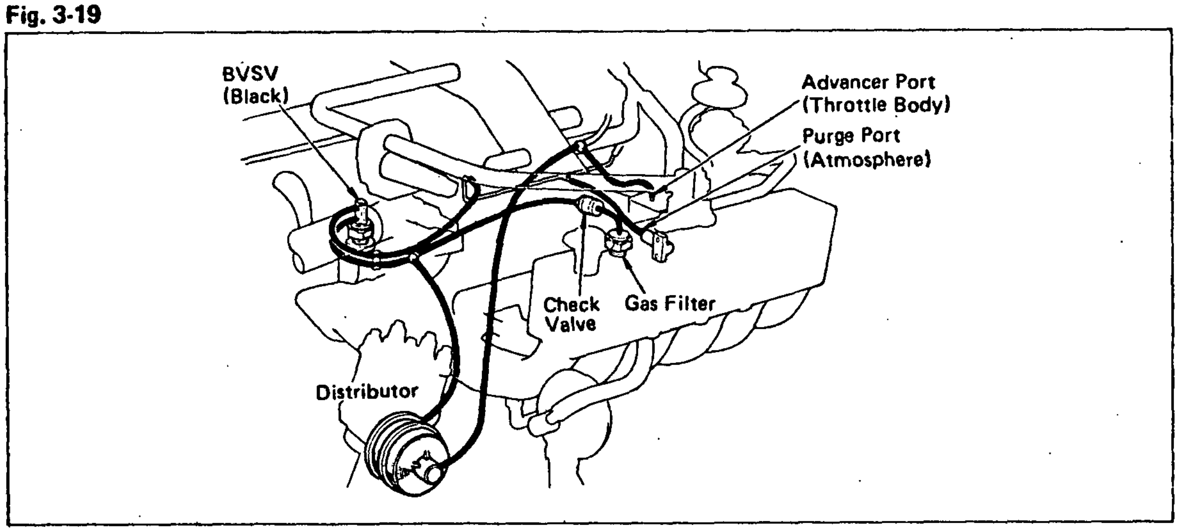
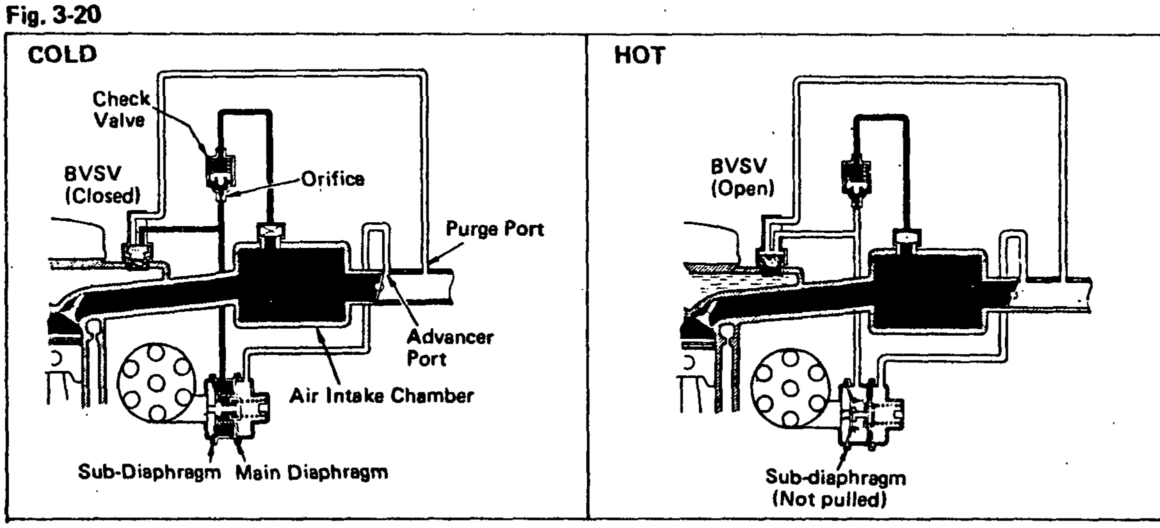
SPARK CONTROL (SC) SYSTEM

