VEHICLE ENGINE OVERHAULING III

Based on May 2019, Version 2 Occupational standard

Module Title: - Servicing Electrical Fuel Injection System and Its Components

LG Code: EIS VEO3 M08 LO (1-2) LG (31-32)

TTLM Code: EIS VEO3 TTLM 1220v1

DEC, 2020

Contents

LG #31	Lo#1 Prepare for work

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying and confirming nature and scope of the work requirements
- Acquiring procedures and information
- applying Methods in identifying diesel and gasoline electronic fuel injection components
- Analysing method options
- Sourcing and supporting technical and/or calibration requirements for the testing and overhaul of diesel fuel injection system
- Observing OHS, personal protection
- Sourcing and observing applicable national environmental protection measure/ guidelines for diesel vehicles

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify and confirm nature and scope of the work requirements
- Acquiring procedures and information
- apply Methods in identify diesel and gasoline electronic fuel injection components
- Analys method options
- Source and support technical and/or calibration requirements for the testing and overhaul of diesel fuel injection system
- Observe OHS, personal protection
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Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1- Identifying and confirming nature and scope of the work requirements

1.1. IDENTIFYING AND CONFIRMING NATURE AND SCOPE OF THE WORK REQUIREMENTS

In the servicing electronic fuel injection system component the lerning out come inclueding the following system, component and repairing procedure:-

2.1. ECU

2.2. Sensors

- 2.2.1. Air flow meter sensor
- 2.2.2. Crank angle sensor
- 2.2.3. Engine speed sensor
- 2.2.4. Water temperature sensor
- 2.2.5. Intake air temperature sensor
- 2.2.6. Throttle position sensor
- 2.2.7. Ignition switch
- 2.2.8. Vehicle speed sensor
- 2.2.9. Oxygen sensor
- 2.2.10. Neutral start switch
- 2.2.11. Taillight and defogger relays
- 2.2.12. Air conditioner
- 2.2.13. Knock sensor

2.3. Electronic Fuel Injection system

2.4. Air Induction System

2.5. Basic System Operation

2.6. Testing Tooling and equipment

2.7. Gasoline Electronic Fuel injection

2.8. Injection systems in Diesel engines

2.9. Fuel Delivery System

2.10. Types of Injectors in Use

2.11. Fuel Injection Pattern and Injection Timing

2.12. Circuit Test

2.13. EFI SERVICES INCLUDE ITEMS SUCH AS

2.13.1.1. Diagnostics, testing and inspection

2.13.1.2. Repairs and replacements

2.13.1.3. Cleaning your Throttle valve, fuel filter and fuel injector

2.13.1.4. Checking sensors

2.13.1.5. Checking engine control unit (ECU)

2.14. ABOUT EFI PROBLEMS AND ABOUT HOW WE DIAGNOSE AND FIX PROBLEMS

Self-cheek -1	Written Test

Direction-I chose the best answer

Instruction:

1. EFI SERVICES INCLUDE ITEMS
   A. Checking sensors
   B. Checking ECU
   C. Fuel Delivery System
   D. All
   E. A and B ONLY

Direction-II Write

Instruction II: Give clear and precise answer for each of the following questions.

2. List at list 5 sensors (5point)
3. List at list 5 electronic fuel injection system component (5point)

Note: **Satisfactory rating –11 points** **Unsatisfactory - below 10 points**

Score = _____

Rating: _____

Name: _____ **Date:** _____

2. Acquiring procedures and information

2.1. Introduction

What is EFI?

EFI is a way of delivering fuel to the engine by electronically controlling injection directly into the intake manifold near the intake valve

System components

All fuel injection systems comprise three basic components: they have at least one fuel injector (sometimes called an injection valve), a device that creates sufficient injection pressure, and a device that meters the correct amount of fuel.

These three basic components can either be separate devices (fuel injector(s), fuel distributor, fuel pump), partially combined devices (injection valve and an injection pump), or completely combined devices (unit injector).

Early mechanical injection systems (except air-blast injection) typically used injection valves (with needle nozzles) in combination with a relatively sophisticated helix-controlled injection pump that both metered the fuel, and created the injection pressure.

They were well-suited for intermittently injecting multi-point injection systems as well as all sorts of conventional direct injection systems, and chamber-injected systems.

Advancements in the field of microelectronics allowed injection system manufacturers to significantly improve the accuracy of the fuel metering device.

In modern engines, the fuel metering and injection valve actuation is usually done by the engine control unit.

Therefore, the fuel injection pump does not have to meter the fuel or actuate the injection valves; it only needs to provide injection pressure.

These modern systems are used in multi-point-injected engines, and common-rail-injected engines.

Unit injection systems have made it into series production in the past, but proved to be inferior to common-rail injection.

2.2. How Electronic Fuel Injection Works

Electronic Fuel injection works on the some very basic principles. The following discussion broadly outlines how a basic or **Convention Electronic Fuel Injection (EFI)** system operates.

The Electronic Fuel Injection system can be divided into **three**: basic sub-systems. These are the

fuel delivery system, air induction system, and **the electronic control system**.

2.3. Fuel Delivery System

- The fuel delivery system consists of the **fuel tank, fuel pump, fuel filter, fuel delivery pipe (fuel rail), fuel injector, fuel pressure regulator, and fuel return pipe.**
- Fuel is delivered from the tank to the injector by means of an electric fuel pump. The pump is typically located or near the fuel tank. Contaminants are filtered out by a high capacity in line fuel filter.
- Fuel is maintained at a constant pressure by means of a fuel pressure regulator. Any fuel which is not delivered to the intake manifold by the injector is returned to the tank through a fuel return pipe.

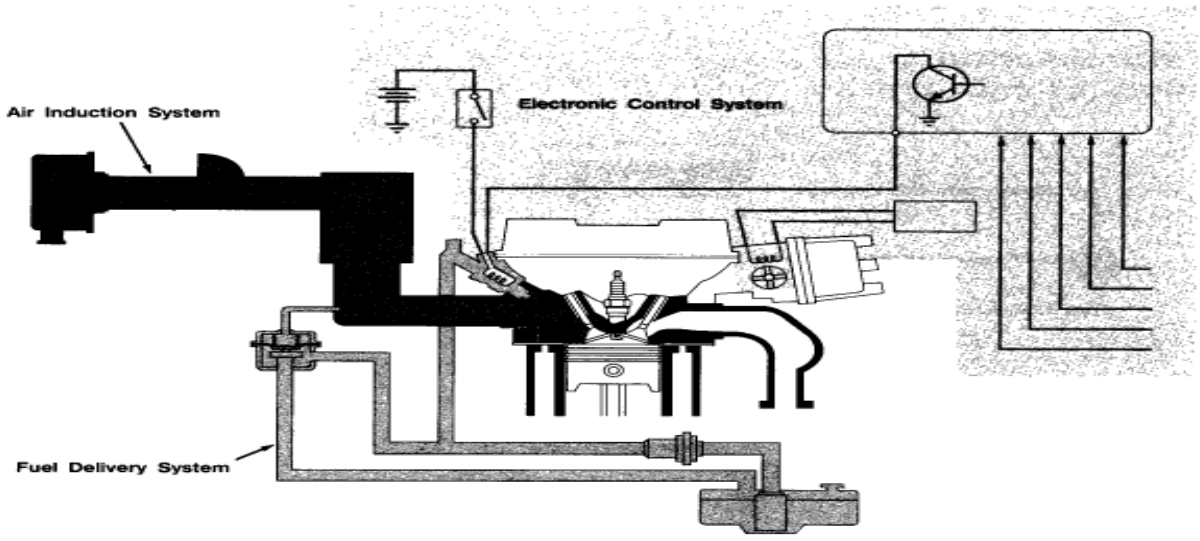


Figure: 2.1 Electronic Fuel Injection system

2.4. Air Induction System

- The air induction system consists of the **air cleaner, air flow meter, throttle valve, air intake chamber, intake manifold runner, and intake valve.**
- When the throttle valve is opened, air flows through the air cleaner, through the air flow meter (on L type systems), past the throttle valve, and through a well-tuned intake manifold runner to the intake valve.
- Air delivered to the engine is a function of driver demand. As the throttle valve is opened further, more air is allowed to enter the engine cylinders.
- Toyota engines use two different methods to measure intake air volume. The **L type EFI system** measures air flow directly by using an air flow meter. The **D type EFI system** measures air flow indirectly by monitoring the pressure in the intake manifold.

2.5. Electronic Control System

- The electronic control system consists of various engine sensors, Electronic Control Unit (ECU), fuel injector assemblies, and related wiring.
- The ECU determines precisely how much fuel needs to be delivered by the injector by monitoring the engine sensors.
- The ECU turns the injectors on for a precise amount of time, referred to as injection pulse width or injection duration, to deliver the proper air/fuel ratio to the engine.

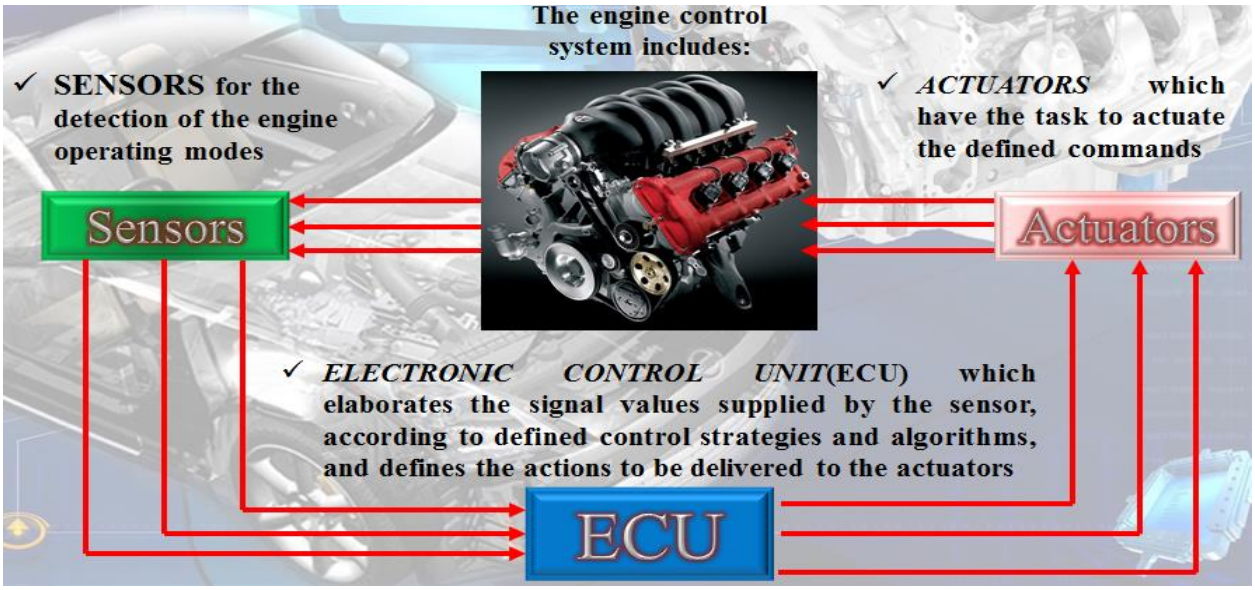


Figure:2.2 Electronic Control System

2.6. Basic System Operation

- Air enters the engine through the air induction system where it is measured by the air flow meter. As the air flows into the cylinder, fuel is mixed into the air by the fuel injector.
- Fuel injectors are arranged in the intake manifold behind each intake valve. The injectors are electrical solenoids which are operated by the ECU
- The ECU pulses the injector by switching the injector ground circuit on and off.
- When the injector is turned on, it opens, spraying atomized fuel at the back side of the intake valve.
- As fuel is sprayed into the intake airstream, it mixes with the incoming air and vaporizes due to the low pressures in the intake manifold. The ECU signals the injector to deliver just enough fuel to achieve an ideal air/fuel ratio of 14.7:1, often referred to as stoichiometry.
- The precise amount of fuel delivered to the engine is a function of ECU control.
- The ECU determines the basic injection quantity based upon measured intake air volume and engine rpm.
- Depending on engine operating conditions, injection quantity will vary. The ECU monitors variables such as coolant temperature, engine speed, throttle angle, and exhaust oxygen content and makes injection corrections which determine final injection quantity.

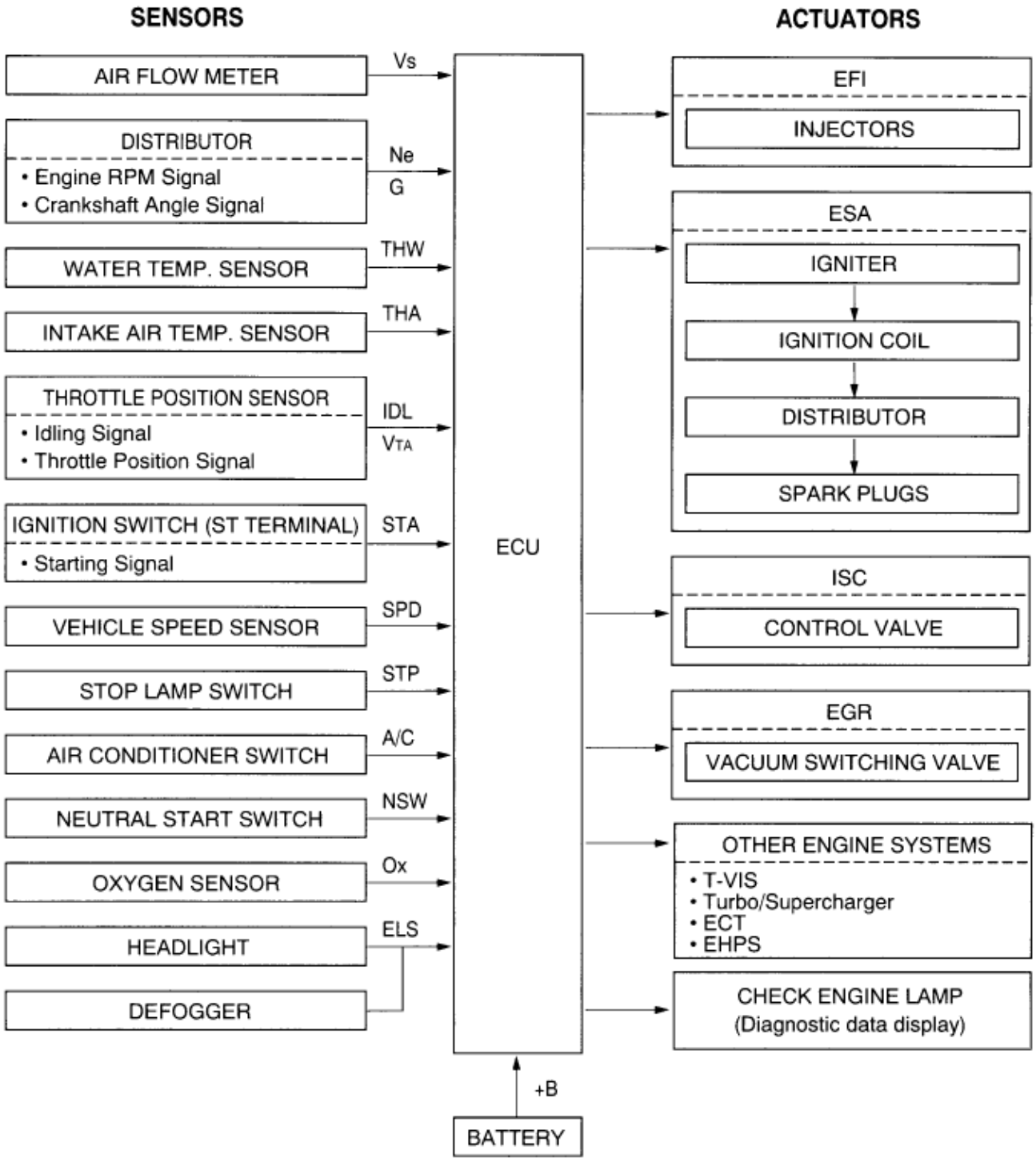


Figure:2.3 Three basic parts of EFI

2.7. Advantages of EFI

- Uniform Air/Fuel Mixture Distribution
- Highly Accurate Air/Fuel Ratio Control at All Engine Operating Conditions
- Superior Throttle Response and Power
- Excellent Fuel Economy with Improved Emissions Control
- Improved Cold Engine Start ability and Operation
- Simpler Mechanics & Reduced Adjustment Sensitivity

2.8. Tooling and equipment

2.8.1. Scan tool

Working on OBD I or II Vehicles Requires Scan Tool with The Correct Connector Cable and installed OBD I or II Software to diagnose trouble of the OBD I or II vehicles.

Figure:2.4 Scan tool

2.8.2. Multimeter

- **Ohmmeter Checks: -** most sensors and output devices can be checked with an ohmmeter.
- **For example**, an ohmmeter can be used to check a temperature sensor. Normally, the ohmmeter reading is low on a cold engine and high or infinity on a hot engine if the sensor is a PTC. If the sensor is an NTC, the opposite readings would be expected.
- **Voltmeter Checks: -** Many sensors, output devices, and their wiring can be diagnosed by checking the voltage to them, and in some cases, from them.
- For example, knock, oxygen, IAT, MAF sensors etc can be checked.

Figure:2.5 Multimeter

2.8.3. Engine analyzer

- The tool combines the functions of a double-trace **oscilloscope** and those of a **digital multimeter**.

- The **oscilloscope section** has been designed on purpose for the analysis of wave forms of electric signals derived from sensors, actuators and transducers.
- The **multimeter section** includes functions of voltmeter– for direct current measures – ammeter to measure direct current with clip-on ammeter (option tool) and ohmmeter, to measure resistance and to check continuity of electric connections.

Figure:2.6 Engine analyzer

2.9. Injection systems in gasoline engines

2.9.1. Carburetor

- Old but well working technology
- Problems with e.g. cold starting (fuel vapor condensation to cold surfaces) and accurate fuel delivery

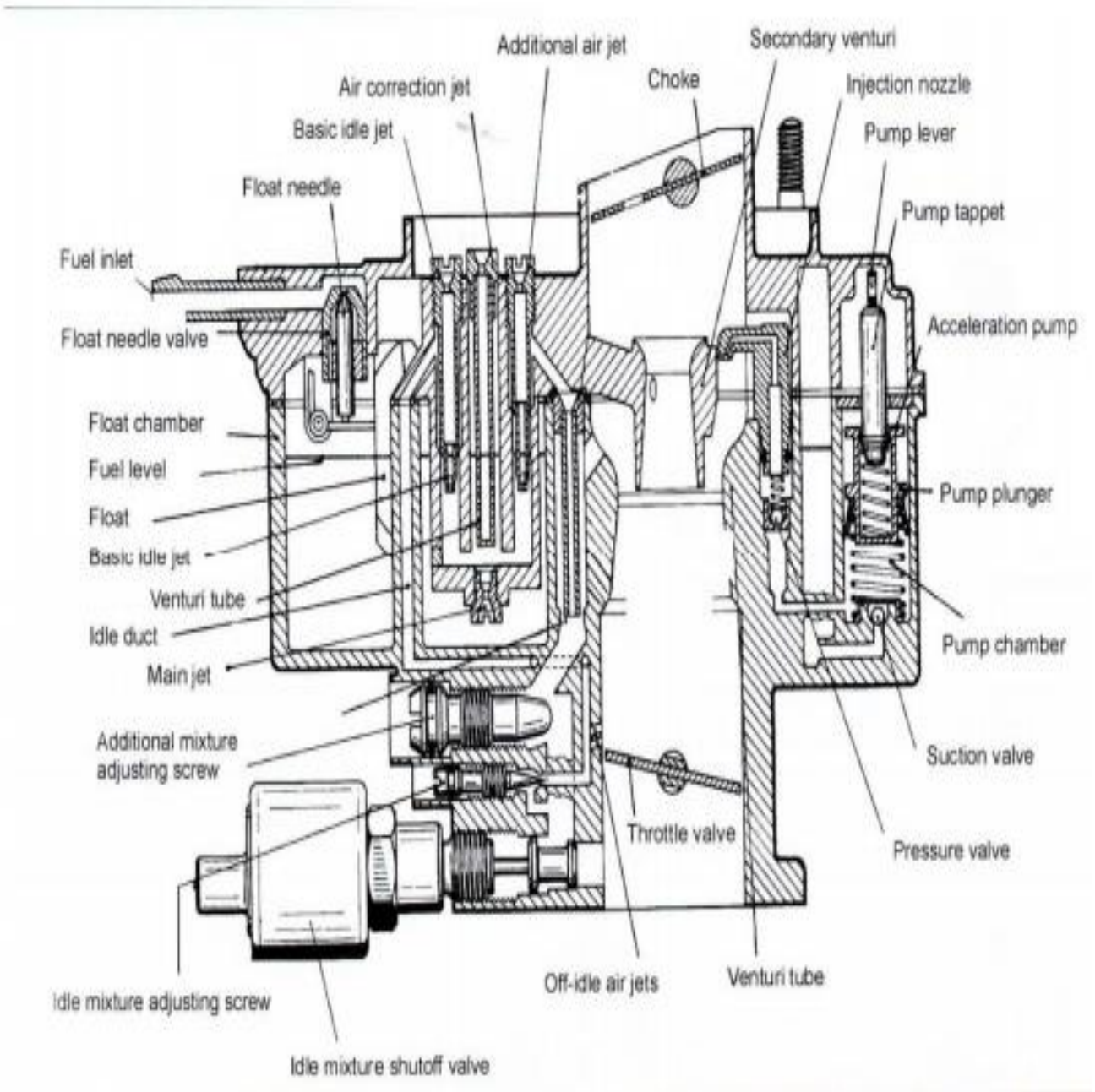


Figure:2.7 Gasoline engine Carburetor

2.9.2. Gasoline Electronic Fuel injection

Single-point injection

Single-point injection uses one injector in a throttle body mounted similarly to a carburetor on an intake manifold.

As in a carbureted induction system, the fuel is mixed with the air before the inlet of the intake manifold.Single-point injection was a relatively low-cost way for automakers to reduce exhaust emissions to comply with tightening regulations while providing better "driveability" (easy starting, smooth running, freedom from hesitation) than could be obtained with a carburetor.

Many of the carburetor's supporting components - such as the air cleaner, intake manifold, and fuel line routing - could be used with few or no changes.

Multi-point injection

Multi-point injection injects fuel into the intake ports just upstream of each cylinder's intake valve, rather than at a central point within an intake manifold. Typically, multi-point injected systems use multiple fuel injectors,but some systems such as the GM central port injection use tubes with poppet valves fed by a central injector instead of multiple injectors.

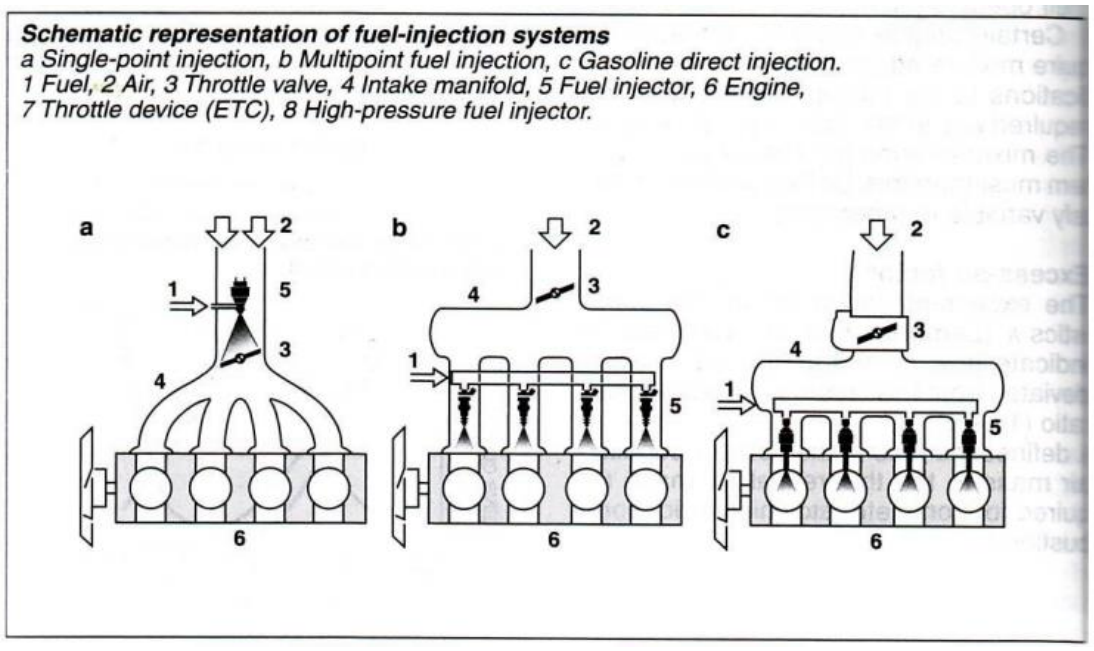


Figure: 2.8 Schematic representation of fuel-injection systems

2.10. Injection systems in Diesel engines

INDIRECT INJECTED

In an indirect injected engine, there are two combustion chambers: a main combustion chamber, and a pre-chamber, that is connected to the main one.

The fuel is injected only into the pre-chamber (where it begins to combust), and not directly into the main combustion chamber. Therefore, this principle is called indirect injection.

There exist several slightly different indirect injection systems that have similar characteristics. All Akroyd (hot-bulb) engines, and some Diesel (compression ignition) engines use indirect injection.

DIRECT INJECTION

Direct injection means that an engine only has a single combustion chamber, and that the fuel is injected directly into this chamber.

This can be done either with a blast of air (air-blast injection), or hydraulically.

The latter method is far more common in automotive engines. Typically, hydraulic direct injection systems spray the fuel into the air inside the cylinder or combustion chamber, but some systems spray the fuel against the combustion chamber walls (M-System).

Hydraulic direct injection can be achieved with a conventional, helix-controlled injection pump, unit injectors, or a sophisticated common-rail injection system.

The latter is the most common system in modern automotive engines. Direct injection is well-suited for a huge variety of fuels, including petrol (see petrol direct injection), and diesel fuel.

Common rail system

In a common rail system, the fuel from the fuel tank is supplied to the common header (called the accumulator). This fuel is then sent through tubing to the injectors, which inject it into the combustion chamber.

The header has a high pressure relief valve to maintain the pressure in the header and return the excess fuel to the fuel tank.

The fuel is sprayed with the help of a nozzle that is opened and closed with a needle valve, operated with a solenoid. When the solenoid is not activated, the spring forces the needle valve into the nozzle passage and prevents the injection of fuel into the cylinder.

The solenoid lifts the needle valve from the valve seat, and fuel under pressure is sent in the engine cylinder. Third-generation common rail diesels use piezoelectric injectors for increased precision, with fuel pressures up to 300 MPa or 44,000 lbf/in^2.

2.10.1. Distributor systems

- Axial piston distributor pump
- Radial piston pump

2.10.2. Unit pump systems

- Pump units assembled in one unit: inline fuel injection pump
  - Separate pump units for every cylinder
  - United injector pump and nozzle, unit injector system and unit pump system

2.10.3. Common Rail (accumulator) systems

- Common pressure reservoir into which all the injector nozzles are connected. Pressure pipe is connected to the injector solenoid valve
- Typical injection pressure level 1200...2000 bar
- The start and ending of the fuel injection are independent of the camshaft

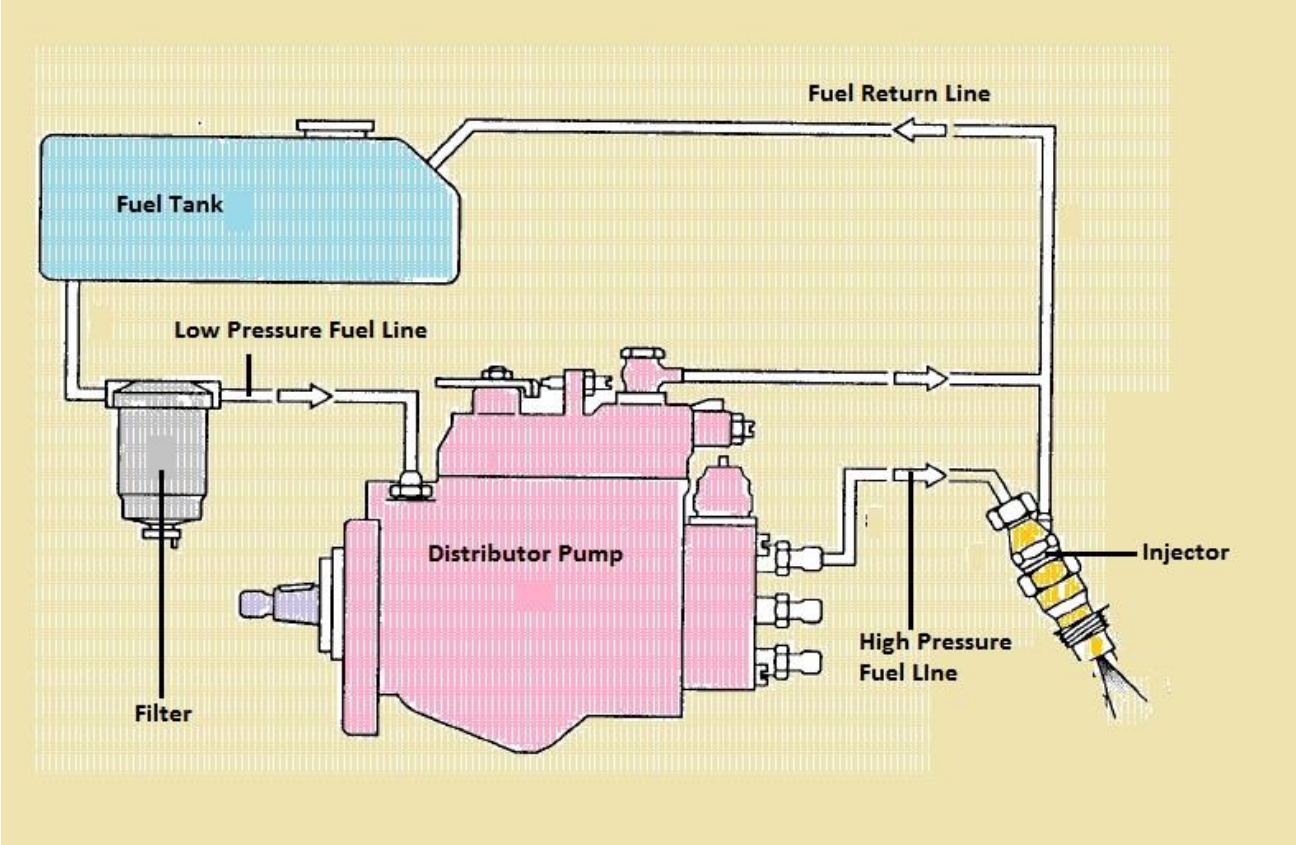


Figure:2.9 fuel delivery and return on a conventional (mechanical) diesel fuel injection.

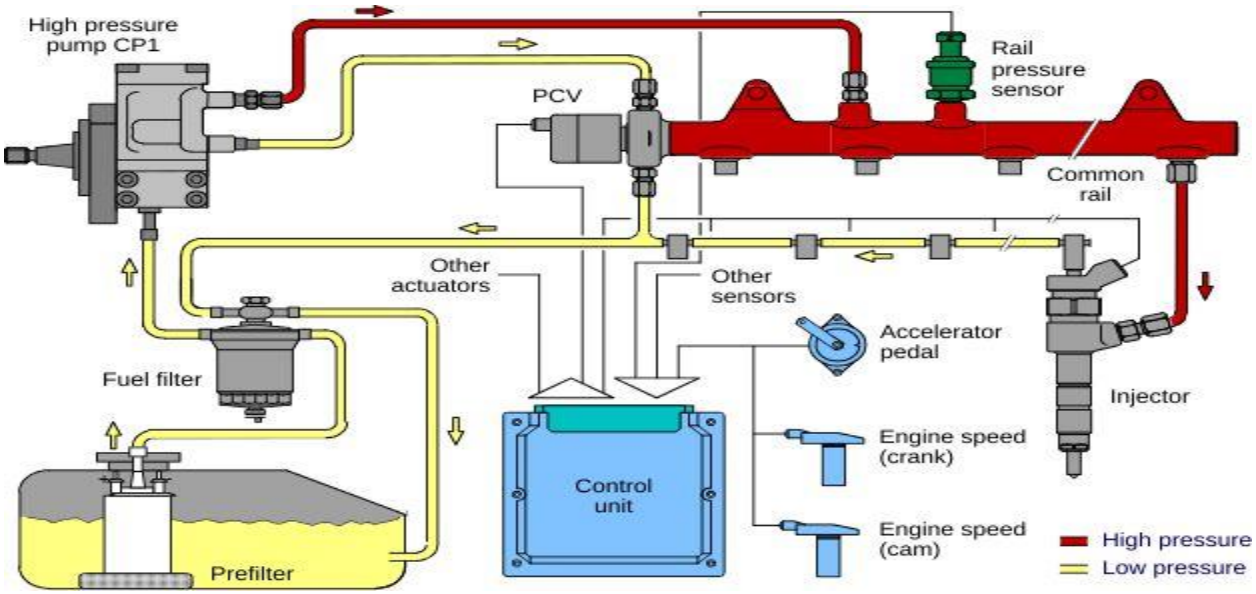


Figure:2.10 Common Rail Injection System Pressure Control

2.11.**Electronic Fuel Injection**

The Electronic Fuel Injection system can be divided into **three**: basic sub-systems. These are:

1. Fuel Delivery System
2. Air Induction System
3. Electronic Control System

2.12. **Fuel Delivery System**

The fuel delivery system incorporates the following components

1. Fuel tank (with evaporative emissions controls)
2. Fuel pump
3. Fuel pipe and in line filter
4. Fuel delivery pipe (fuel rail)
5. Pulsation damper (many engines)

6. Fuel injectors
7. Cold start injector (most engines)
8. Fuel pressure regulator
9. Fuel return pipe

Fuel is pumped from the tank by an **electric fuel pump** which is controlled by the circuit opening relay. Fuel flows through the fuel filter to the **fuel rail (fuel delivery pipe)** and up to the pressure regulator where it is held under pressure.

The **pressure regulator** maintains fuel pressure in the rail at a specified value above intake manifold pressure.

This maintains a constant pressure drop across the fuel injectors regardless of engine load. Fuel in excess of that consumed by engine operation is returned to the tank by way of the fuel return line.

A **pulsation damper**, mounted to the fuel rail, is used on some engines to **absorb pressure variations** in the fuel rail due to injectors opening and closing.

The **fuel injectors**, which directly control fuel metering to the intake manifold, are pulsed by the ECU.

The **ECU completes the injector ground** circuit for a calculated amount of time referred to as injection duration or injection pulse width.

The ECU determines which air/fuel ratio the engine runs at based upon engine conditions monitored by input sensors and a program stored in its memory.

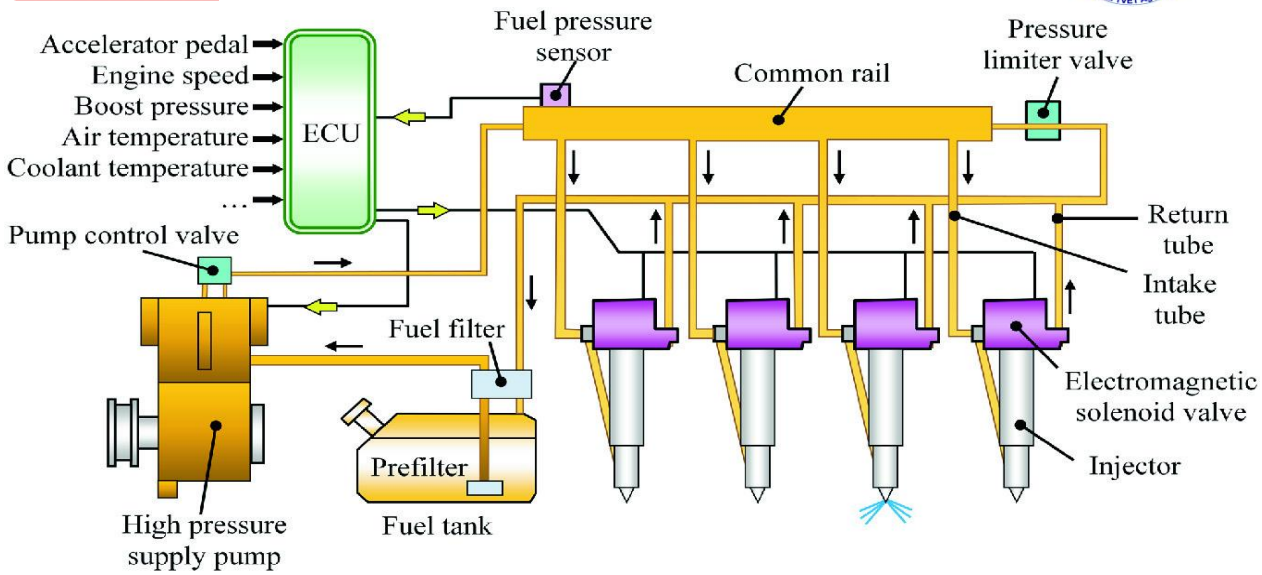
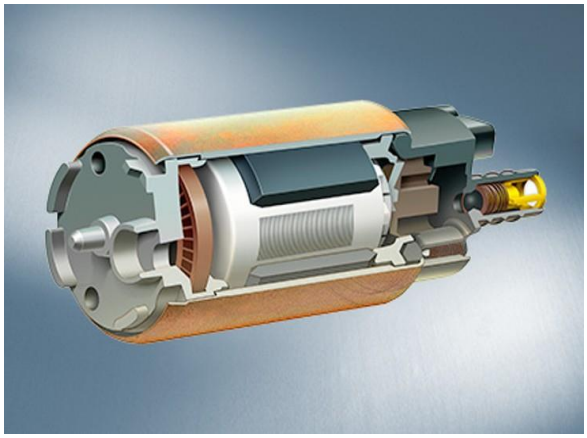


Figure: 2.11 Fuel Delivery and Injection Control Components

Toyota has used **two types** of electric fuel pumps on EFI systems. The early Conventional EFI system used an **externally mounted in-line pump**. These roller cell pumps incorporate an integral pressure pulse damper or silencer designedto smooth out pressure pulses and provide quiet operation.



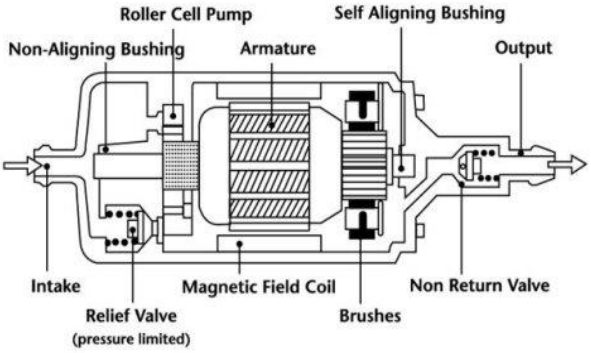


Figure: 2.12 externally mounted in-line pump

Later model production engines utilize an **in-tank pump integrated with the fuel sender unit**. These turbine pumps operate with less discharge pulsation and run quieter than the in-line variety. In-tank pumps can be serviced by removing the fuel sender unit from the tank.

2.13. Fuel Pump Electrical Controls and Circuit Opening Relay

Circuit Opening Relay Circuits There are **three types of fuel pump control** circuits used on Toyota's EFI engines. **One type** of control, used exclusively with **L type injection**, utilizes the **air flow meter Fc contact** to complete the circuit opening relay run winding ground. This is a safety feature which prevents the fuel pump from operating when the engine is not running.

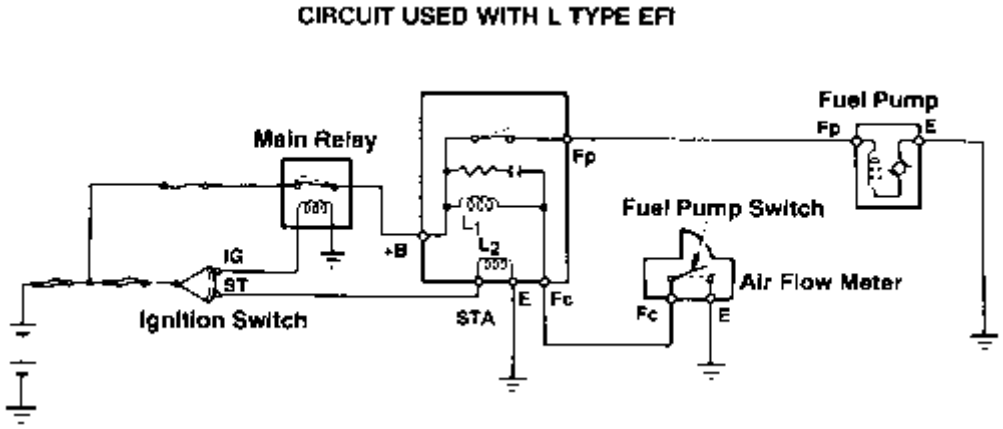


Figure: 2.13 L-type injection Circuit

A **second type** of fuel pump control uses the **ECU to control circuit** opening relay run winding current. Used on engines equipped with **D type EFI**, which uses a Karman vortex air flow meter, this safety feature prevents fuel pump operation whenever the ECU fails to see an Ne (engine rpm) signal. Under these conditions, the ECU removes ground from the circuit opening relay run winding.

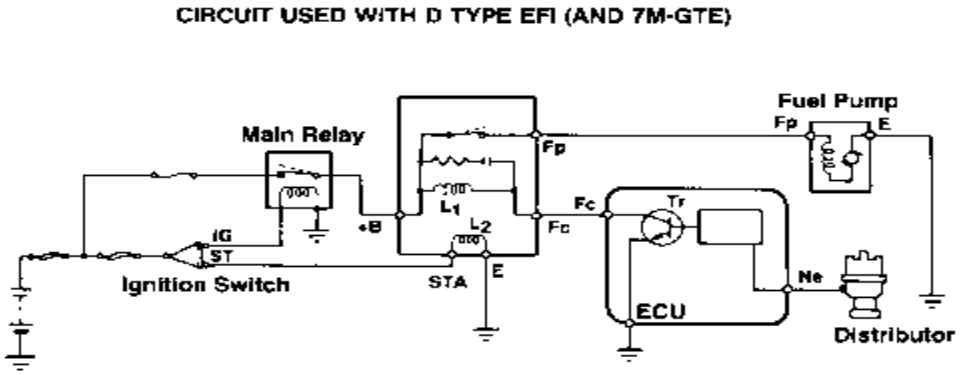


Figure: 2.14 D- type injection Circuit

2.14. Fuel Pump Speed Control

The **third type** of fuel pump control circuit utilizes a two-speed pump electrical circuit. Depending upon engine, the circuit opening relay may be **driven by the ECU** or **by the air flow meter Fc contact**. Pump current, however, is supplied either through a current limiting resistor or directly to the pump depending on engine load, rpm and status of the STA signal. When the engine is cranked, or operated at high speed and/or heavy load, the ECU turns off TR1, closing contact A of the Fuel Pump Control Relay. This allows current to flow directly to the fuel pump, causing it to run at high speed.

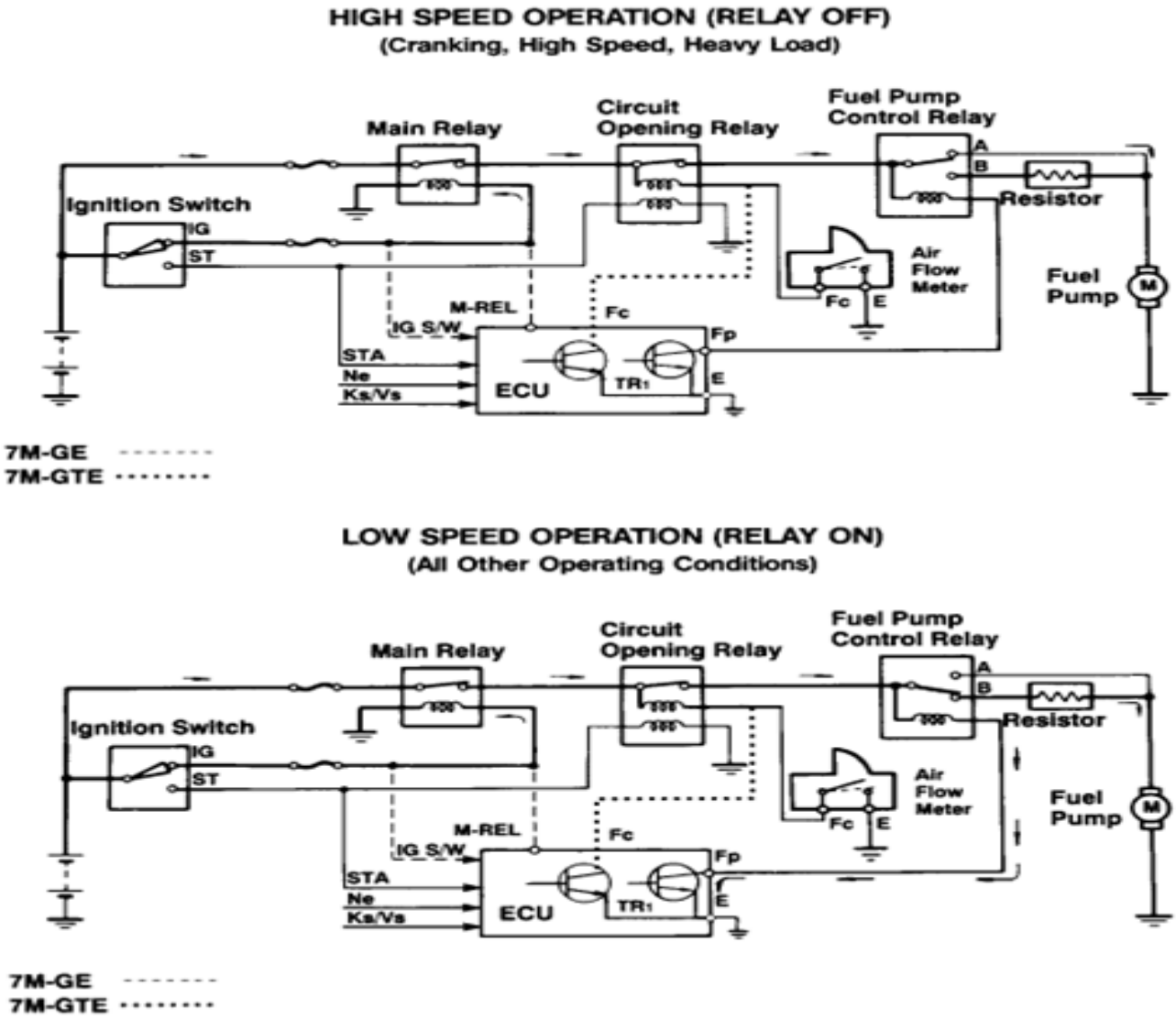


Figure: 2.15 high/low speed injection Circuit

2.15. Fuel Filter

The fuel filter, which is installed between the pump and the fuel rail, removes dirt and contaminants from the fuel before it is **delivered to the injectors and pressure regulator**.