Fig. 3-19



OPERATION

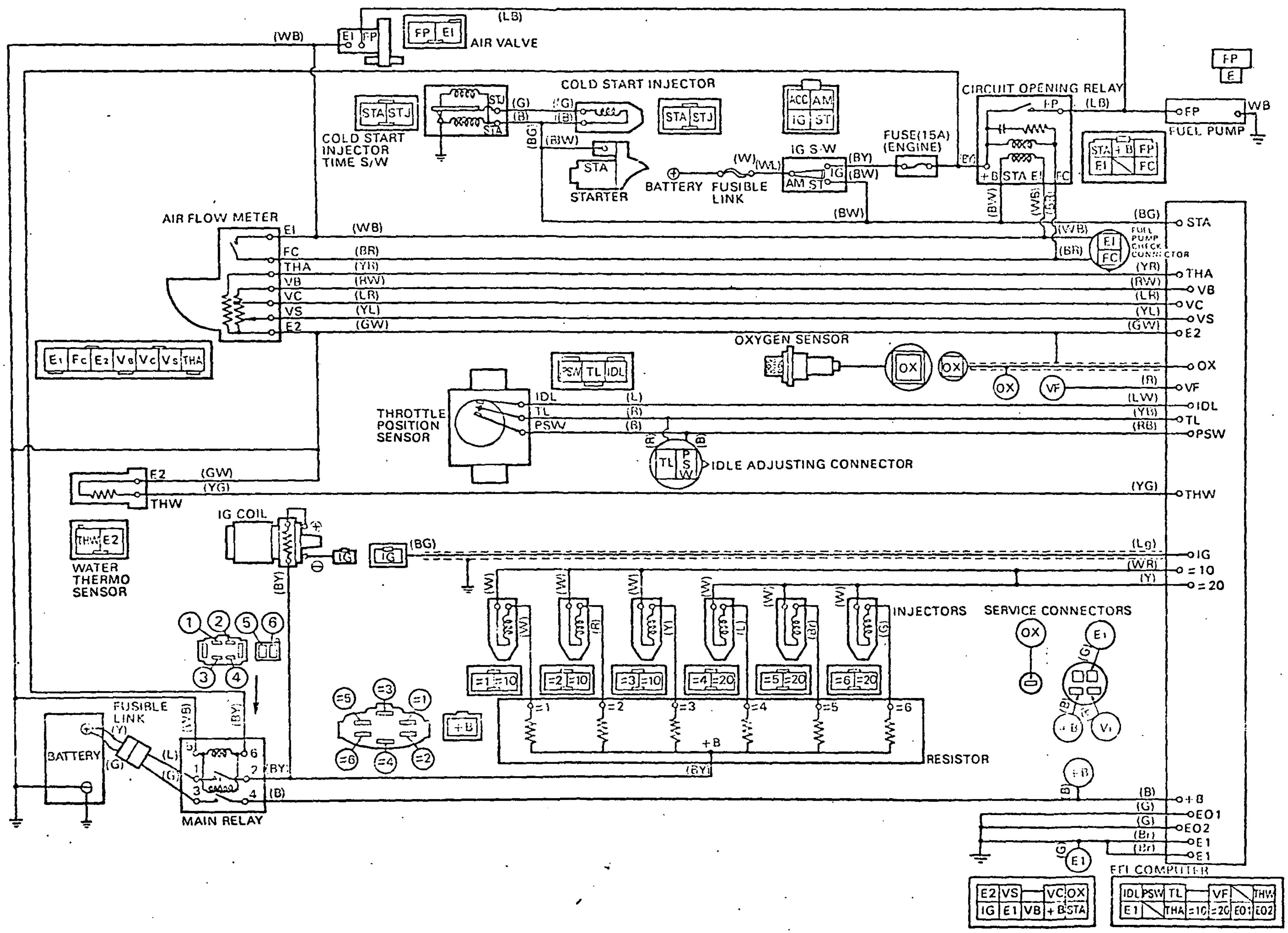
Fig. 3-20



To improve cold engine performance, this ignition system advances the ignition timing only when the engine is cold. The disributor is equipped with two diaphragms that have different vacuum advance characteristics.