2.16. Fuel Delivery Pipe (Fuel Rail)

The fuel delivery pipe, commonly referred to as a fuel rail is designed to hold the injector in place on the intake manifold. Mounted to the fuel delivery pipe are the **pulsation damper** (when used) and the **fuel pressure regulator**. The fuel delivery pipe acts as a reservoir for fuel which is held under pressure prior to delivery by the fuel injector.

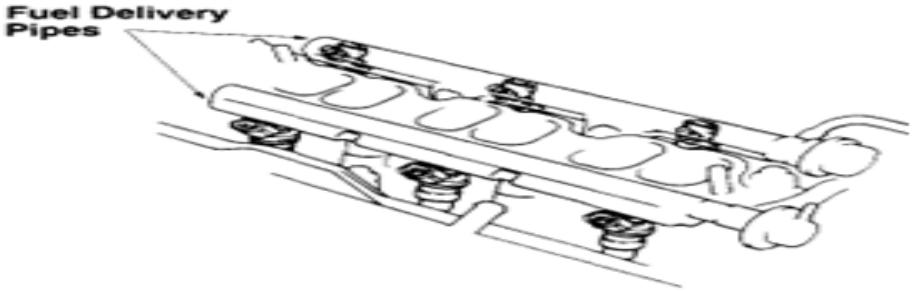


Figure: 2.16 Fuel Delivery Pipe (Fuel Rail)

2.17. Fuel Pressure Regulator

The fuel pressure regulator is a diaphragm operated pressure relief valve. To maintain precise fuel metering, the fuel pressure regulator maintains a constant pressure differential across the fuel injector. This means that the pressure in the fuel rail will always be at a constant value above manifold absolute pressure.

The specified pressure differential is either 36 PSI (2.55 kg/cm^2) or 41 PSI (2.90 kg/cm^2) depending on engine application. Maintenance of this pressure differential is accomplished by balancing a spring, assisted by manifold pressure against a diaphragm which holds a ball valve on its seat.

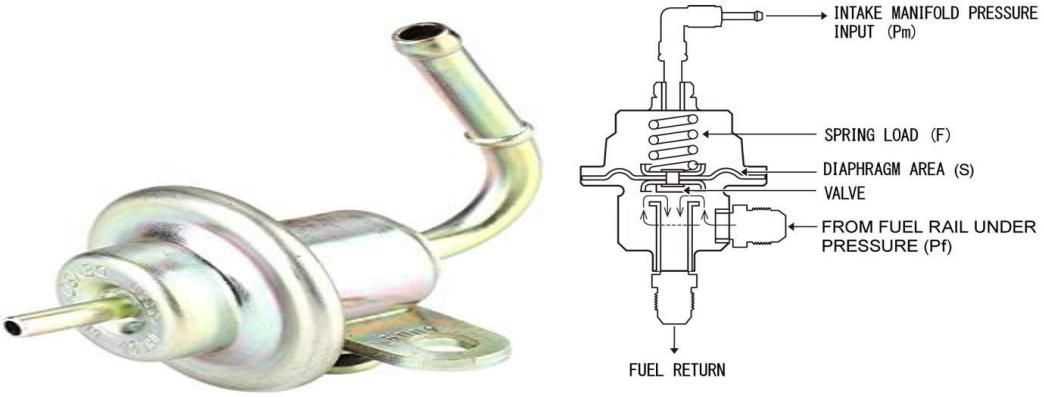


Figure: 2.17 Fuel Pressure Regulator

2.18. **Pulsation Damper**

Although fuel pressure is maintained at a constant value by the pressure regulator, the pulsing of the injectors causes minor fluctuations in rail pressure. The pulsation damper acts as an accumulator to smooth out these pulsations, ensuring accurate fuel metering.

The fuel pulsation damper is not used on all engines but can be used as a fuel pressure quick check on those engines which it is used.

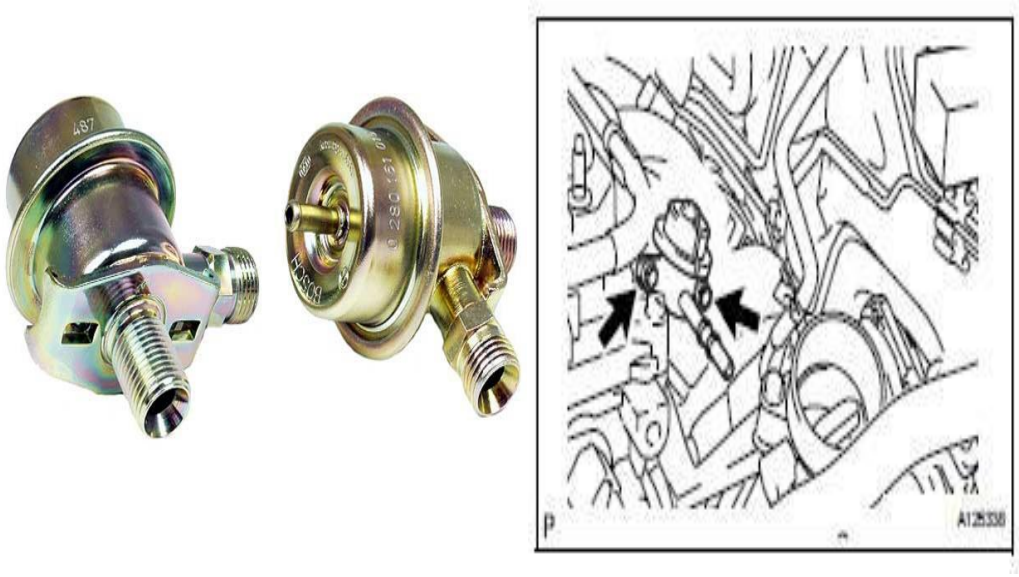


Figure: 2.18 Pulsation Damper

2.19. **Fuel Injectors**

The fuel injector is an electro-mechanical device which meters, atomizes and directs fuel into the intake manifold based on signals from the ECU driver circuit(s). Position the injectors, one per cylinder, directly behind the intake valve. The injectors are installed with an insulator/seal on the manifold end to isolate the injector from heat and to prevent an atmospheric pressure leak into the manifold.

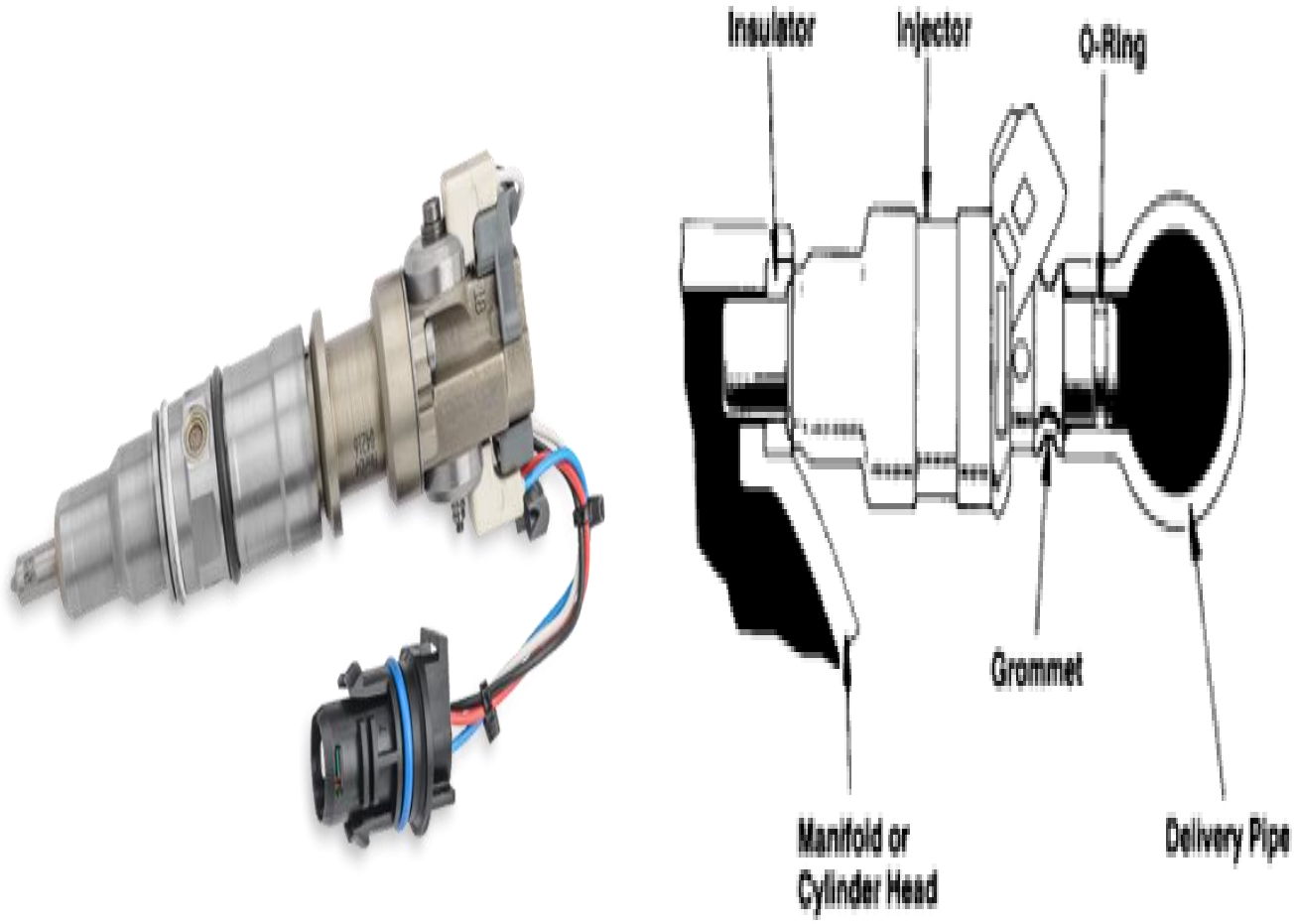


Figure: 2.19 Fuel Injectors

2.20. **Types of Injectors in Use**

different types of fuel injectors depending on engine application. These can be broken down into **pintle** type and **hole** type (cone valve and ball valve), **high resistance** and **low resistance**.

Figure: 2.20 Types of Injectors in Use

2.21. **Injector Driver Circuits**

Current is supplied to the ECU driver circuits through the fuel injectors. Current flows either directly from the ignition switch or from the EFI Main Relay. When the ECU driver circuit turns on, current flows to ground through the injector solenoid coil. The magnetic field created causes the injector to open against spring tension. When the ECU driver circuit turns off, the spring closes the injector valve. There are **two common types** of driver circuits currently in use on EFI engines; both of these driver circuits work on the voltage control principle. **One** uses an external solenoid resistor and a **low resistance injector**, the **other** using a **high resistance injector** without the solenoid resistor. In both cases, the high circuit resistance is required to limit current flow through the injector winding. **Without this control of the current flow through the injector, the solenoid coil would overheat, causing injector failure.**

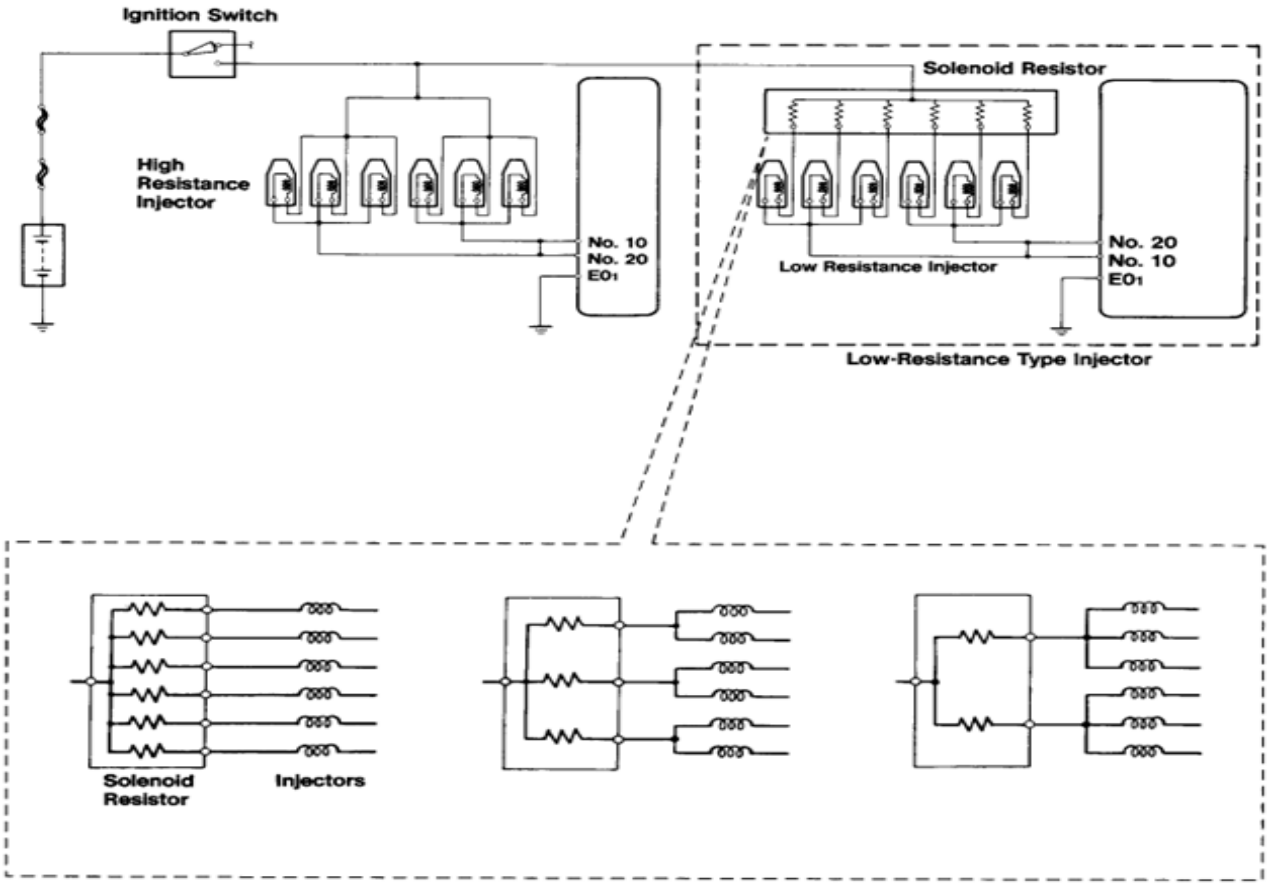


Figure:2.21 Low resistance and high resistance injector diagram

2.22. **Fuel Injection Pattern and Injection Timing**

Fuel injectors can be pulsed in one of four patterns depending on application. These injection patterns are:

- Simultaneous
- Two groups of two injectors each (four-cylinder engines)
- Three groups of two injectors each (six-cylinder engines)
- Independent (sequential)

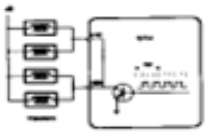
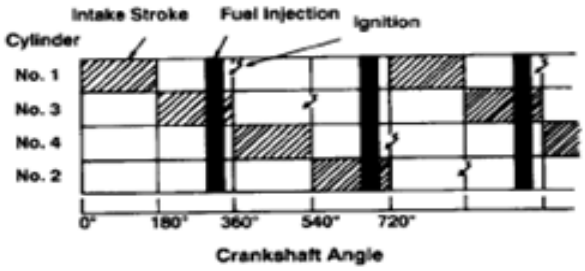
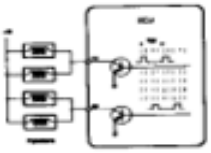
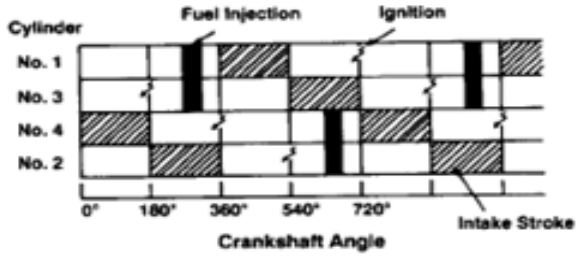
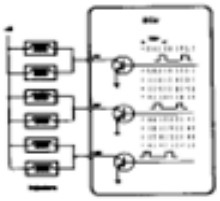
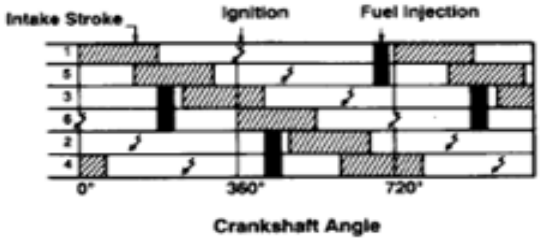
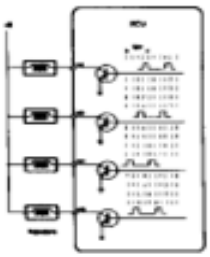
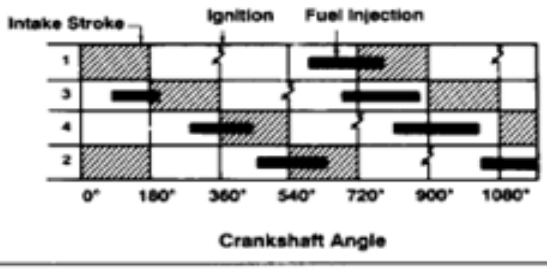
Injection Pattern	Injection Timing	Engines
Simultaneous 		4K-E, 4A-FE 2S-E, 3S-FE, 5S-FE (GEN 1) 4M-E, 5M-E, 5M-GE, 3Y-E, 4Y-E 22R-E, 22R-TE 3VZ-E, 3F-E 3E-E
2 Groups 		4A-GE (L type EFI) 4A-GZE 5S-FE (GEN 2) 5E-FE
3 Groups 		7M-GE 7M-GTE 2VZ-FE
Independent 		3S-GE 3S-GTE 3VZ-FE

Figure:2.22 Fuel Injection Pattern and Injection Timing

2.23. Cold Start Injection System

To improve engine starting when coolant temperatures are low a supplementary injector is installed on many EFI engines. The cold start injection system consists of the following components:

1. Cold Start Injector
2. Start Injector Time Switch
3. ECU (most EFI/TCCS)

1. Cold Start Injector

The cold start injector is located at some central location in the intake manifold. It is designed to supplement the cranking air/fuel ratio and prime the intake manifold in much the same way as a choke valve does while cranking a carbureted engine. This injector, **controlled by the start injector time switch** and **ECU.**

2. Start Injector Time Switch

The function of the start injector time switch is to control the cold start injector ground circuit and to determine maximum injection duration while cranking. Its bi-metallic switch is heated by both engine coolant and an electrical heater.

ECU Cold Start Injector Control

On most TCCS engines, an alternate ground may be supplied to the cold start injector by the ECU at the STJ terminal. Based on signals from the coolant temperature sensor, the ECU can operate the cold start injector for up to three seconds regardless of the status of the time switch. Maximum coolant temperature for ECU control is 113’F (45’C), above which the cold start injector will not operate from any source.

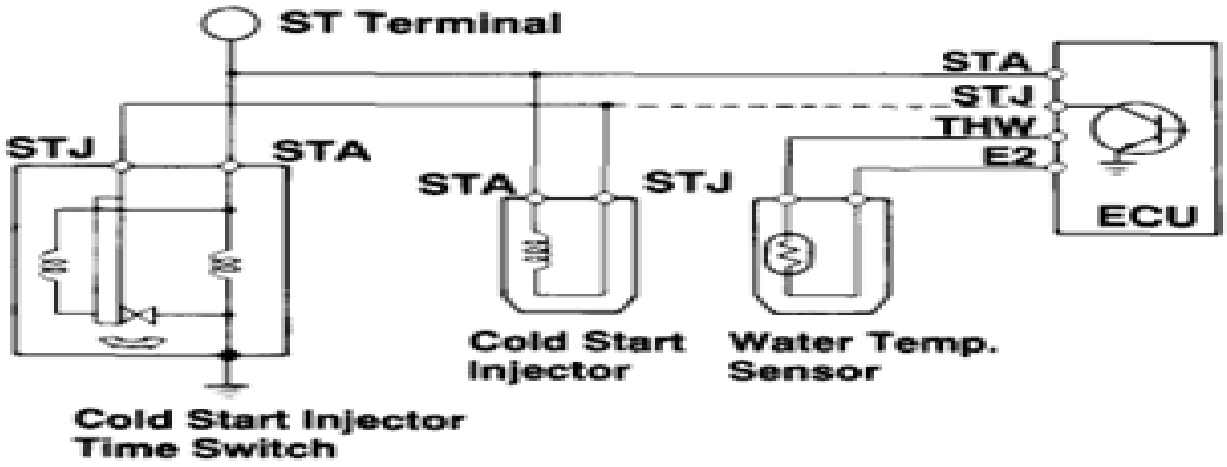


Figure:2.23 ECU Cold Start Injector Control

2.24. Alternative Method of Cold Cranking Enrichment

Some engines have eliminated use of a cold start injector entirely. Starting with the '91 model year, cold start injectors have been eliminated on the 3E-E and 4A-FE engine. During cranking, the ECU looks at THW and lengthens injector pulse width sufficiently to start the engine.

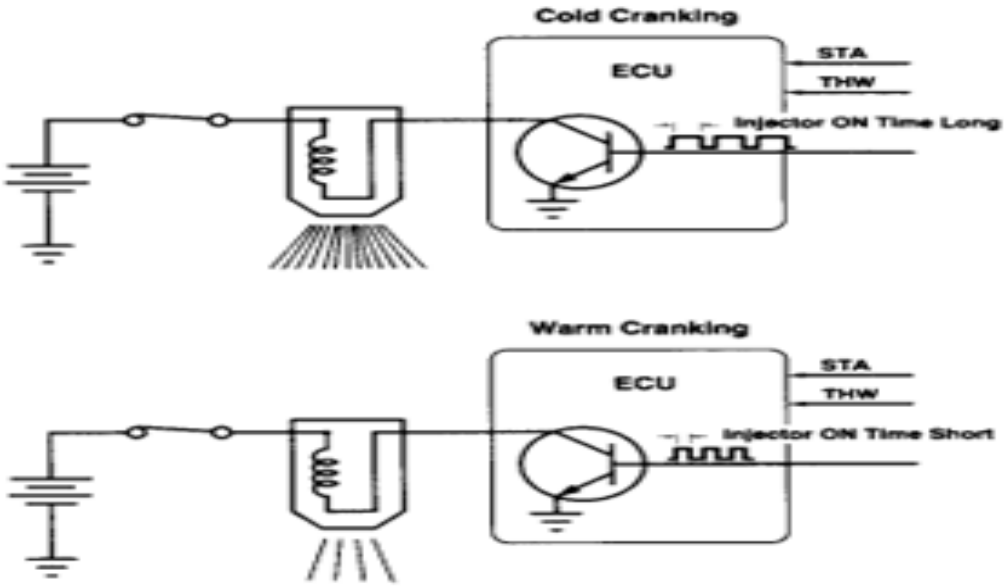


Figure:2.24 Alternative Method of Cold Cranking Enrichment

2.25. Air Induction System

The purpose of the air induction system is to filter, meter, and measure intake air flow into the engine.

Air, filtered by the air cleaner, passes into the intake manifold in varying volumes.

The amount of air entering the engine is a function of throttle valve opening angle and engine rpm.

Intake **air volume is measured** by movement of the air flow meter measuring plate or by detecting vortex frequency on engines equipped with **L type EFI**.

On engines equipped with **D type EFI**, air volume is **measured by monitoring the pressure** in the intake manifold, a value which varies proportionally with the volume of air entering the engine

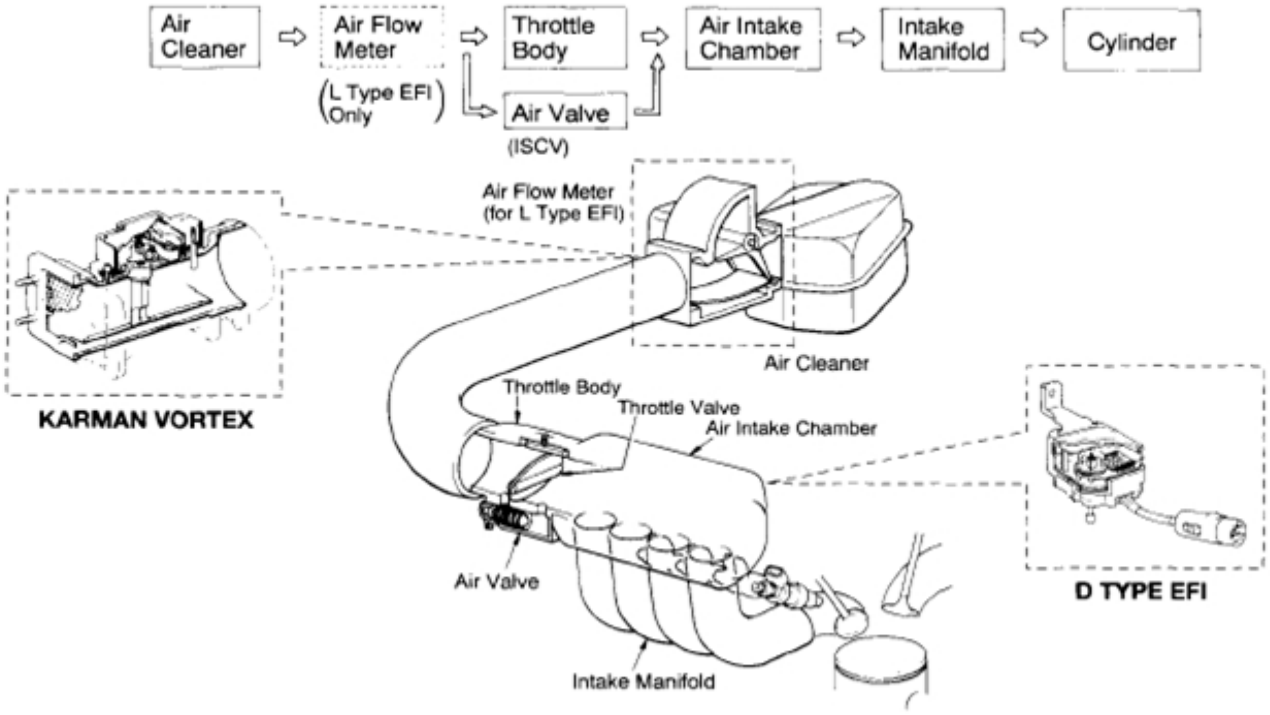


Figure:2.25 Air Induction System Components

2.26. Vane Air Flow Meter (L Type EFI)

The vane type air flow meter is a commonly used air volume measurement device on Toyota EFI engines. The meter consists of a measuring plate, which is spring loaded closed by a return spring, and a **potentiometer** attached to the plate, which varies an electrical signal to the ECU as the position of the plate changes.

Air volume entering the engine is directly proportional to the amount of movement detected from the measuring plate.

Additionally, the air flow meter incorporates a fuel pump enable contact which breaks the ground circuit of the circuit opening relay if the engine stops running.

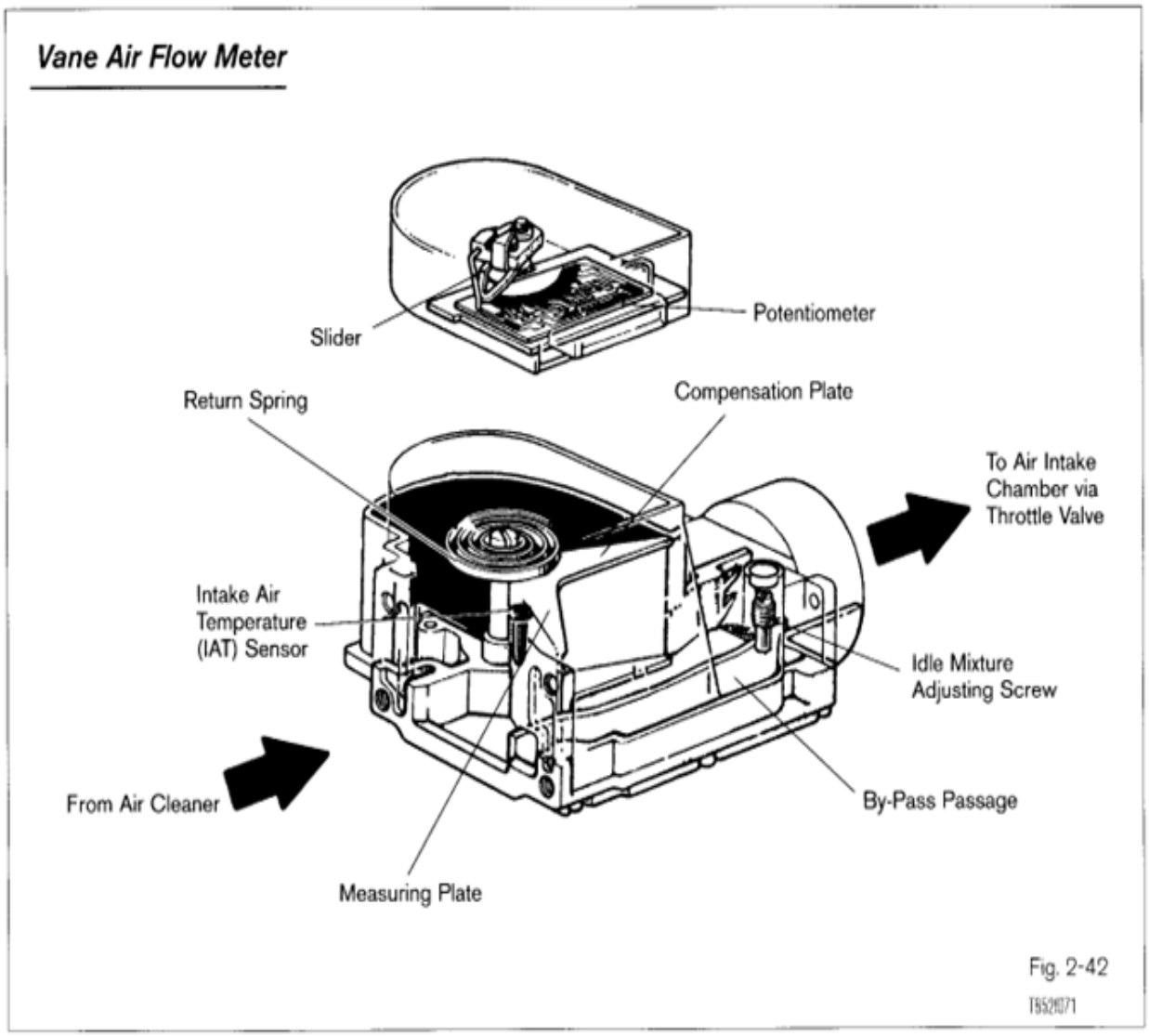


Figure: 2.26 Vane Air Flow Meter (L Type EFI)

2.27. Air Valves

There are **two types** of non-ECU controlled air valves used on some engines to control cold engine fast idle. These valves, the **electrically heated bi-metal type** and the **coolant heated wax type**, vary the amount of air bypassing the closed throttle valve during cold engine operation.

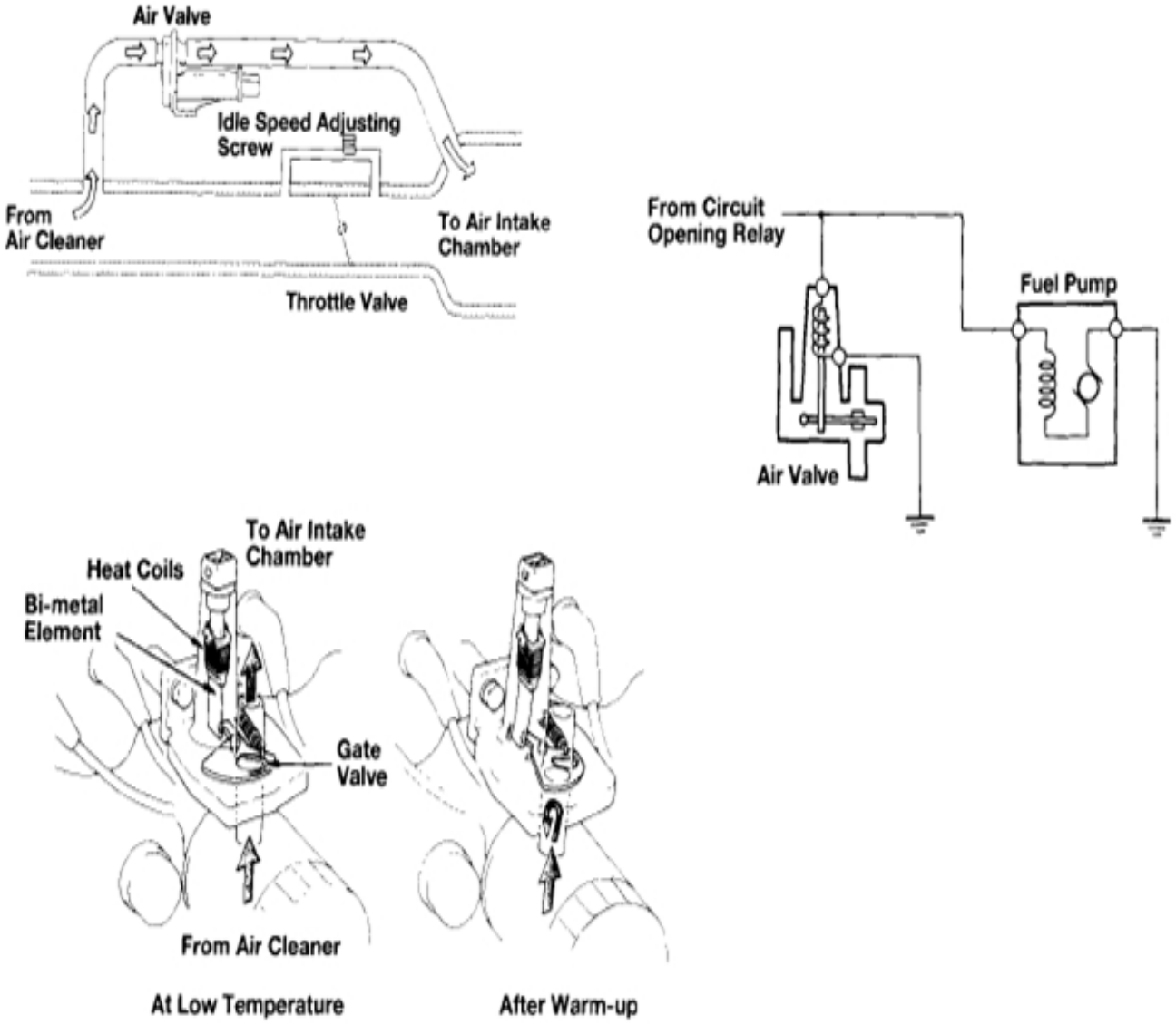


Figure: 2.27 Air Valves

2.28. Bi-metal Type Air Valve

This gate valve operates on the principle of a spring-loaded gate balanced against a bi-metal element. The tension of the bi-metallic element varies the position of the gate as its temperature changes. The bi-metal element is heated by an electrical heater coil and by the temperature of the ambient air surrounding it. The air valve assembly is installed on the surface of the cylinder head to keep the gate valve closed during hot soak periods.

2.29. Wax Type Air Valve

The wax type air valve is integrated with the throttle body and varies an idle air by-pass opening as coolant temperature changes. The valve works on the principle of a spring-loaded gate valve balanced against a coolant heated, wax filled thermo valve. The wax type air valve should be fully closed by the time engine coolant temperature reaches approximately 80'C (176'F).

2.30. Purpose of ECU Controlled Idle Speed Control Systems

The Idle Speed Control (ISC) system regulates engine idle speed by adjusting the volume of air that is allowed to by-pass the closed throttle valve. The ECU controls the Idle Speed Control Valve (ISCV) based on input signals received from various sensors. The system is necessary to provide stabilization of curb idle when loads are applied to the engine and to provide cold fast idle on some applications. The Idle Speed Control system regulates idle speed under at least one or more of the following conditions, depending on application:

- Fast Idle
- Warm Curb Idle
- Air Conditioner Load
- Electrical Load
- Automatic Transmission Load

Difference Between Mechanical Air Valves and ECU Controlled ISCV The ECU controlled ISC systems addressed in this chapter should not be confused with the mechanical air valves which were addressed in Chapter 2, "Air Induction System." The ISC valve is totally controlled by the ECU based on inputs received from the various sensors, and it controls many different idle speed parameters.

The Wax type and Bi-metal mechanical air valves are used only to regulate cold engine fast idle and are not ECU controlled. There are some engines which utilize a mechanical air valve, for cold fast idle control, in combination with an ECU controlled ISC Vacuum Switching Valve (VSV) to control warm curb idle.

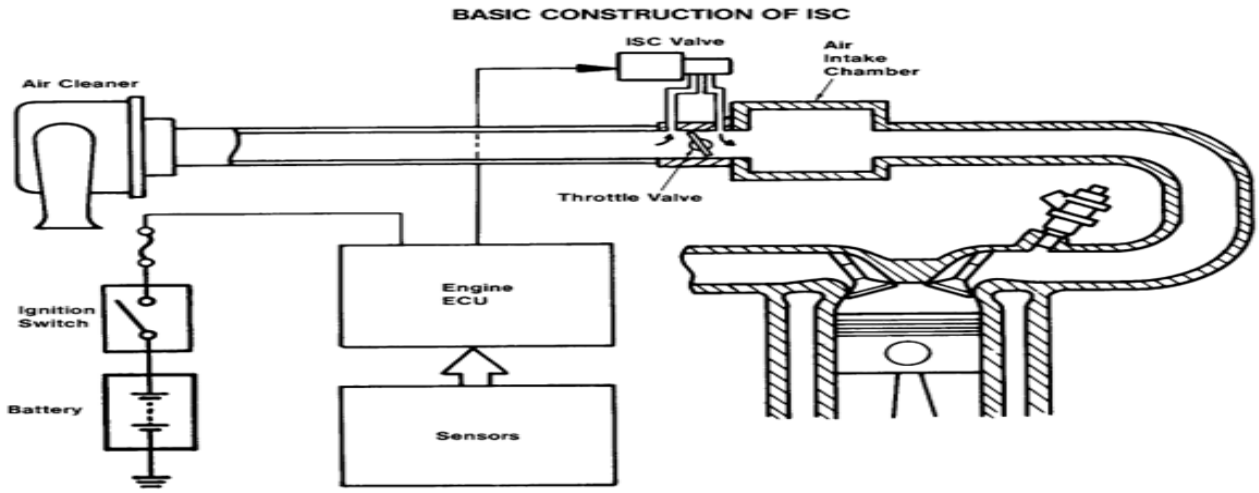


Figure: 2.28 Idle Speed Control Systems

2.31. Four Different ECU Modulated Idle Speed Control Systems (ISC)

There are **four different types** of ECU controlled ISC systems used on Toyota engines. These systems are referred to as:

1. Stepper motor type
2. Rotary solenoid type
3. Duty control ACV type
4. On-off control VSV type

1. Step Motor Type ISC Valve

The Step Motor type ISCV is located on the intake air chamber or throttle body. It regulates engine speed by means of a stepper motor and pintle valve which controls the volume of air by-passing the closed throttle valve.

The ISCV throttle air by-pass circuit routes intake air past the throttle valve directly to the intake manifold through a variable opening between the pintle valve and its seat.

The valve assembly consists of four electrical stator coils, a magnetic rotor, a valve and valve shaft. The valve shaft is screwed into the rotor so that as the rotor turns, the valve assembly will extend and retract.

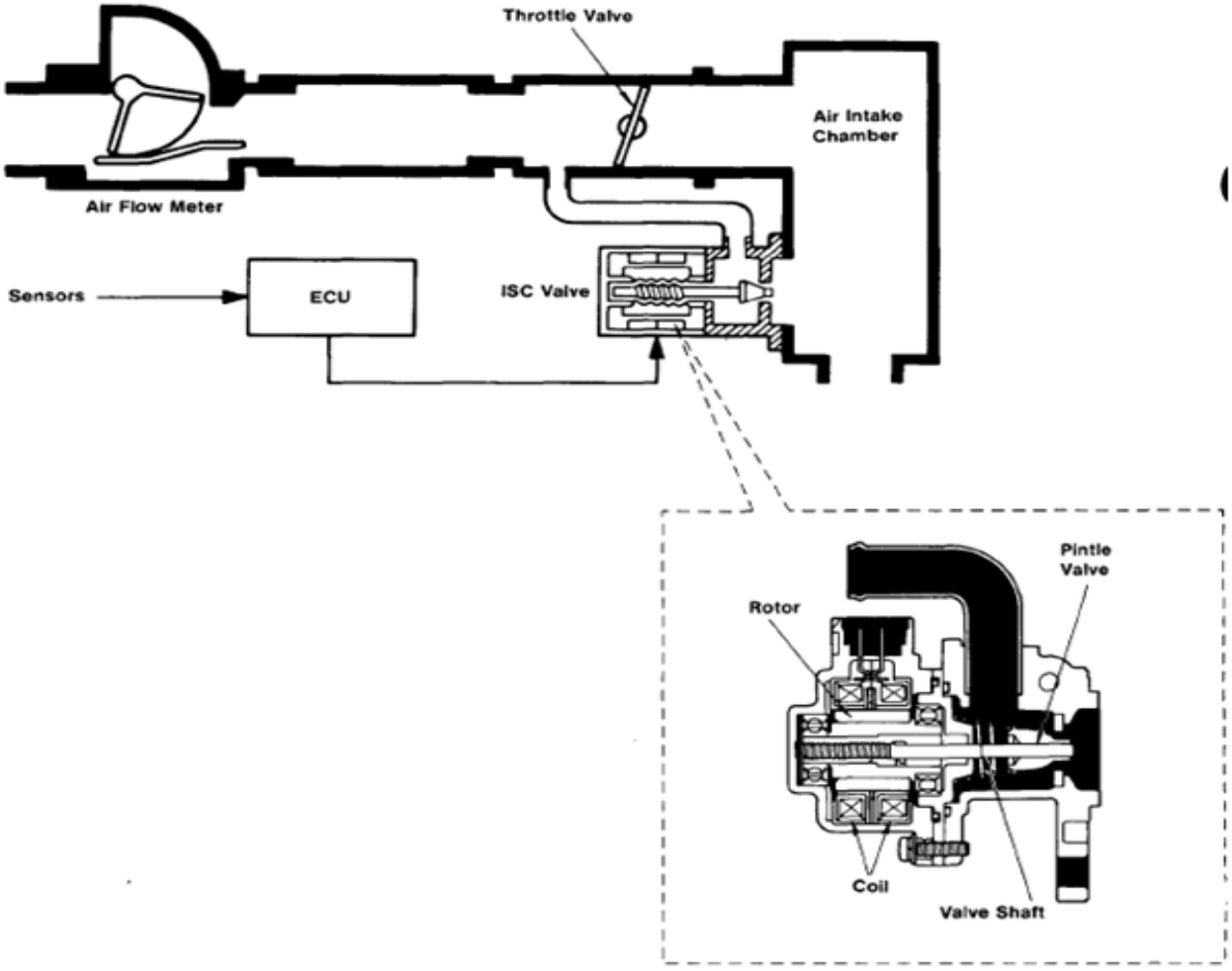


Figure: 2.29 Step Motor Type ISC Valve

2. Rotary Solenoid ISCV

The Rotary Solenoid ISCV is mounted to the throttle body. This small, lightweight and highly reliable valve controls the volume of intake air which is allowed to by-pass the closed throttle valve. Air volume control is accomplished by means of a movable rotary valve which blocks or exposes the air by- pass port based on signals received from the ECU.

3. Duty Control Air Control Valve (ACV) ISC

The Duty Control ACV is typically mounted on the intake manifold. It regulates the volume of air by-passing the closed throttle valve by opening and closing an air by-pass. Valve opening time is a function of a duty cycle signal received from the ECU. The ACV is incapable of flowing large volumes of air; therefore, a separate mechanical air valve is used for cold fast idle on engines equipped with this system.

4. On-Off Control Vacuum Switching Valve (V-ISC System)

The simple On-Off Vacuum Switching Valve (VSV) ISC system is controlled by signals from the ECU or directly by tail lamp and rear window defogger circuits. The Vacuum Switching Valve (VSV) is typically located on the engine (often under the intake manifold) or in the engine compartment, controlling a fixed air bleed into the intake manifold.

The valve is a normally closed (N/Q design which is opened when current is passed through the solenoid windings. Unlike most ECU controlled circuits which are ground circuit driven, the ECU controls this VSV by supplying current to the solenoid coil when pre-programmed conditions are met. Additionally, current can be supplied to the solenoid from the rear window defogger or taillight circuits by passing through isolation diodes.

2.32. Idle Mixture Air By-pass Circuit

For proper calibration of the engine air/fuel ratio at idle speed, an idle mixture air by-pass circuit is incorporated into the air flow meter.A screw is used to adjust the amount of air which by-passes the measuring plate. This screw is adjusted and sealed at the factory to discourage improper adjustment and

tampering. There are no provisions or specifications for field adjustment.

2.33. Fuel Pump Circuit Control

A fuel pump switch is incorporated into theair flow meter to prevent the fuel pump from running unless the engine is running. Any movement of the air flow meter measuring plate will cause the fuel pump switch contact to close. When the engine is not running, the measuring plate forces the fuel pump switch contact open, preventing the circuit opening relay from operating.

2.34. Electronic Control System

The EFl/TCCS system is an electronic control system which provides Toyota engines with the means to properly meter the fuel and control spark advance angle. The system can be divided into three distinct elements with three operational phases. The **three system elements** are:

1. **Input Sensors**

   Sensors convert temperature, pressure, speed, position and other data into either digital or analog electrical signals.