Coolant temp.	BVSV	Distributor sub-diaphragm	Throttle valve opening	Distributor main diaphragm	Vacuum ignition timing
Below 50°C (122°F)	CLOSED	Pulled by intake manifold vacuum	Positioned below advancer port	Not pulled	8° (Sub) ⊕ (Initial timing)
			Positioned above advancer port	Pulled by advancer port vacuum	8° (Sub) ⊕ Main vacuum adv. angle ⊕ (Initial timing)
Above 64°C (147°F)	OPEN	Released by spring tension	Positioned below advancer port	Not pulled	(Initial timing)
			Positioned above advancer port	Pulled by advancer port vacuum	Main vacuum adv. angle ⊕ (Initial timing)

EFI WIRING DIAGRAM FOR 4M-E ENGINE



ATTACHMENT 4

Test Vehicle Description

Model/Year	1980
Make	Toyota Celica Supra
Emission Control System	EGR, Closed Loop EFl, 3-Way, catalysts (TWO)
Engine Configuration	I-6
Engine Type	Otto Spark
Bore x Stroke	80 MM x 85 mm
Displacement	2563 cc
Rated Horsepower	108
Transmission	A 4 OD
Chassis Type	Sedan
Tire Size	195/70 HR 14
Inertial Weight	3000 lbs.
Vin	MA46100183
AHP	10.2
Engine Family	4-ME
Fuel Type	Unleaded - IND HO
Compression Rato	8.5:1

ATTACHMENT 5

DILUTE SAMPLE TESTING

		FTP					HFET					
Date	**Test Numbers**	**HC**	**CO**	**CO_2**	**NOx**	**FE**	**HC**	**CO**	**CO_2**	**NOx**	**FE**	**Comments**
3 Sept. 80	80-5383, 84	.160	1.25	432.	.40	20.4	.012	.34	324.	.10	27.3	Baseline
4 Sept. 80	80-5385, 86	.214	1.67	418.	.36	21.0	.010	.32	316.	.07	28.0	Baseline
11 Sept. 80	80-5387, 88	2.747	61.74	357.	.55	19.2	1.658	48.76	253.	.21	26.5	Closed Loop disabled
24 Sept. 80	80-5389, 90	2.819	84.15	318.	.38	19.3	1.955	72.92	240.	.11	24.6	O_2 sensor lead grounded
25 Sept. 80	80-5391, 92	.280	2.01	414.	2.38	21.2	.017	0.0	315.	2.38	28.1	O_2 sensor lead open
30 Sept. 80	80-5393, 94	.199	.81	424.	1.32	20.8	.011	0.0	337.	.69	26.3	Injector disconnected
1 Oct. 80	80-6292, 93	.219	2.21	416.	.59	21.1	.008	.19	316.	.24	28.0	EGR disabled
2 Oct. 80	80-6291, 94	.161	1.32	406.	.36	21.7	.007	.19	321.	.07	27.6	T.P.S. disconnected
7 Oct. 80	80-6328, 29	.176	1.95	404.	.38	21.8	.007	.22	318.	.09	27.9	Baseline
8 Oct. 80	80-6355, 56	.216	1.52	405.	.36	21.7	.005	.12	292.	.10	30.3	S.C. BVSV closed
9 Oct. 80	80-6357, 58	.191	1.57	416.	.40	21.2	.006	.11	316.	.12	28.0	Baseline
15 Oct. 80	80-6359, 60	.193	1.48	441.	.30	20.0	.011	.36	343.	.08	25.8	Baseline

ATTACHMENT 6

I/M Testing Before Catalysts

		50 Cruise	4 Mode Idle				2 Mode Loaded	
Date	Test Numbers	HC/CO	HC/CO Idle	HC/CO 2500 RPM	HC/CO Idle	HC/CO Drive	HC/CO 30 MPH	HC/CO Idle
3 Sept. 80	80-5383, 84	160/.55	140/.50	60/.60	150/.55	180/.40	199/.55	103/.55
4 Sept. 80	80-5385, 86	160/.60	120/.60	130/.90	120/.50	180/.45	185/.50	120/.50
11 Sept. 80	80-5387, 88	220/3.7	155/2.5	110/2.7	170/2.25	120/2.05	260/3.55	165/2.20
24 Sept. 80	80-5389, 90	240/5.1	200/4.1	175/4.9	195/3.95	275/3.8	280/4.9	225/4.1
25 Sept. 80	80-5391, 92	140/.08	130/.40	70/.60	160/.30	170/.30	180/.20	150/.30
30 Sept. 80	80-5393, 94	260/2.7	240/1.95	235/2.2	235/2.0	300/1.8	250/2.45	220/2.2
1 Oct. 80	80-6292, 93	150/.63	140/.50	50/.55	200/.55	180/.40	205/.55	135/.45
2 Oct. 80	80-6291, 94	170/.55	135/.53	38/.59	135/.57	175/.46	185/.50	140/.58
7 Oct. 80	80-6328, 29	160/.50	140/.50	60/.50	140/.60	170/.40	200/.45	150/.50
8 Oct. 80	80-6355, 56	170/.50	250/.50	70/.50	170/.50	200/.40	230/.50	160/.50
9 Oct. 80	80-6357, 58	150/.55	140/.50	50/.58	140/.50	180/.50	190/.45	140/.45
15 Oct. 80	80-6359, 60	120/.50	130/.42	60/.55	140/.55	180/.40	195/.45	130/.55

I/M Testing Between Catalysts

Date	Test Numbers	50 Cruise	4 Mode Idle				2 Mode Loaded	
		HC/CO	HC/CO Idle	HC/CO 2500 RPM	HC/CO Idle	HC/CO Drive	HC/CO 30 MPH	HC/CO Idle
3 Sept. 80	80-5383, 84	40/.04	25/.02	22/.02	25/.02	21/.02	55/.04	20/.02
4 Sept. 80	80-5385, 86	45/.05	25/.02	25/.02	25/.02	25/.02	50/.06	25/.02
11 Sept. 80	80-5387, 88	230/3.7	155/1.95	110/1.7	170/2.2	125/1.85	260/3.4	180/2.1
24 Sept. 80	80-5389, 90	260/5.2	199/4.0	170/5.0	210/3.9	260/3.6	285/4.85	220/4.0
25 Sept. 80	80-5391, 92	30/.02	30/.02	30/.03	30/.03	30/.03	50/.03	30/.03
30 Sept. 80	80-5393, 94	40/.06	40/.06	20/.06	20/.08	25/.08	40/.15	20/.06
1 Oct. 80	80-6292, 93	30/.10	40/.06	25/.08	30/.08	25/.07	60/.15	35/.06
2 Oct. 80	80-6291, 94	30/.15	15/.02	10/.03	10/.02	15/.03	38/.05	25/.02
7 Oct. 80	80-6328, 29	40/.12	40/.12	35/.15	40/.12	40/.15	60/.15	40/.12
8 Oct. 80	80-6355, 56	40/.10	40/.02	30/.04	30/.02	40/.06	70/.05	40/.03
9 Oct. 80	80-6357, 58	30/.05	30/.02	30/.02	30/.02	20/.02	60/.05	30/.02
15 Oct. 80	80-6359, 60	20/.11	20/.05	20/.06	30/.05	20/.06	60/.12	25/.06