2. **Processor Electronic Control Unit (Microcomputer)**
   - Electronic control unit (**ECU**) with microprocessors which processes the information in accordance with specific control algorithms, and outputs corresponding electrical signals.
   - The ECU employs digital technology. The microprocessors with their input and output interface circuits form the heart of the ECU. The circuitry is completed by the memory units and devices for the conversion of the sensor signals into computer-compatible quantities.
   - The ECU is installed in the passenger compartment to protect it from external influences. There are a number of different maps stored in the ECU, and these come into effect as a function of such parameters as: Load, engine speed, coolant temperature, air quantity etc.
3. **Output Actuators**

   Actuators which convert the ECU's electrical output signals into mechanical quantities

Components		Function
Sensor	Manifold pressure (vacuum) sensor or Air flow meter	Senses intake manifold pressure (D-type EFI) Senses intake air volume. (L-type EFI)
	Crank angle sensor Engine speed sensor	Senses crank angle Senses engine speed
	Water temperature sensor	Senses coolant temperature
	Intake air temperature sensor	Senses intake air temperature
	Throttle position sensor	Senses throttle valve opening angle
	Ignition switch	Senses when IGSW is start position
	Vehicle speed sensor	Senses vehicle speed
	Oxygen sensor	Senses oxygen density in the exhaust gas
	Neutral start switch	Senses whether the transmission is in “P” or “N”, or in some other gear
	Taillight and defogger relays	Senses electrical load
	Air conditioner	Senses whether air con. is On or Off
	Knock sensor	Senses engine knocking
ECU		Determines injection duration and timing, ignition timing, idle speed, etc., based upon data from sensors and data stored in memory, and sends appropriate signals to control actuators.
Actuators	Injectors	Injects fuel into intake manifold in accordance with signals from engine computer
	Igniter/power transistor	Controls primary ignition circuit On Off time
	Idle speed control valve	Controls idle speed by changing volume of air flowing through throttle valve bypass in accordance with signals from engine computer

Table: 2.1 Component and Function Electronic control system for gasoline

2.35. Electronic Diesel Control (EDC)

2.35.1. Closed control loops Injected fuel quantity

The injected fuel quantity has a decisive influence upon the vehicle's starting, idling, power output and drivability characteristics, as well as upon its particulate emissions. For this reason, the corresponding maps for start quantity, idle, full load, accelerator-pedal characteristic, smoke limitation, and pump characteristic, are programmed into the ECU.

The driver inputs his or her requirements regarding torque or engine speed through the accelerator sensor.

Taking into account the stored map data, and the actual input values from the sensors, a set point is calculated for the setting of the rotary actuator in the pump. This rotary actuator is equipped with a check-back signaling unit and ensures that the control collar is correctly set.

2.35.2. Start of injection

The start of injection has a decisive influence upon starting, noise, fuel consumption, and exhaust emissions. Start of-injection maps programmed into the ECU take these interdependencies into account.
A closed control loop is used to guarantee the high accuracy of the start-of-injection point. A needle-motion sensor (NBF) registers the actual start of injection directly at the nozzle and compares it with the programmed start of injection .

Deviations result in a change to the on/off ratio of the timing-device solenoid valve, which continues until deviation reaches zero.

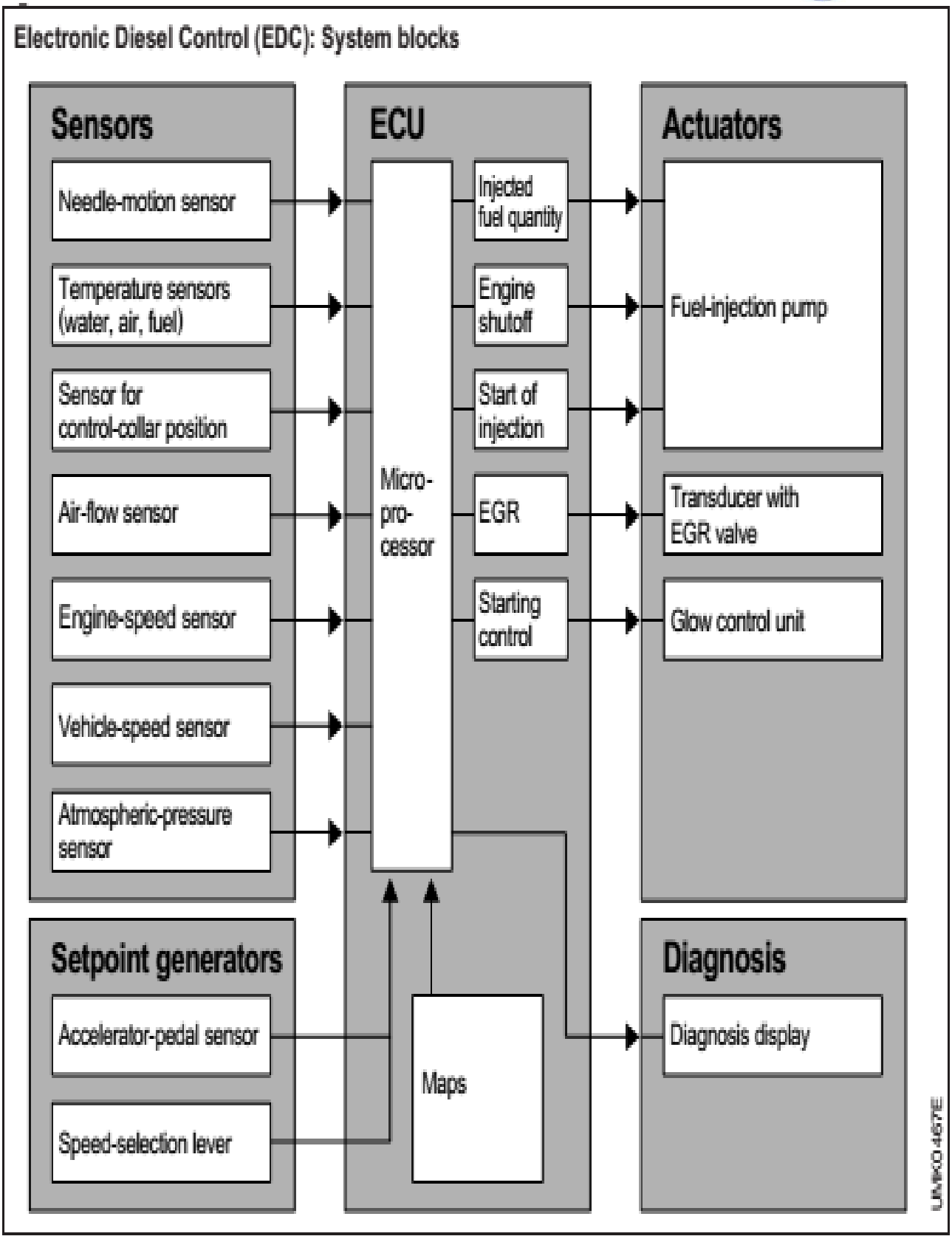


Table : 2.2 Electronic control for distributor pumps

Engine Management Sensors with mounting location

Measured variable	Direct/indirect measurement	Sensor technology/ reference	Sensor mounting location
Intake manifold absolute pressure	Indirect measurement of engine load or mass air-flow intake	Wheatstone bridge arrangement of thick film resistors bonded onto a thin alumina diaphragm	Within intake manifold
Mass airflow	Direct and indirect measurement of fuel injector basic pulse width	Various forms including 'flap' type, 'hot-wire', Karman vortex and thick film diaphragm	Within air intake
Temperature	Direct measurement at various locations	Thermistor or thermocouple depending on temperature range	Intake air, outside air, catalytic converter, engine coolant, hydraulic oil
Engine speed and crankshaft reference position	Direct measurement	Magnetic reluctance or Hall effect device	Flywheel on end of engine crankshaft
Battery voltage	Direct measurement	Resistive attenuator	
Throttle position	Direct measurement	Potentiometer	Accelerator pedal
Knock (engine cylinder pressure oscillations during ignition)	Direct measurement	Piezoelectric accelerometer type.	Cylinder block or head
Oxygen concentration in exhaust gas (Lambda sensor)	Direct measurement	Zirconia or Titania based exhaust gas oxygen sensors	Exhaust manifold (normal operation above 300^0 C)

Table:2.3 Engine Management Sensors with mounting location

Self-Check 2	Written Test

Directions: **Write the function of each sensor listed below in the provided space**

Name: _____ **Date:** _____

1) Crank angle sensor(2point)

---

2) Engine speed sensor(2point)

---

3) Water temperature sensor(2point)

---

4) Intake air temperature sensor(2point)

---

5) Throttle position sensor(2point)

Note: **Satisfactory rating –10 points** **Unsatisfactory - below 10 points**

Score = _____

Rating: _____

Information Sheet 3- applying Methods in identifying diesel and gasoline electronic fuel injection components

3. applying Methods in identifying diesel and gasoline electronic fuel injection components

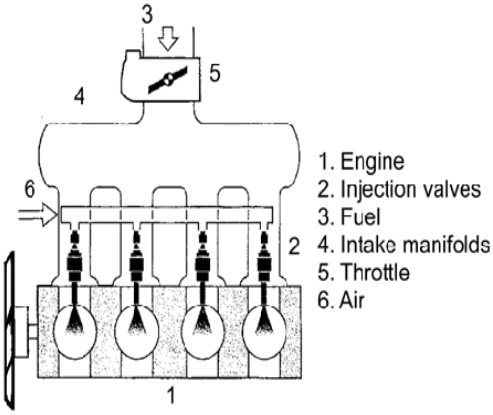
The term "fuel injection" is vague and comprises various distinct systems with fundamentally different functional principles.

Typically, the only thing in common all fuel injection systems have is the lack of carburetion. There are two main functional principles of mixture formation systems for internal combustion engines: internal mixture formation, and external mixture formation.
A fuel injection system that uses external mixture formation is called a manifold injection system; there exist two types of manifold injection systems: multi-point injection (port injection), and single-point injection (throttle-body injection).

Internal mixture formation systems can be separated into direct, and indirect injection systems. There exist several different varieties of both direct and indirect injection systems, the most common internal mixture formation fuel injection system is the common-rail injection system, a direct injection system.

The term electronic fuel injection refers to any fuel injection system having an engine control unit.

3.1. Basic multi point electrical fuel injection system:



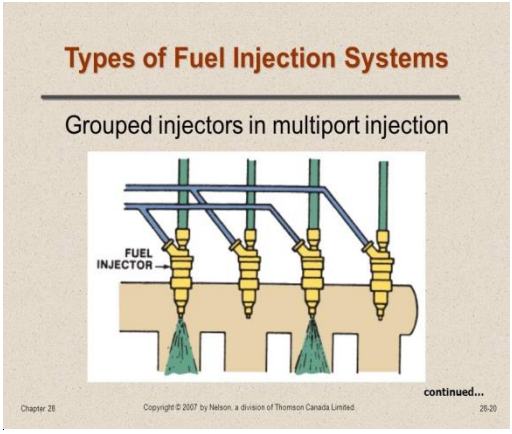


Fig.3.1 Basic multi point electrical fuel injection

3.2. fuel delivery system

The purpose of the fuel delivery system is to quietly deliver the proper volume of fuel at the correct pressure. The fuel delivery system must also meet emission and safety regulations. The fuel delivery system

incorporates the following components:

1. Fuel tank (with evaporative emissions controls)
2. Fuel pump
3. Fuel pipe and in line filter
4. Fuel delivery pipe (fuel rail)
5. Pulsation damper (most engines)
6. Fuel injectors
7. Cold start injector (some engines)
8. Fuel pressure regulator
9. Fuel returns pipes

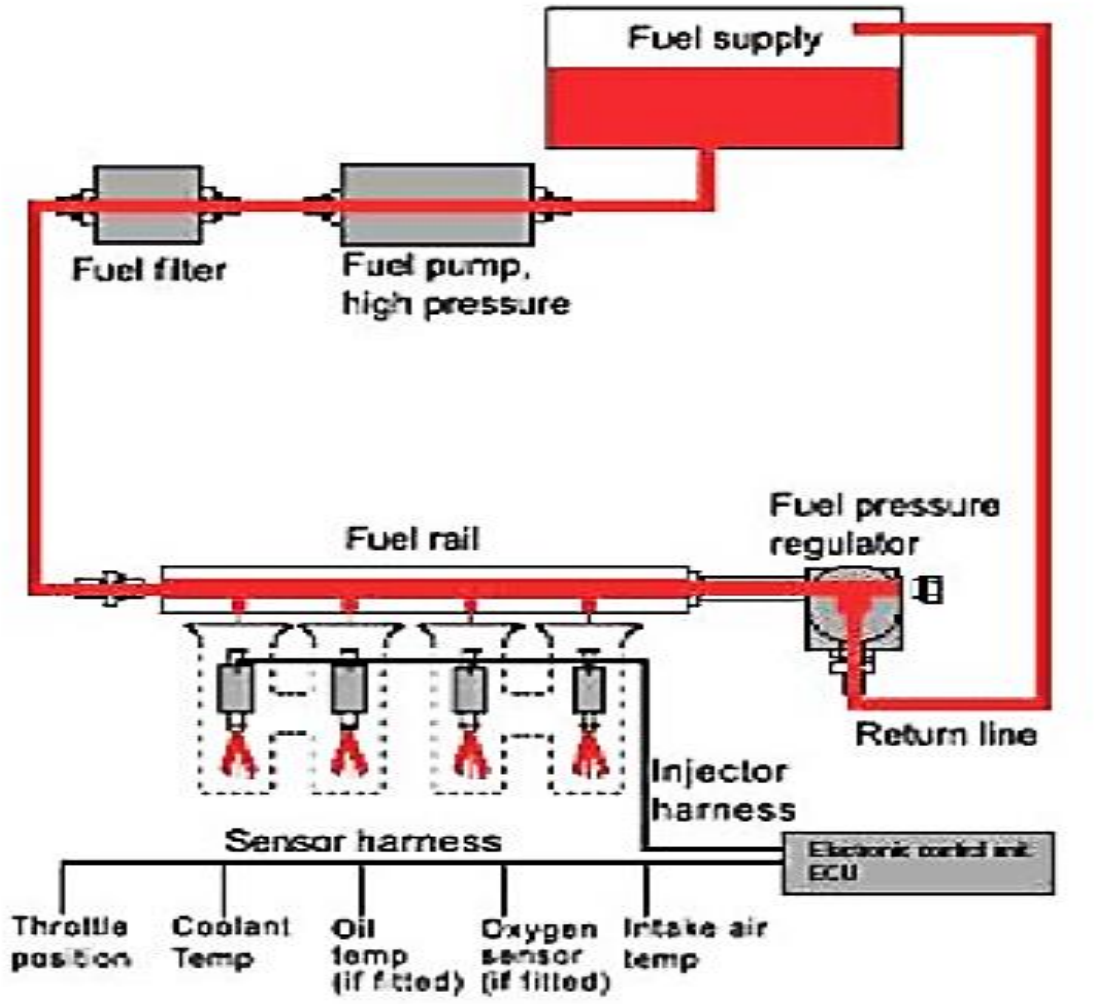


Fig.3.2 fuel deliver system

The fuel system can be divided into three basic circuits such as:-

- Low pressure supply circuit
- High pressure delivery circuit
- Fuel leak back and return

The following diagram show the hall fuel circuit system of diesel

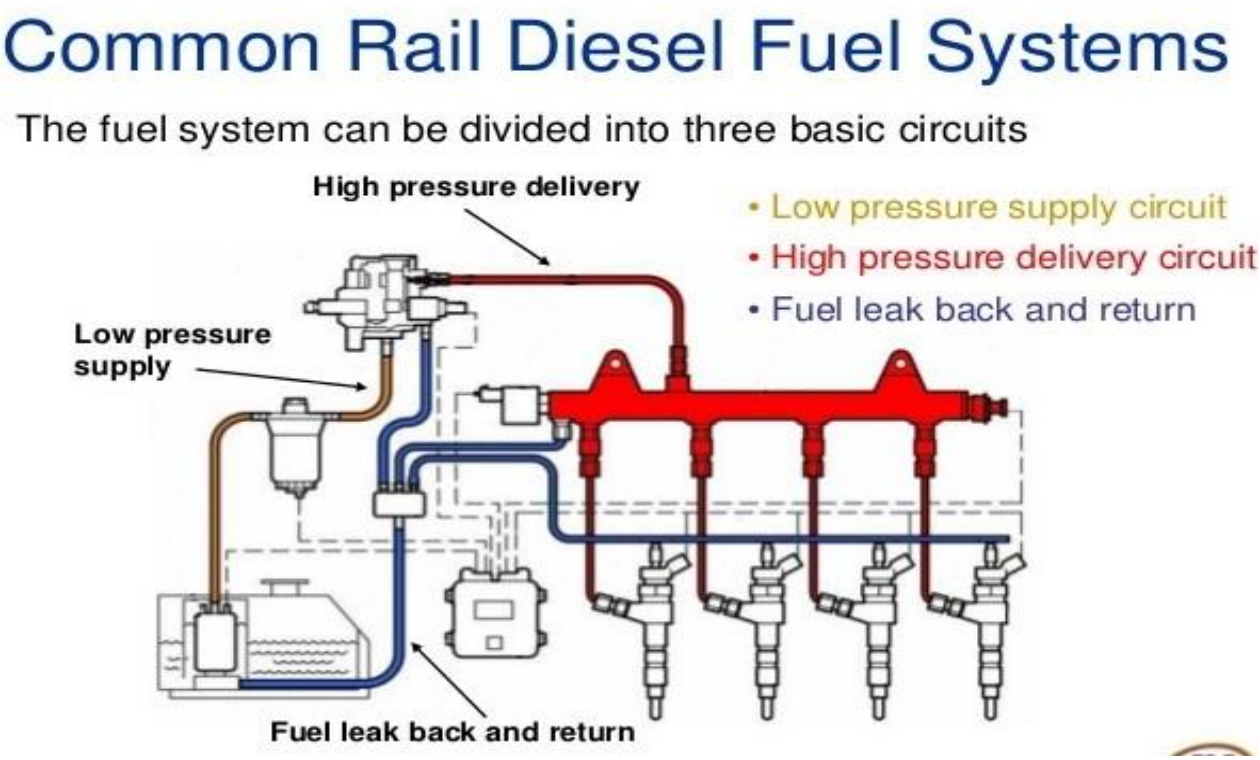


Fig.3.3 fuel circuit

3.2.1. Fuel pump

Fuel is pumped from the tank by an electric fuel pump, which is controlled by the circuit opening relay. Fuel flows through the fuel filter to the fuel rail (fuel delivery pipe) and up to the pressure regulator where it is held under pressure.

The pressure regulator maintains fuel pressure in the rail at a specified value above intake manifold pressure. This maintains a constant pressure drop across the fuel injectors regardless of engine load.

Fuel in excess of that consumed by engine operation is returned to the tank by way of the fuel return line.

3.2.2. Pulsation damper

A pulsation damper, mounted to the fuel rail, is used on some engines to absorb pressure variations in the fuel rail due to injectors opening and closing.

The fuel injectors, which directly control fuel metering to the intake manifold, are pulsed by the ECU. The ECU completes the injector ground circuit for a calculated amount of time referred to as injection duration or injection pulse width.

The ECU determines which air/fuel ratio the engine runs at based upon engine conditions monitored by input sensors and a program stored in its memory.

During cold engine starting, many engines incorporate a cold start injector designed to improve start ability below a specified coolant temperature.

Self-cheek -3	Written Test

Direction-I true false item

Instruction: Write “true” if the statement is correct write “false” if the statement incorrect and write the word on the space provided. (12 pts.)

…….. A. Distributor diesel injection pump is a high-pressure pump assembly with lines leading to each individual injector.

……..,2. The ECU calculates injected fuel quantity, start of injection, duration of injection, and rate of discharge curve, as well Supervises the correct functioning of the injection system as a whole.

……. 3. The higher the cetin rating of diesel fuel, the more easily the fuel is ignited.

……. 4. The fuel in a diesel engine is not ignited with a spark, but is ignited by the heat generated by high compression.

…….. 5. Some common rail injectors are controlled by a magnetic solenoid on the injector.

……6. The pressure is set by the engine control unit and is independent of the engine speed and quantity of fuel being injected into any of the cylinders.

Note: **Satisfactory rating –10 points** **Unsatisfactory - below 10 and points**

Score = _____

Rating: _____

Name: _____ **Date:** _____

Information Sheet 4- Analysing method options

4. Analysing method options

Select and preparing method options.

Various systems differ in design, components layout and specific functions. However, all operate in a similar way Fuel Rail Pressure Sensor.

A fuel rail pressure sensor is located on the fuel rail. Monitors the fuel pressure in the common rail.

Typically, a pies resistive type sensor has three wires: 5 Volt supply from engine ECM. Sensor ground via engine ECM. Linear signal voltage output to ECM. Signal utilization – To enable the engine ECM to determine the fuel rail pressure.

Used by the ECM as part of the calculation for the % duty cycle applied to the rail pressure control solenoid and fuel metering solenoid.

The engine ECM applies a stabilized 5 Volts supply to the signal wire of the fuel pressure sensor. The resistive value of the sensor creates a change in the voltage on the signal wire relative to the fuel rail pressure. Typical signal voltages from rail pressure sensor (Model – Bosch EDC16) Engine stationary approximately 0.5 volts and Engine idling: approximately 1.32 volts. Snap acceleration: approximately 3.77 volts + Engine management closed loop control functions

The following diagram shows the rail pressure calculation.

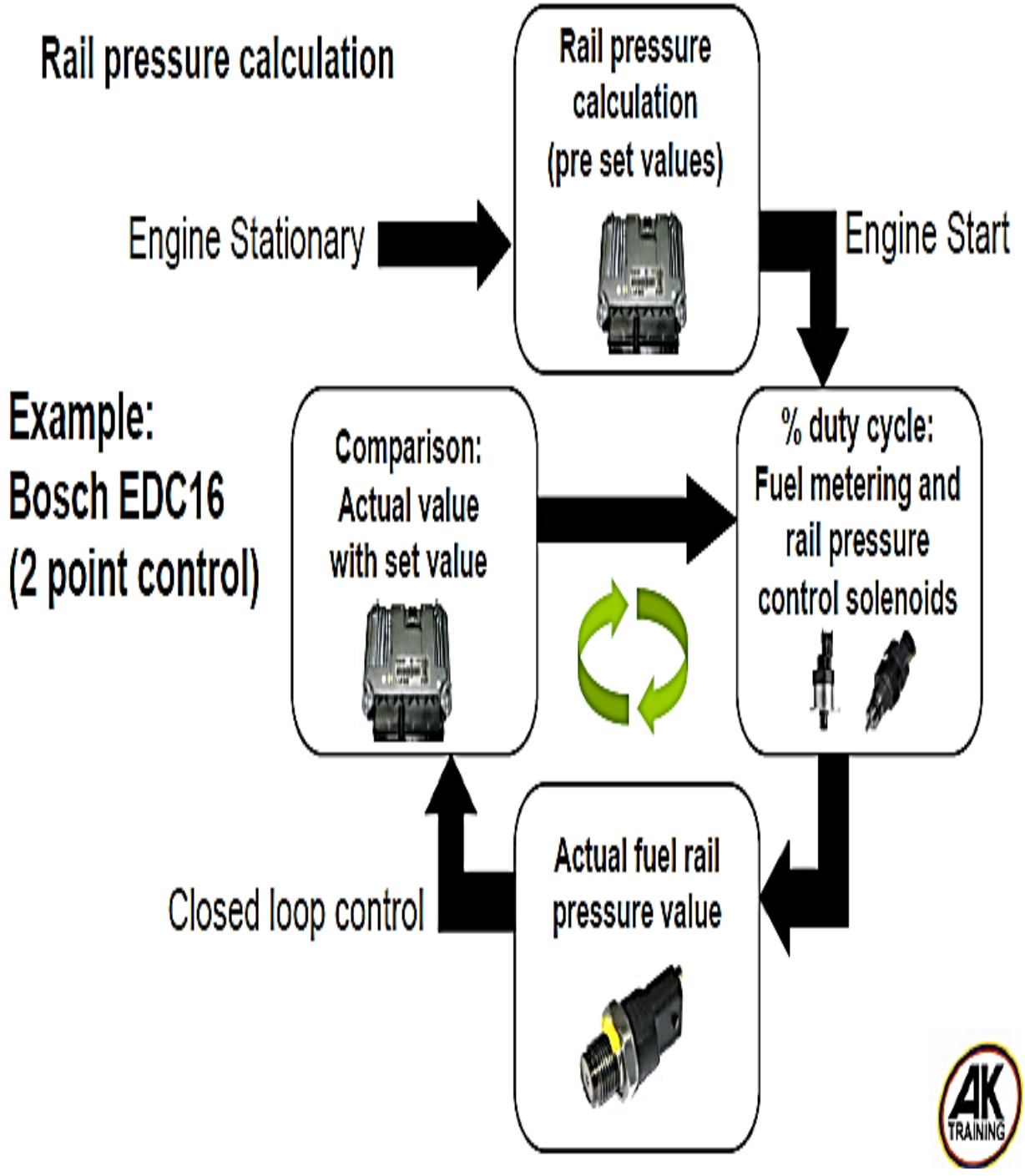


Fig: 4.0 The rail pressure calculation system.