I/M Testing After Catalysts

Date	Test Numbers	50 Cruise HC/CO	4 Mode Idle HC/CO Idle	4 Mode Idle HC/CO 2500 RPM	4 Mode Idle HC/CO Idle	4 Mode Idle HC/CO Drive	2 Mode Loaded HC/CO 30 MPH	2 Mode Loaded HC/CO Idle
3 Sept. 80	80-5383, 84	20/.02	22/.02	25/.02	20/.02	21/.02	20/.02	20/.02
4 Sept. 80	80-5385, 86	35/.03	20/.02	20/.02	20/.02	20/.02	30/.03	25/.02
11 Sept. 80	80-5387, 88	225/3.6	160/1.9	105/2.65	180/2.0	140/1.95	260/3.4	180/2.2
24 Sept. 80	80-5389, 90	245/4.95	210/3.95	165/4.8	220/3.95	245/3.5	275/4.55	220/4.0
25 Sept. 80	80-5391, 92	20/.02	20/.02	20/.03	20/.03	20/.03	30/.03	30/.03
30 Sept. 80	80-5393, 94	10/.03	20/.06	20/.06	20/.08	20/.08	20/.06	20/.06
1 Oct. 80	80-6292, 93	20/.05	25/.06	25/.06	25/.06	25/.06	35/.08	35/.06
2 Oct. 80	80-6291, 94	10/.05	15/.02	10/.02	12/.02	15/.02	10/.02	18/.02
7 Oct. 80	80-6328, 29	20/.05	35/.02	30/.02	35/.02	30/.02	40/.02	35/.02
8 Oct. 80	80-6355, 56	30/.02	30/.02	30/.02	30/.02	30/.02	40/.03	35/.03
9 Oct. 80	80-6357, 58	20/.02	30/.02	30/.02	30/.02	20/.02	20/.02	20/.02
15 Oct. 80	80-6359, 60	19/.04	20/.04	20/.05	20/.05	20/.05	25/.06	25/.06

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
3 Sept. 80	80-5383, 84	-	-	-	-	-	-	-	-	-	-	Baseline
4 Sept. 80	80-5385, 86	880	.02	2		855	.02	2		850	.02	Baseline
11 Sept. 80	80-5387, 88	930	2.05	3	945	940	3.4	4	925	920	2.2	Closed Loop disabled
24 Sept. 80	80-5389, 90	950	3.95	3	960	960	5.0	4	950	940	3.8	O_2 sensor lead grounded
25 Sept. 80	80-5391, 92	840	.07	3	895	890	.07	4	840	840	.07	O_2 sensor lead open
30 Sept. 80	80-5393, 94	880	.06	2		865	.06	2		860	.06	Injector disconnected
1 Oct. 80	80-6292, 93	850	.05	3	860	860	.05	4	820	840	.06	EGR disabled
2 Oct. 80	80-6291, 94	900	.03	7		900	.03	7		900	.03	T.P.S. disconnected
7 Oct. 80	80-6328, 29	840	.02	7		840	.02	7		840	.02	Baseline
8 Oct. 80	80-6355, 56	1010	0	7		1010	.02	7		1010	.02	S.C. BVSV closed
9 Oct. 80	80-6357, 58	920	.02	7		920	.02	7		920	.02	Baseline
15 Oct. 80	80-6359, 60	850	.05	3	880	875	.05	4	850	850	.05	Baseline

Notes
1) The data presented on this attachment corresponds to the data entry blanks on Attachment 1.
2) The 1 CFH propane test segment was not accomplished for the initial baseline.

2 CFH Propane

Date	Test Numbers	RPM	ICO	Code	RPM	RPM	ICO	Code	RPM	RPM	ICO	Comments
3 Sept. 80	80-5383, 84	840	.02	3	900	840	.02	4	840	840	.02	Baseline
4 Sept. 80	80-5385, 86	860	.02	3	910	910	1.22	4	860	860	.02	Baseline
11 Sept. 80	80-5387, 88	940	2.05	3	960	965	4.20	4	940	940	2.2	Closed Loop disabled
24 Sept. 80	80-5389, 90	960	3.95	3	965	963	6.0	4	955	955	3.8	O_2 sensor lead grounded
25 Sept. 80	80-5391, 92	840	.07	3	925	920	1.6	4	840	840	.07	O_2 sensor lead open
30 Sept. 80	80-5393, 94	860	.06	2		855	.06	1		860	.06	Injector disconnected
1 Oct. 80	80-6292, 93	840	.05	3	900	890	1.15	4	850	850	.06	EGR disabled
2 Oct. 80	80-6291, 94	950	.03	1		975	.03	2		950	.03	T.P.S. disconnected
7 Oct. 80	80-6328, 29	820	.02	3	840	840	1.2	2		800	.02	Baseline
8 Oct. 80	80-6355, 56	1010	.02	1		1040	1.0	2		1010	.02	S.C. BVSV closed
9 Oct. 80	80-6357, 58	920	.02	1		970	1.2	2		900	.02	Baseline
15 Oct. 80	80-6359, 60	850	.06	3	910	910	.90	4	850	850	.06	Baseline

3 CFH Propane

Date	Test Numbers	RPM	ICO	Code	RPM	RPM	ICO	Code	RPM	RPM	ICO	Comments
3 Sept. 80	80-5383, 84	-	-	-	-	-	-	-	-	-	-	Baseline
4 Sept. 80	80-5385, 86	-	-	-	-	-	-	-	-	-	-	Baseline
11 Sept. 80	80-5387, 88	935	2.1	3	960	955	5.2	4	935	930	2.25	Closed Loop disabled
24 Sept. 80	80-5389, 90	925	3.8	4	910	900	6.8	3	925	925	3.8	O_2 sensor lead grounded
25 Sept. 80	80-5391, 92	840	0.2	3	935	935	2.45	4	840	840	.07	O_2 sensor lead open
30 Sept. 80	80-5393, 94	860	.05	3	880	850	.05	4	820	860	.06	Injector disconnected
1 Oct. 80	80-6292, 93	840	.05	3	920	920	1.15	4	840	850	.05	EGR disabled
2 Oct. 80	80-6291, 94	975	.03	1		990	.03	2		950	.03	T.P.S. disconnected
7 Oct. 80	80-6328, 29	800	.02	3	860	860	2.2	2		800	.02	Baseline
8 Oct. 80	80-6355, 56	1010	.02	1		1045	1.8	2		1010	.02	S.C. BVSV closed
9 Oct. 80	80-6357, 58	880	.02	1		960	2.0	2		880	.02	Baseline
15 Oct. 80	80-6359, 60	850	.06	3	930	930	1.8	4	850	850	.06	Baseline

Note: The 3 CFH propane test segment was not accomplished for initial baselines one and two.

4 CFH Propane

Date	Test Numbers	RPM	ICO	Code	RPM	RPM	ICO	Code	RPM	RPM	ICO	Comments
3 Sept. 80	80-5383, 84	840	.02	3	940	940	.02	4	840	840	.02	Baseline
4 Sept. 80	80-5385, 86	850	.02	3	940	935	3.10	4	850	850	.02	Baseline
11 Sept. 80	80-5387, 88	935	2.05	3	940	950	6.0	4	930	940	2.25	Closed Loop disabled
24 Sept. 80	80-5389, 90	925	3.8	4	900	900	7.5	3	940	940	3.8	O_2 sensor lead grounded
25 Sept. 80	80-5391, 92	820	.07	3	940	945	3.2	4	840	840	.06	O_2 sensor lead open
30 Sept. 80	80-5393, 94	860	.06	3	880	885	.07	4	780	860	.06	Injector disconnected
1 Oct. 80	80-6292, 93	850	.06	3	935	935	2.7	4	840	850	.06	EGR disabled
2 Oct. 80	80-6291, 94	1000	.03	5		990	.03	2		950	.03	T.P.S. disconnected
7 Oct. 80	80-6328, 29	820	.02	3	860	860	2.8	2		800	.02	Baseline
8 Oct. 80	80-6355, 56	1010	.02	1		1055	2.6	2		1010	.02	S.C. BVSV closed
9 Oct. 80	80-6357, 58	860	.02	1		940	3.0	2		860	.02	Baseline
15 Oct. 80	80-6359, 60	850	.06	3	930	930	2.6	4	850	850	.05	Baseline