Self-cheek -4	Written Test

Direction-I true false item

Instruction: Write “true” if the statement is correct write “false” if the statement incorrect and write the word on the space provided.(9pts)

…….1 the fuel in a diesel engine is not ignited with a spark, but is ignited by the heat generated by high compression.

……..2, some common rail injectors are controlled by a magnetic solenoid on the injector.

……3, the pressure is set by the engine control unit and is independent of the engine speed and quantity of fuel being injected into any of the cylinders.

Note: **Satisfactory rating –8 points** **Unsatisfactory - below 8 and points**

Name: _____ Date: _____

5. Sourcing and supporting technical and/or calibration requirements for the testing and overhaul of diesel fuel injection system

5.1. Stethoscope

A stethoscope is used to locate the source of engine and other noises. The stethoscope pickup is placed on the suspected component, and the stethoscope receptacles are placed in the technician's ears.

Some sounds can be heard easily without using a listening device, but others are impossible to hear unless amplified, which is what a stethoscope does. It can also help you distinguish between normal and abnormal noise.

The best results, however, are obtained with an electronic listening device. With this tool you can tune into the noise, which allows you to eliminate all other noises that might distract or mislead you

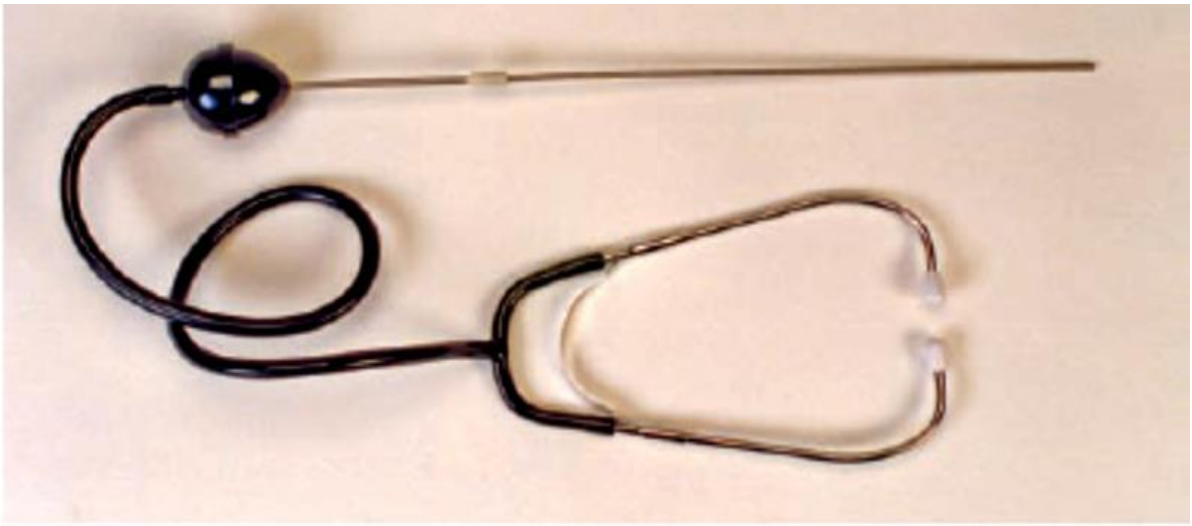


Fig: 5.0Stethoscope

5.2. ELECTRICAL / ELECTRONIC SYSTEM TOOLS

Circuit Tester

Circuit testers are used to check for voltage in an electrical circuit. A circuit tester commonly called a test-light. Its handle is transparent and contains a light bulb.

A probe extends from one end of the handle and a ground clip and wire from the other end. When the ground clip is attached to a good ground and the probe touched to a live connector, the bulb in the handle will light up. If the bulb does not light, voltage is not available at the connector.

A self-powered test-light is called a continuity tester. It is used on open circuits. It looks like a regular test-light but has a small internal battery.

When the ground clip is attached to one end of the wire or circuit an the probe touched to the other end, the lamp will light if there is continuity in the circuit.

If an open circuit exists, the light will not illuminate.the probe touched to the other end, the lamp will light if there is continuity in the circuit. If an open circuit exists, the light will not illuminate.

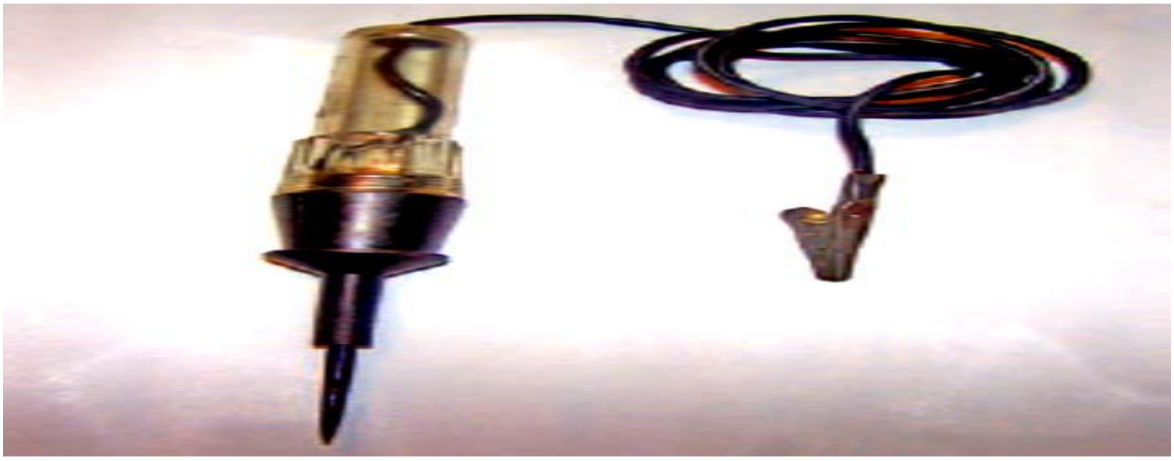


Fig: 5.1 ELECTRICAL / ELECTRONIC SYSTEM TOOLS

Multi-meters

A multi-meter is a must for diagnosing the individual components of an electrical system. A digital multi-meter (DMM) can measure volts, ohms, and low current such as direct current (dc) and alternating current (ac) amperes, diode continuity, frequency, temperature, engine speed, and dwell, and/or duty-cycle.

DMMs provide great accuracy by measuring volts, ohms, or amperes in tenths, hundredths, or thousandths of a unit.

Several test ranges are usually provided for each of these functions. Some meters have multiple test ranges that must be manually selected; others are auto-ranging.

Some DMM has the capacity to measure frequency and temperature, also an IP-67 protection making the body waterproof even if dipped in 1m deep water for 30 mines

Fig: 5.2 Multi-meters Multi meter

5.3. Lab Scopes

An oscilloscope or lab scope is a visual voltmeter. A lab scope converts electrical signals to a visual image representing voltage changes over a specific period of time.

This information is displayed in the form of a continuous voltage line called a waveform or trace. With a scope, precise measurement is possible. A scope displays any change in voltage as it occurs.

Fig: 5. 3 Lab Scopes(Hand-Held Engine Analyzer)

5.4. Hand-Held Engine Analyzer

With the help of powerful functions, MT3500 Hand-held Engine Analyzer supplies serial testing items, and meets serial testing demands; the following is the function explanation: Dual-track oscilloscope can directly test the signal waveforms and data, AC and DC voltage, frequency, Pulse-Width and duty cycle.

There are six testing channels that can test the secondary ignition of the six cylinders at the same time. The following function.

- *The accuracy of Time Base Display is up to 125 us/DIV.*
- *The functions of digital meter.*
- *Functions of testing components.*
- *Storage capacity is more than 32Mb.*
- *Power Supply: 3 pieces of batteries, low consumption design, and AUTO OFF function can last the life of batteries.*
- *Document and data management function.*
- *Function of system* setup.

Fig : 5.4 Hand-Held Engine Analyzer

5.5. ENGINE PERFORMANCE TOOLS

Scan Tools

A scan tool is a microprocessor designed to communicate with the vehicle's computer. Connected to the computer through diagnostic connectors, a scan tool can access diagnostic trouble codes (DTCs), run tests to check system operations, and monitor the activity of the system.

Trouble codes and test results are displayed on a screen or printed out on the scanner printer. The scan tool is connected to specific diagnostic connectors on the vehicle. It must be programmed for the model year, make of vehicle, and type of engine.

With OBD-II, the diagnostic connectors (commonly called Data Link Connector or DLCs) are located in the same place on all vehicles. Most OBD-II scan tools have the ability to store, or "freeze," data during a road test and then play back this data when the vehicle is returned to the shop. Scan Tool may have the following capabilities Retrieve DTCs.

- Monitor system operational data.
- Reprogram the vehicle's electronic control modules.
- Perform systems diagnostic tests.
- Display appropriate service information, including electrical diagrams.
- Display TSBs.
- Display troubleshooting instructions
- (PC■ Perform easy tool updating through a personal computer

Fig : 5.5 Scan Tool

5.6. Fuel Pressure Gauge

A fuel pressure gauge is essential for diagnosing fuel injection systems. These systems rely on very high fuel pressures, from 35 to 70 psi.

A drop in fuel pressure reduces the amount of fuel delivered to the injectors and results in a lean air-fuel mixture.

A fuel pressure gauge is used to check the discharge pressure of fuel pumps, the regulated pressure of fuel injection systems, and injector pressure drop.

This test can identify faulty pumps, regulators, or injectors and can identify restrictions present in the fuel delivery system. Restrictions are typically caused by a dirty fuel filter, collapsed hoses, or damaged fuel lines.

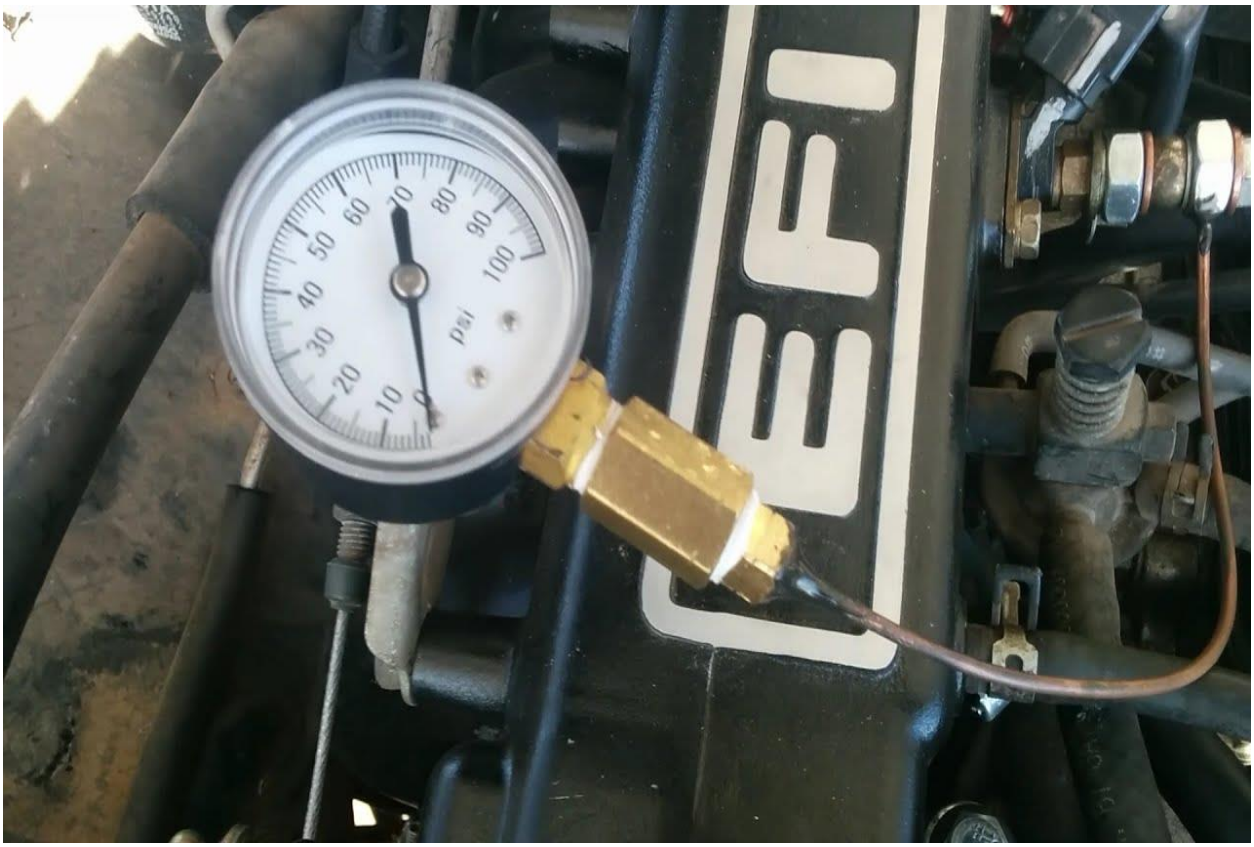


Fig: 5.6 Fuel Pressure Gauge

Self-Check -5	Written Test

Directions: I multiple choice item.

A. Instruction: - choose the best answer for the following questions and write the letter of the correct answer on the space provided using block letters?

……..1_____ is the process of engine analyzer device. (3%)

A .scan tool C. OBD 1

A. Cooperation test D. A and b

Note: **Satisfactory rating –3 points** **Unsatisfactory - below 3 and 4 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Name: _____ Date: _____

6. Observing OHS, personal protection

GENERAL PRECAUTIONS

- Do not operate the engine for an extended period of time without proper exhaust ventilation.
- Keep the work area well ventilated and free of any inflammable materials. Special care should be taken when handling any inflammable or poisonous materials, such as gasoline, refrigerant gas, etc.
- When working in a pit or other enclosed area, be sure to properly ventilate the area before working with hazardous materials. Do not smoke while working on the vehicle.

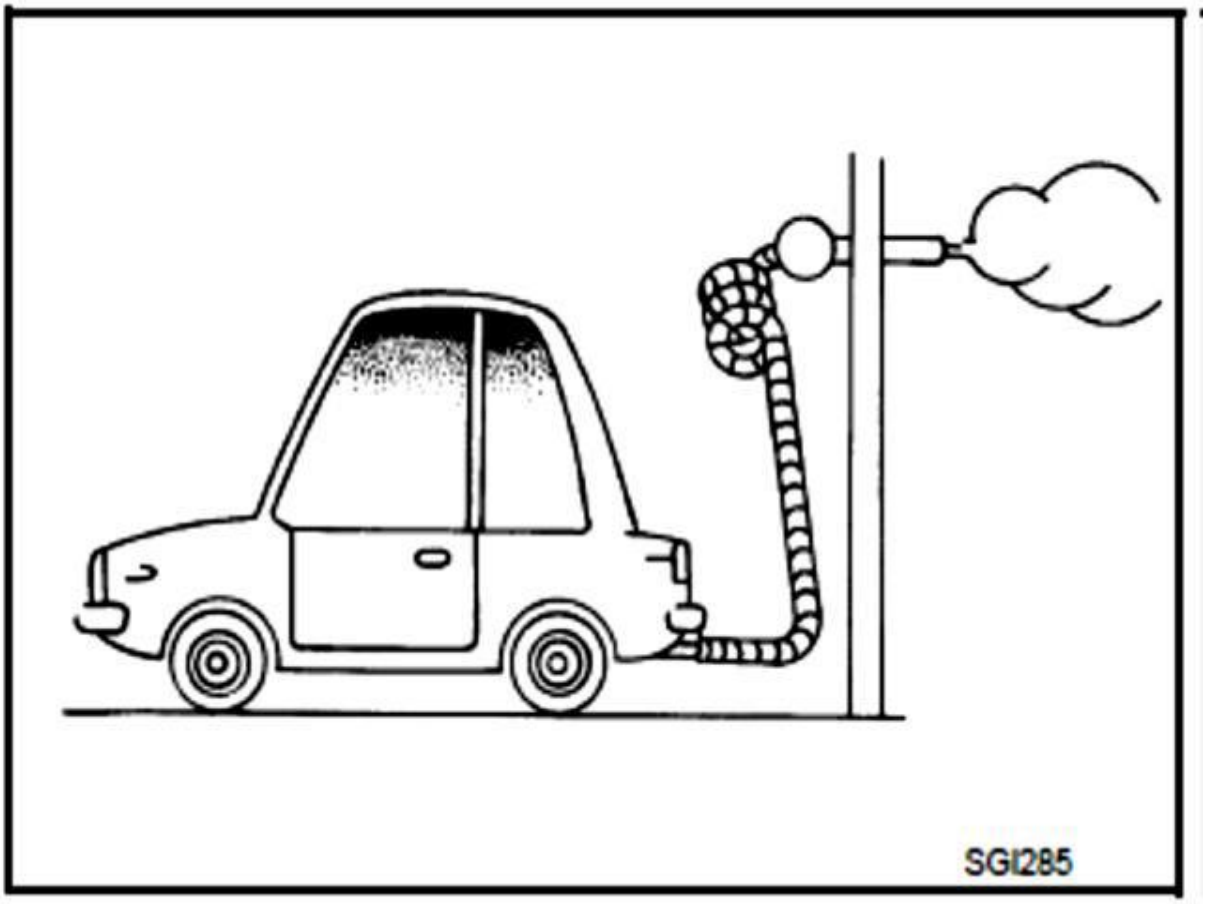


Fig.6.0 General Precautions

JACKING

Before jacking up the vehicle, apply wheel chocks or other tire blocks to the wheels to prevent the vehicle from moving.

After jacking up the vehicle, support the vehicle weight with safety stands at the points designated for proper lifting before working on the vehicle.

These operations should be done on a level surface.

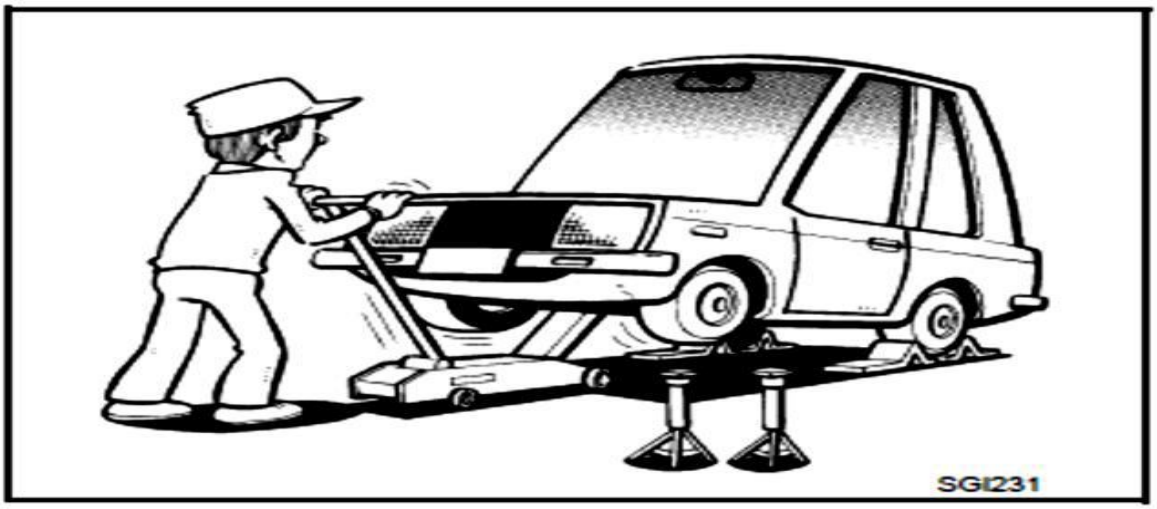


Fig.6.1 General Precautions

BATTREY

- Before starting repairs which do not require battery power: Turn off ignition switch. Disconnect the negative battery terminal.
- If the battery terminals are disconnected, recorded memory of radio and each control unit is erased**.**

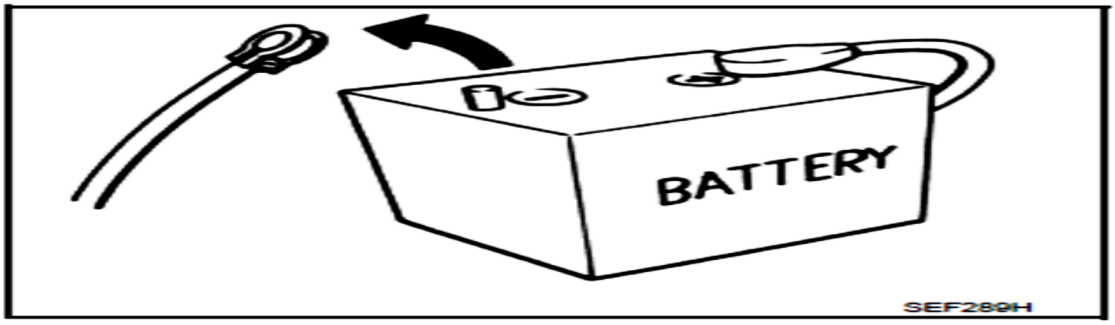


Fig.6.2 battery precaution

TO PREVENT SERIOUS BURNS:

- Avoid contact with hot metal parts.
- Do not remove the radiator cap when the engine is hot.
- Clean all disassembled parts in the designated liquid or solvent prior to inspection or assembly.
- Arrange the disassembled parts in accordance with their assembled locations and sequence.
- Do not touch the terminals of electrical components which use microcomputers (such as ECM). Static electricity may damage internal electronic components.

Fig.6.3 to prevent serious burns

Do not touch the terminals of electrical components which use microcomputers (such as ECM). Static electricity may damage internal electronic componentsAfter disconnecting vacuum or air hoses, attach a tag to indicate the proper connection.

Use approved bonding agent, sealants or their equivalents when required.

Use hand tools, power tools (disassembly only) and recommended special tools where specified for safe and efficient service repairs.

When repairing the fuel, oil, water, vacuum or exhaust systems, check all affected lines for leaks..

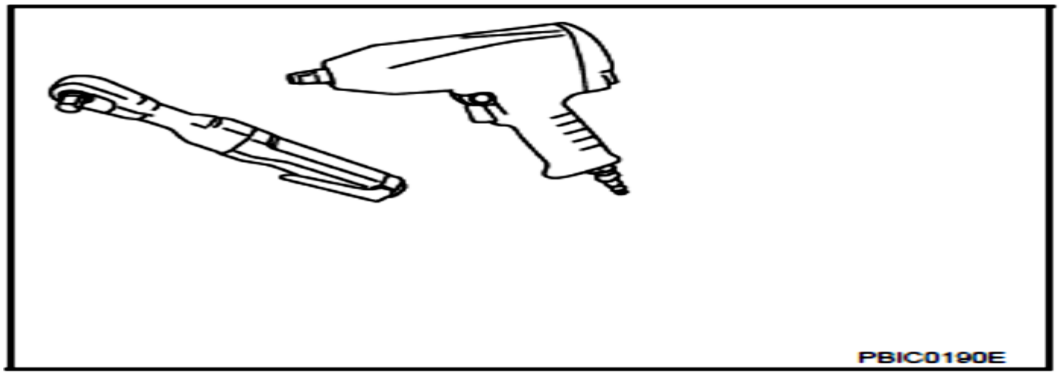


Fig .6.4 hand tool

Before servicing the vehicle:

- Protect fenders, upholstery and carpeting with appropriate covers.
- Take caution that keys, buckles or buttons do not scratch paint

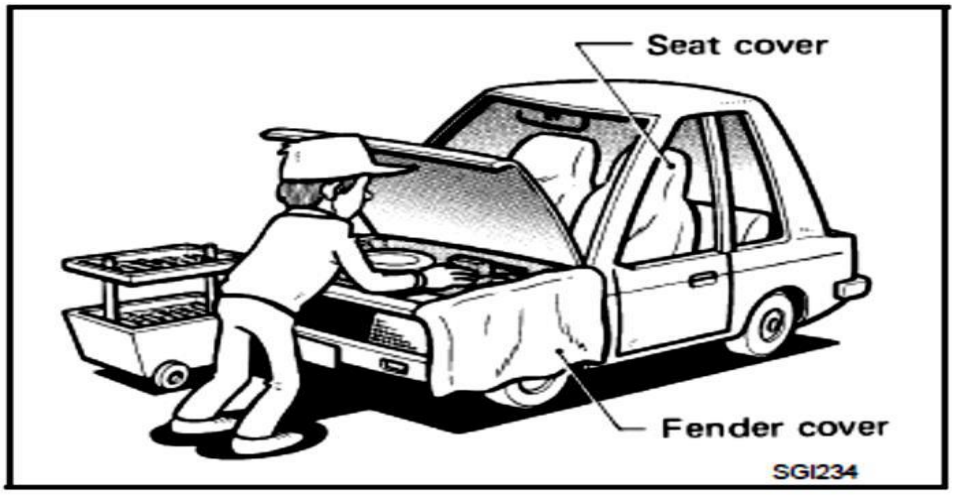


Fig .6.5 hand tool

Self-Check -6	Written Test

Direction I: writing short items

Instruction. Give the answer for the following question on the space provided in the next page

1. Write types of prevent serious burns in work shop and there function. (4pts)

Note: **Satisfactory rating –3 points** **Unsatisfactory - below 3 and points**

You can ask you teacher for the copy of the correct answers.

Name: _____ **Date:** _____

Score____

Rating___

Answer sheet

1……

……

……

……

……

……

……

……

……

……

……

……

Information Sheet 7-Sourcing and observing applicable national environmental protection measure/ guidelines for diesel vehicles

7. Sourcing and observing applicable national environmental protection

Measure/ guidelines for diesel vehicle

Diesel fuel as well as other fuels is not ideal, therefore, it has both its advantages and disadvantages. Before you buy one petroleum product or another, getting to know with its string and weak points is a good idea.

This will help you make the fullest use of its advantages and reduce the effects of its drawbacks. So, let's begin. For a long time the basic value of diesel fuel was in its price, which used to be lower than that of gasoline.

It was especially advantageous for fleets to acquire such fuel due to the bulk volumes of use, which helped to make tremendous savings. But by this day the price of diesel fuel has increased slightly, which makes us look for its other benefits.

Diesel fuel emits such harmful substances as nitrogen dioxide, nitrogen oxide, carbon oxide, sulfur dioxide and carbon black (soot). But their number less than other fuels. Therefore, there is some cost saving on a variety of environmental charges and fees.

Another feature of diesel fuel is its safety. Diesel engines are designed so that high flammability limit of the oil product can be maintained. That is why diesel fuel is preferred when fuelling military combat vehicles, battle tanks in particular.

Due to the high efficiency of diesel fuel it is quite economical, so regardless of the type of transport, in which it is used, the number of additional refills is minimal.

Having good lubricating properties, diesel fuel has a positive effect on moving parts of engines, increasing their reliability and extending engine lifetime.

Speaking about the disadvantages, they are caused mainly by the chemical composition of diesel fuel. So, one of the problems is increasing oil viscosity at low temperatures. At minus twenty degrees Celsius it is getting hard to pump the fuel and ignition problems occur. But it

is no longer critical, as we already have solutions that allow the use diesel fuel even in arctic climate.

Cheap and low-quality fuel grades have a lot of substances with poor combustibility, which results in their deposition on the surfaces of engine components, and the corrosion of such surfaces.

Also it should be noted that diesel engines typically produce more noise during operation than gasoline ones. And the smell of burnt diesel fuel is rather unpleasant.

During storage, diesel fuel can be oxidized, become contaminated with harmful impurities and darken.

This complicates its use in automobile engines, so this fuel should be subjected to a specific treatment in order to restore its original properties.

To solve this problem *Globe Core* company has developed and manufactures plants. They allow cleaning and brightening of diesel fuel, as well as removing aromatics mere captains, hydrogen sulfide, and some sulfur *Globe Core* processes provide an economical solution to the problem of contaminated diesel fuel, which allows full restoration of its properties and ensures a long and reliable service life of engines and fuel systems.

EFI Advantages..... Assuming new engine..... More fuel efficient, easier to keep in tune, less maintenance.

Disadvantages costly to repair, harder to diagnose problems without electronic diagnosis downloading equipment, more sensors that can fail.

Simple ignition systems with simple fuel systems work well but require regular "tune ups" and are not as efficient. Cars from the 1960's had simple systems and as electronics became cheaper and with the costs of fuel increasing and the need to clean up combustion engine emissions, the manufacturers went the way of fuel management systems to improve efficiency (mainly due to government mandate Exhaust Gases Remember it is not just the carbon monoxide (CO) that might make you ill or even kill you, other exhaust components could cause asthma or even cancer.

Fire pre question in work aria

- Do not smoke when working on a vehicle.
- Fuel leaks must be attended to immediately.
- Remember the triangle of fire – (heat/fuel/oxygen) – don't let the three sides come together.
- Only lift what is comfortable for you; ask for help if necessary and/or use lifting equipment. As a general guide, do not lift on your own if it feels too
- Apply brakes and/or chock the wheels and when raising a vehicle on a jack or drive on lift.
- Only jack under substantial chassis and suspension structures.
- Use axle stands in case the jack fails.
- Running Engines
- Do not wear loose clothing; good overalls are ideal.
- Keep the keys in your possession when working on an engine to prevent others from starting it.

Self-Check -7	Written Test

Direction I: short answer items

Instruction I: -Give short answer for the following question on space provided on the next page.

1. How to prevent an accident in the work area ? (5%)

Note: **Satisfactory rating –3 points** **Unsatisfactory - below 3 and points**

You can ask you teacher for the copy of the correct answers.

Name: _____ date____ **Score = _____**

Rating: _____

Answer sheet

1……

……

……

……

……

……

……

……

……

Operation Sheet-1 Identify sensor mounting location

Identify the following sensor mounting location in the work shop

1. Air flow meter sensor
2. Crank angle sensor
3. Engine speed sensor
4. Water temperature sensor
5. Intake air temperature sensor
6. Throttle position sensor
7. Ignition switch
8. Vehicle speed sensor
9. Oxygen sensor
10. Neutral start switch
11. Taillight and defogger relays
12. Air conditioner
13. Knock sensor

List of Reference Materials

1. SAE International; 3 edition (March 5, 2014**Community Needs Assessment. Available on:** https://www.cdc.gov/globalhealth/healthprotection/fetp/training_modules/15/community-needs_pw_final_9252013.pdf

2 Auer Automotive TTA-812 LED Fog Light Referring a Client to Therapy A SET OF GUIDELINES. Available on: https://coachfederation.org/app/uploads/2018/06/Whitepaper-Client-Referral-June-2018.pdf

3. **Bishop automotive literature 2001 Toyota 4-Runner Shop Service Repair Manual Book Engine Drivetrain somewhat is report writing? Available on:** https://www.quora.com/What-is-report-writing-1

LG #32	LO #2- Repair/service diesel and gasoline electronic fuel injection components

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- determining and confirming Extent of work
- Implementing appropriate system test
- Verifying and indicating Results
- carrying out Repair/Service of diesel and gasoline fuel system and its components
- Documenting results with evidence
- Forwarding Report to appropriate persons

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- determine and confirm Extent of work
- Implement appropriate system test
- Verify and indicat Results
- carry out Repair/Service of diesel and gasoline fuel system and its components
- Document results with evidence
- Forward Report to appropriate persons

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets” ,
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

Information Sheet 1 determining and confirming Extent of work

1. DETERMINING AND CONFIRMING EXTENT OF WORK

1.1. Fuel Filter

Automobiles and light trucks usually have an in-tank strainer and a gasoline filter. The strainer, located in the gasoline tank, is made of a finely woven fabric. The purpose of this strainer is to prevent large contaminant particles from entering the fuel system where they could cause excessive fuel pump wear or plug fuel metering devices. It also helps to prevent passage of any water that might be present in the tank.
The fuel filter, which is installed between the pump and the fuel rail, removes dirt and contaminants from the fuel before it is delivered to the injectors and pressure regulator. Although it is possible for the fuel filter to become contaminated. In the event that this filter becomes restrictive to fuel flow, the engine will suffer from surging, loss of power under load and hard starting problems. If it becomes necessary to replace this filter there are some important safety matters to consider. A fuel filter is connected in the fuel line between the fuel tank and the engine

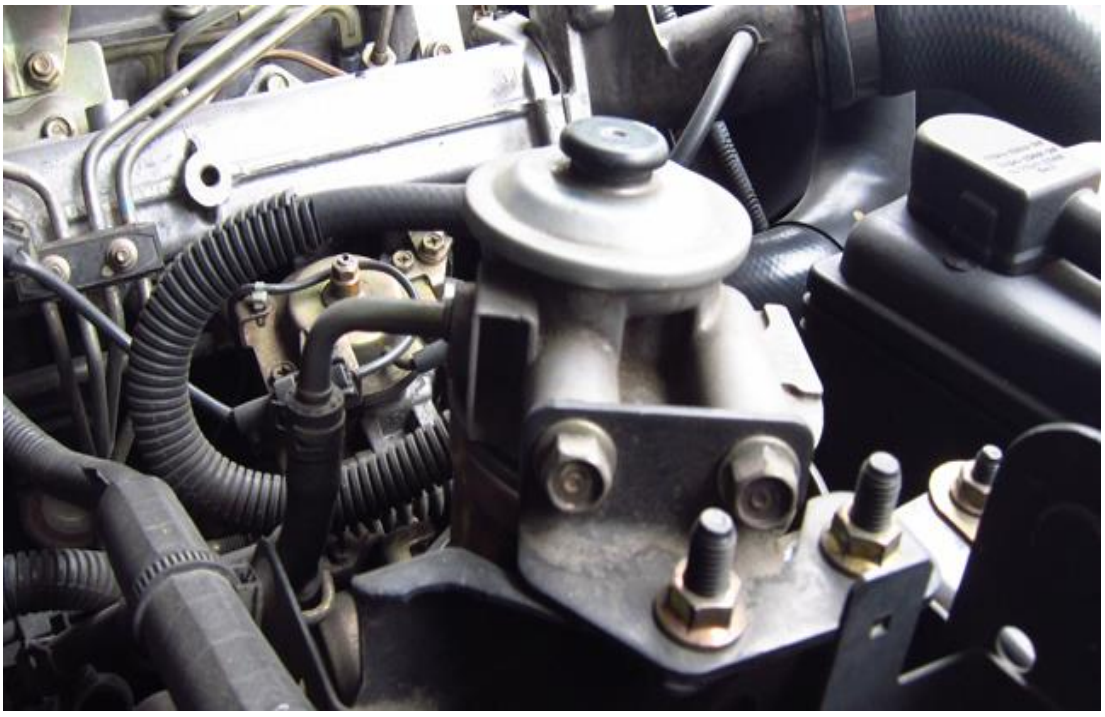


Fig.1.0 Fuel Filter

1.2. Fuel Delivery Pipe (Fuel Rail)

The fuel delivery pipe, commonly referred to as a fuel rail, is designed to hold the injector in place on the intake manifold. Mounted to the fuel delivery pipe are the pulsation damper (when used) and the fuel pressure regulator. The fuel delivery pipe acts as a reservoir for fuel which is held under pressure prior to delivery by the fuel injector

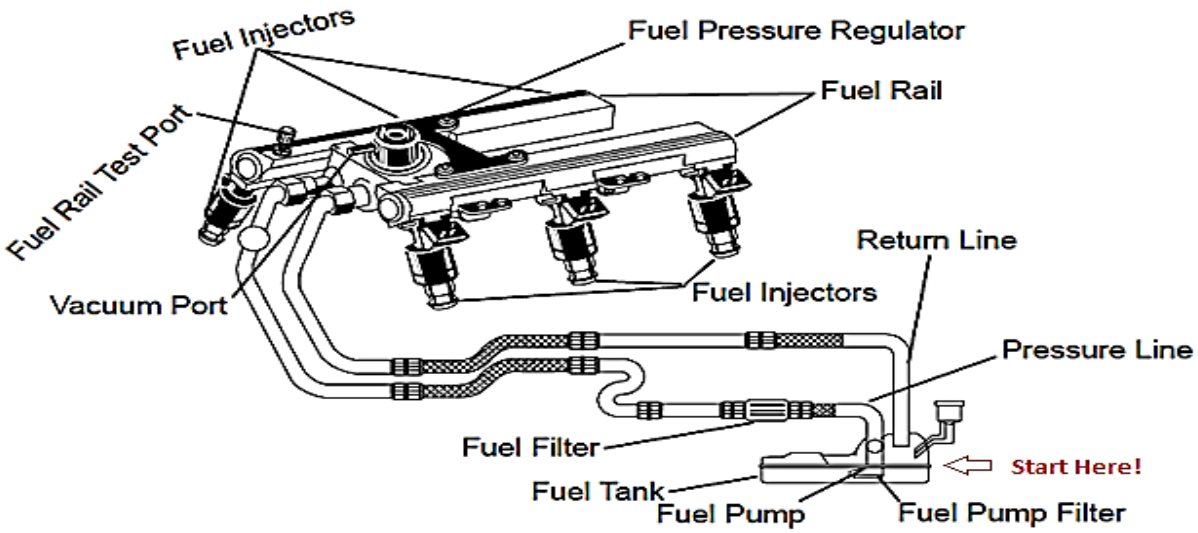


Fig1.2 Fuel Delivery Pipe (Fuel Rail)

1.3. Pulsation Damper

The rapid opening and closing of the fuel injectors cause pressure fluctuations in the fuel rail. Mounted on the fuel rail, the pulsation damper reduces these pressure fluctuations. Although fuel pressure is maintained at a constant value by the pressure regulator, the pulsing of the injectors causes minor fluctuations in rail pressure. The pulsation damper acts as an accumulator to smooth out these pulsations, ensuring accurate fuel metering. The screw mounted at the top of the damper provides an easy check for fuel system pressure. When the screw is up it means the fuel rail is pressurized. Under most conditions, this check is adequate. The screw is nonadjustable and it is used to calibrate the damper at the factory

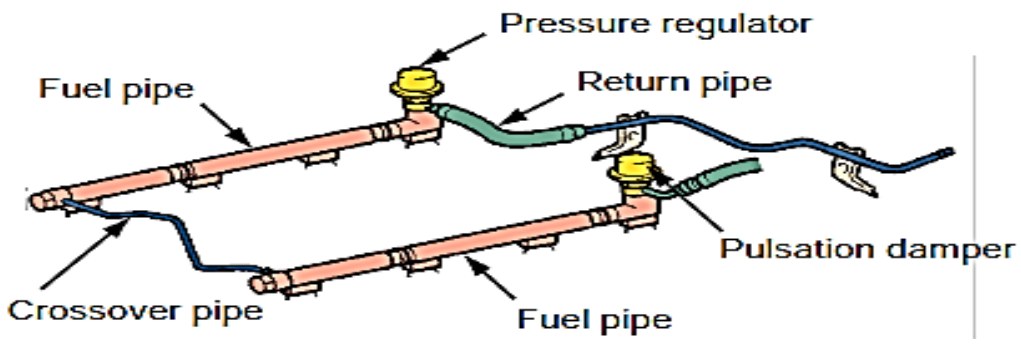


Fig 1.3 Pulsation Damper

1.4. Fuel Injectors

Fuel injectors are electromechanical devices that meter and atomize fuel so it can be sprayed into the intake manifold. Fuel injectors resemble a spark plug in size and shape.

O-rings are used to seal the injector at the intake manifold, throttle body, and/or fuel rail mounting positions.
These O-rings provide thermal insulation to prevent the formation of vapor bubbles and promote good hot start characteristics.

They also dampen potentially damaging vibration. When the injector is electrically energized, a fine mist of fuel sprays from the injector tip.

Most injectors consist of a solenoid, a needle valve, and a nozzle. The solenoid is attached to the nozzle valve.
The PCM controls the injector by controlling its ground circuit through a driver circuit. When the solenoid winding is energized, it creates a magnetic field that draws the armature back and pulls the needle valve from its seat.
Fuel then sprays out of the nozzle. When the solenoid is de-energized, the magnetic field collapses and a helical spring forces the needle valve back on its seat, shutting off fuel.
The amount of fuel released by an injector depends on fuel pressure and the length of time the injector is energized.

Fuel pressure is mainly controlled by a pressure regulator, and the injector's pulse width is controlled by the PCM.

Typical pulse widths range from 1 to 10 milliseconds at full load. The PCM controls the pulse width according to various input sensor signals, operating conditions, and its programming.

The primary inputs are related to engine load and engine coolant temperature. Cold starting requires the longest pulse width.

Fig 1.4 Fuel Injectors

1.5. FUEL-PRESSURE REGULATOR

Fuel-pressure regulators on fuel-return-type fuel-injection systems are installed on the return (downstream) side of the injectors at the end of the fuel rail, or are built into or mounted upon the throttle-body housing.

Downstream regulation minimizes fuel-pressure pulsations caused by pressure drop across the injectors as the nozzles open.

It also ensures positive fuel pressure at the injectors at all times and holds residual pressure in the lines when the engine is off.

On mechanical return-less systems, the regulator is located back at the tank with the fuel filter.

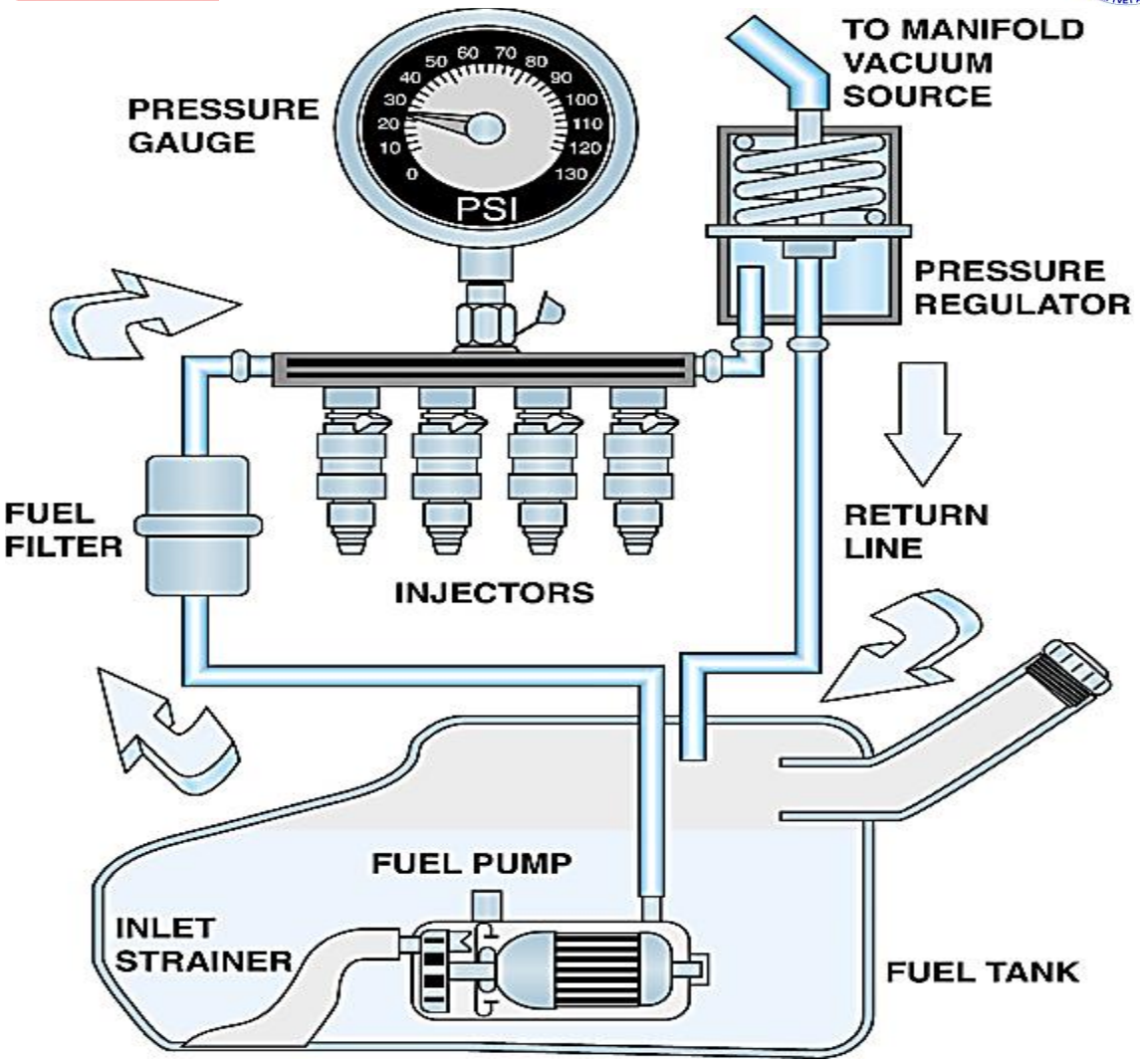


Fig.2.4 FUEL-PRESSURE REGULATOR

A typical port fuel-injected system showing a vacuum-controlled fuel-pressure regulator. A typical fuel-pressure regulator that has a spring that exerts 46 pounds of force against the fuel. If 20 inches of vacuum are applied above the spring, the vacuum reduces the force exerted by the spring on the fuel, allowing the fuel to return to the tank at a lower pressure

VACUUM-BIASED FUEL-PRESSURE REGULATOR

The primary reason why many port fuel-injected systems use a vacuum-controlled fuel-pressure regulator is to ensure that there is a constant pressure drop across the injectors.

EngineOperating Condition	**Intake Manifold Vacuum**	**Fuel Pressure**
Idle or Cruise	High	Lower
Heavy Load	Low	Higher

1.6. RETURN FUEL DELIVERY SYSTEM

When the fuel pump is activated by the ECM, pressurized fuel flows out of the tank, through the fuel filter to the fuel rail and up to the pressure regulator.

The pressure regulator maintains fuel pressure in the rail at a specified value. Fuel in excess of that consumed by engine operation is returned to the tank by a fuel return line.

A pulsation damper, mounted on the fuel rail, is used on many engines to dampen pressure variations in the fuel rail. The injectors, when turned on by the ECM deliver fuel into the intake manifold. When the fuel pump is turned off by the ECM, a check valve in the fuel pump closes maintaining a residual pressure in the fuel system.

In a return system, the fuel sent back to the tank has been heated by under hood temperatures. The introduction of the warm fuel to the tank causes the fuel to evaporate.

An evaporative emission control is intergraded to avoid fuel vapors from entering the atmosphere. Fuel pressure and volume are controlled by the PCM according to the existing operating conditions.

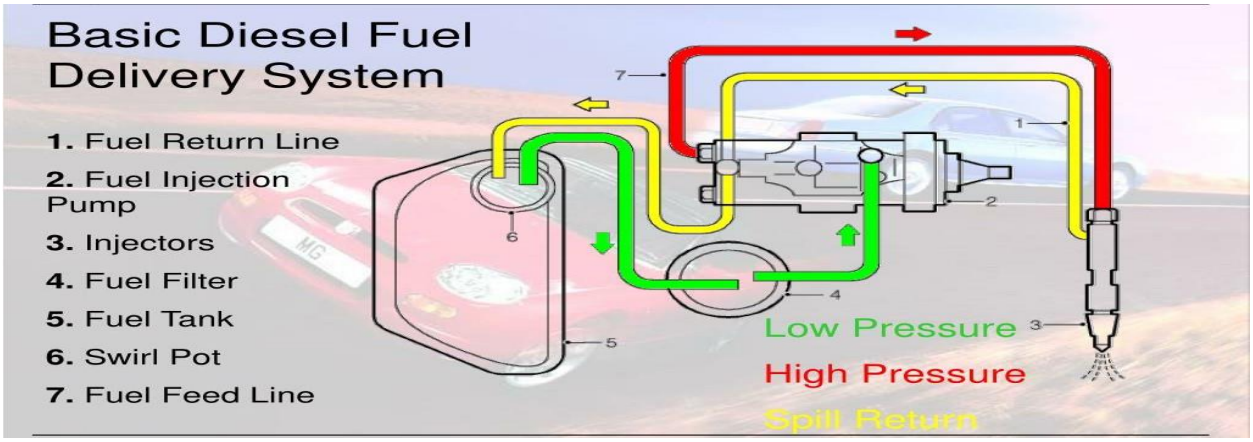


Fig.2.5 RETURN FUEL DELIVERY SYSTEM

1.7. High pressure fuel pump

The High pressure pump is the interface between the low pressure and the high pressure side of the fuel system

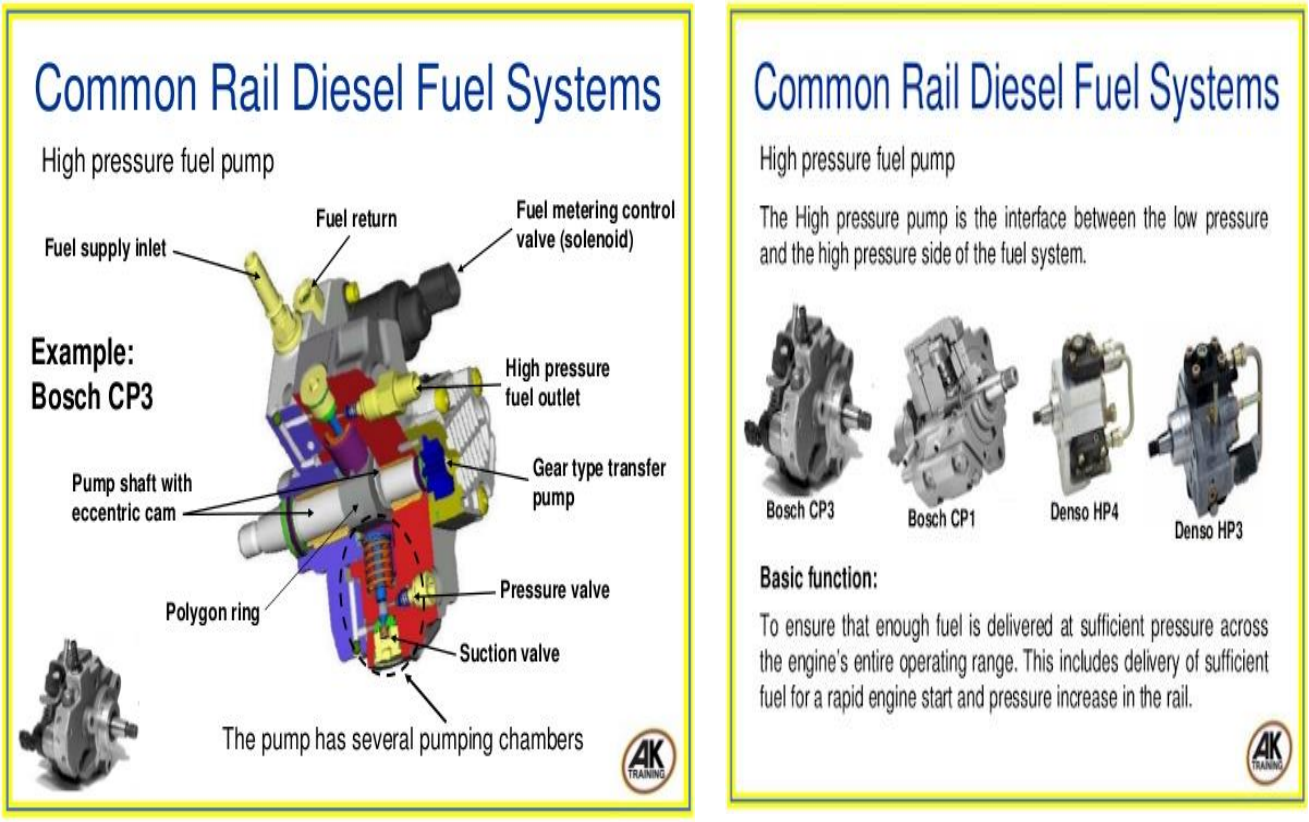


Fig 2.6 .High pressure fuel pump

1.8. Transfer pump:-

supplies fuel from the fuel tank to the pumping chambers of the high pressure pump. An electric pre supply pump in fuel tank may be used instead of a transfer pump. Some systems may use a combination of electric pump and transfer pump

1.9. Fuel metering valve regulates

The fuel intake volume to the pumping chambers of the high pressure pump. Located at back of high pressure pump. Controls the fuel intake volume to the pump. Receives battery voltage supply from engine ECM. Energized by ECM via negatively triggered PWM. Operating frequency: approximately 180Hz.The fuel volume intake is controlled as follows: When solenoid de energized, valve is open= LOW fuel volume intake to pump. When solenoid energized, valve is closed= HIGH fuel volume intake to pump

1.10. Fuel metering valve regulates

The fuel intake volume to the pumping chambers of the high pressure pump there function.

- Controls the fuel intake volume to the pump.
- Receives battery voltage supply from engine ECM.
- Energized by ECM via negatively triggered PWM.
- Operating frequency: approximately 180Hz.
- The fuel volume intake is controlled as follows

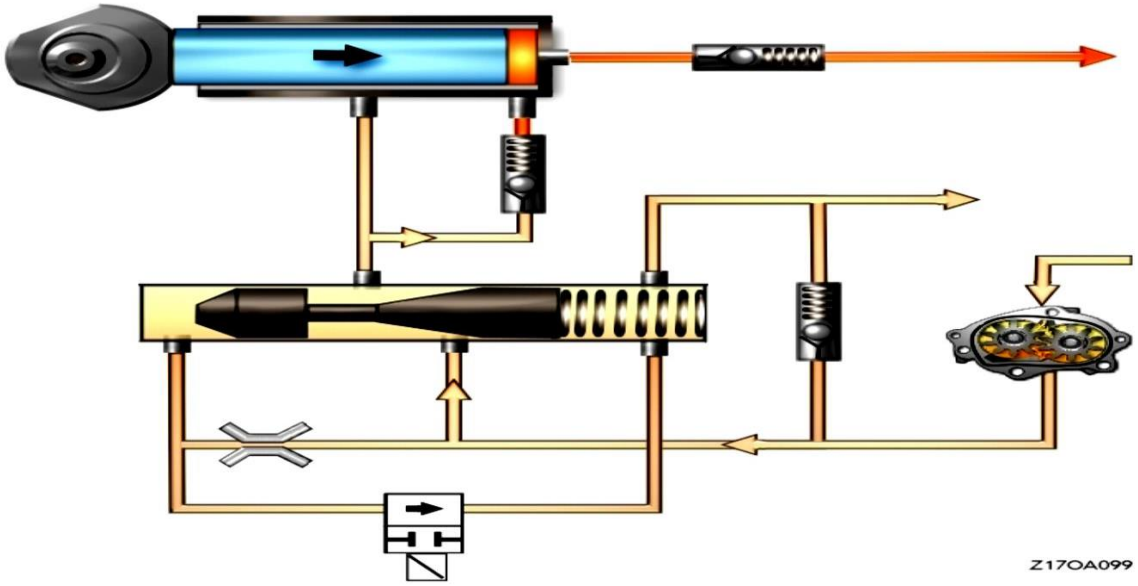


Fig 2.7Fuel metering valve regulates

When the solenoid is energized, the injector valve opens

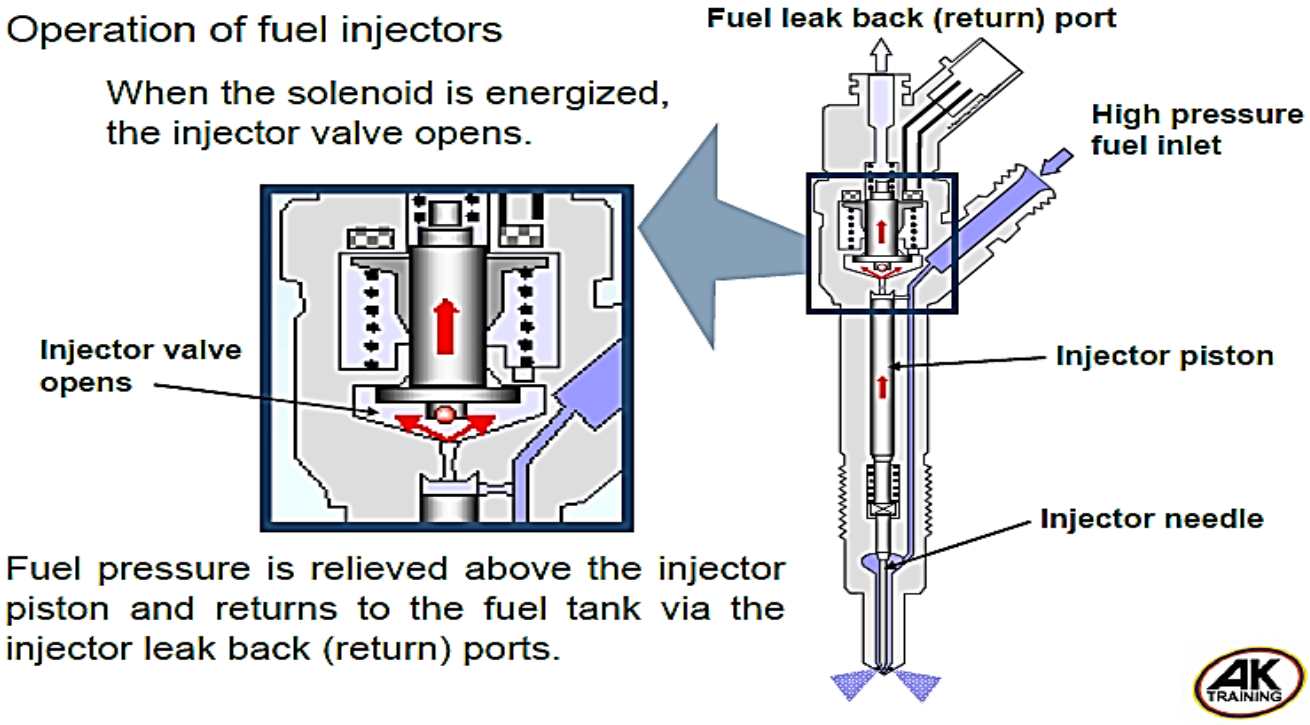


Fig.2.8 the solenoid is energized

Fuel is now injected into the cylinder

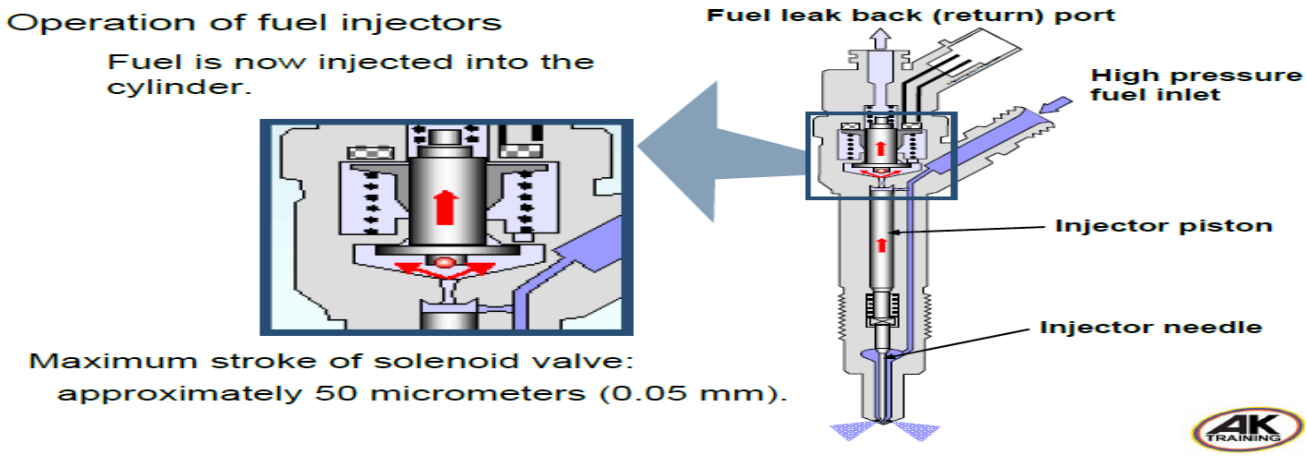


Fig.2.9 Fuel is now injected into the cylinder

Self-Check -1	Written Test

Direction I: short answer

Instruction: Give short answer the following question on space provided.

1. Write the function of Fuel metering valve regulates. (5pts)

Note: **Satisfactory rating ≥ 3 points** **Unsatisfactory - below 3 points**

You can ask your teacher for the copy of the correct answers.

Name: _____ Date: _____

Score = _____

Rating: _____

Answer sheet

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2. IMPLEMENTING APPROPRIATE SYSTEM TEST

2.1. Fuel Injector Testing

A fuel injector is responsible for allowing fuel into the engine and is controlled by the PCM as part of the fuel injection system.

Fuel pressure supplied by the fuel pump is metered by the duty cycle of the computer which varies by engine load.

This guide will show you how to check the trigger (ground) signal from the PCM, power circuit and the operation of the injector itself.

To test the injector signal from the computer a test light works best. You will need a voltmeter to check resistance through the injector.

Fuel maybe present during testing so the usual fire precautions are necessary. Use protective gloves and eye wear for safety. **Test for FI systems only.**

Fig:3.0 Fuel Injector Testing

Fuel injector Testing

- Observe audible clicking confirming injector operation
- Check trigger signal output from the PCM
- Confirm the injector has power
- Test the coil windings resistance using a volt meter
- Confirm injector valve operation
- Inspect the injector casing for leaks
- Check flow and spray pattern

Let's Get Started

Simple Test

1. Start the engine and allow it to idle. Using a long metal rod like a screwdriver touch the end of the screwdriver to the injector. Gently lay an ear to the opposite end of the rod or handle to observe an audible clicking sound to confirm the injector is working.

Fig 3.1 Injector Circuit Power Test

2. With the key in the on position use a test light or voltmeter connected to the negative side of the battery.

   Gently probe both sides of the injector wiring connector, one of the wires should react by registering around 12 volts on the meter or illuminating the test light.

   If neither wire reacts test the fuel injector fuse in the PDC. If the fuse is okay a fuel injection wiring diagram is needed to help trace the wire and repair the connection.

   Seal test points with a small dab of silicone rubber once testing is complete.

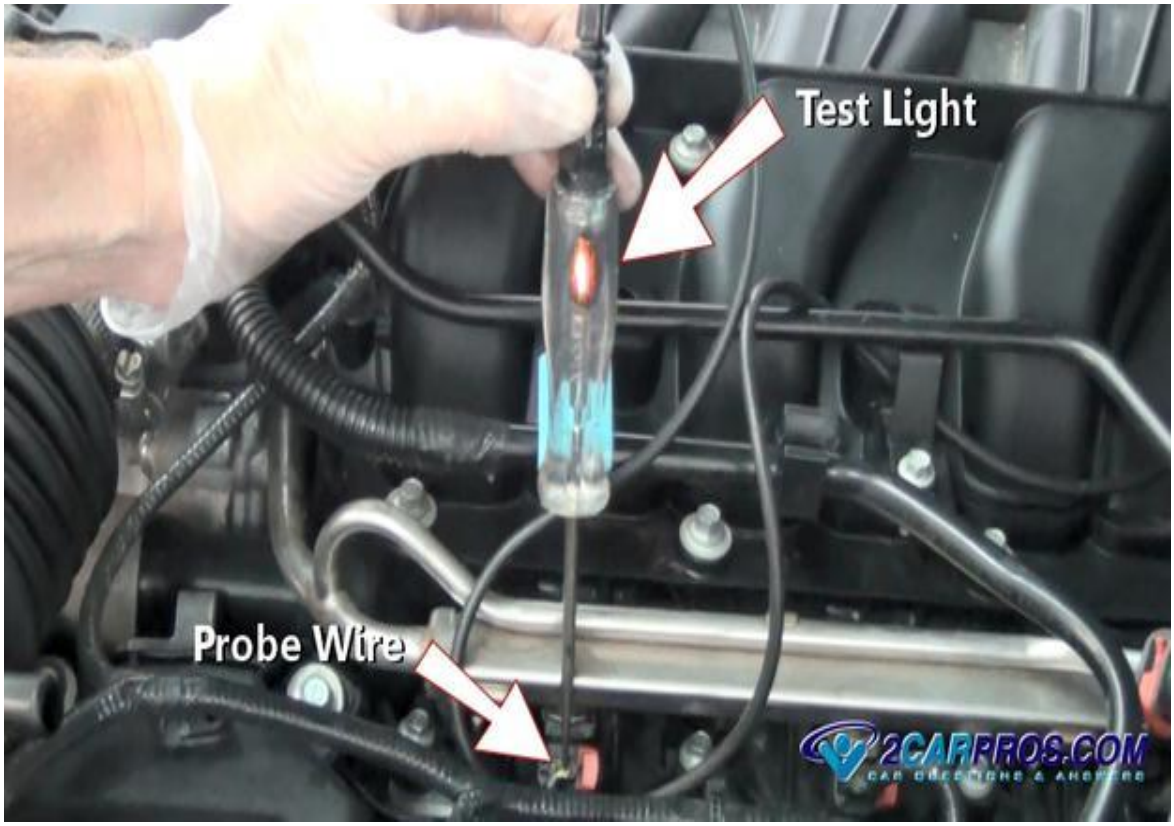

Fig 3.2 Injector Ground Trigger Test

3. The PCM closes the injector circuit to trigger the injector operation. For this a test light works best to observe the pulse produced by the PCM.

   Attach the test light lead to the positive side of the battery and have a helper start or crank the engine.

   Probe the opposite side of the injector connector from the power circuit, you should observe the test light flicking which will respond to engine RPM/Load.

   If the engine is running and no pulse is observed suspect a bad wiring connection or a failed PCM injector driver which will warrant a PCM replacement.

   A shorted injector can hinder the injector driver operation for additional injectors, unplug all injectors and re-test the signal.

   If pulse returns plug the injectors back in one at a time until the pulse fails then replace the shorted injector.

   If the engine is not running check the crankshaft angle sensor which the computer uses to open the injectors (Note: A failed crankshaft angle sensor will not set a trouble code in most cases).

Fig 3.3Fuel Injector Winding Test (key off)

4. Using a voltmeter, adjust the setting to ohms. This test can be performed with the injector installed or uninstalled.

Fig 3.4 voltmeter, adjust the setting to ohms

5. Remove the injector electrical connector

Fig 3.5 Remove the injector electrical connector

6. This will expose the injector electrical terminals.

fig 3.6 injector electrical terminals

7. Connect the voltmeter leads to the terminals, the polarity of the leads is irrelevant. This test gives a baseline ohm reading of all injectors, a service manual also has this information. Most injector readings should range between 11 and 24 ohms. Fuel injectors should be tested cold unless otherwise specified, temperature variances will change the readings. If the test shows high resistance or an open circuit the injector needs replacement.

Fig 3.7Connect the voltmeter leads to the terminals

2.2. Injector Spray Pattern Test

1. For this test the injector must be removed. Inspect the injector housing for leaks and electrical connectors for corrosion.

Fig 3.8 Injector

2. The valve and spray pattern is the most important part of testing a fuel injector. Valve testing can be done with the injector still installed using a fuel pressure gauge while hot wiring the fuel pump to stay on. Carefully attach a 12 volt power (power and ground) source to the injector, you should be able to see the gauge fluctuate as you connect and disconnect the circuit if the injector valve is working and not plugged.
3. To check the injector spray pattern the injector must be removed. Attach pressurized air to the injector inlet. Attach a 12 volt power and ground source to energize the injector. Compressed air should be released from the outlet valve with traces of fuel still remaining from the injector (use fire precautions). Observe the pattern which should be robust, if the pattern is muted the injector should be replaced.

Fig 3.9 Injector Spray Pattern Test

3. Steps on how to test fuel pressure and flow

Replacing a fuel pump can become a costly mistake if it is not the true cause of a fuel related problem. A fuel system should be carefully tested for pressure, volume, and electrical integrity before condemning the fuel pump.

Step 1: Safety first

Let's take a look at fuel pressure and flow testing on a return fuel delivery system. Before you get started performing any diagnostic tests, the most important thing to remember is that releasing fuel under pressure can cause fire and injury. So put safety first. Wear safety glasses and gloves, work in a well-ventilated area, and don't smoke or have anything around that can cause a spark.

Step 2: Fuel pressure

First, check the fuel pressure. Start the car and let it idle. Install a fuel pressure gauge, run the pump, and note the pressure reading. Then compare it to the manufacturer's specification. If the pressure is low, you should address that problem. If the fuel pump is supplying sufficient pressure, perform a fuel volume test to determine if the proper amount of fuel is being delivered to the fuel injectors.

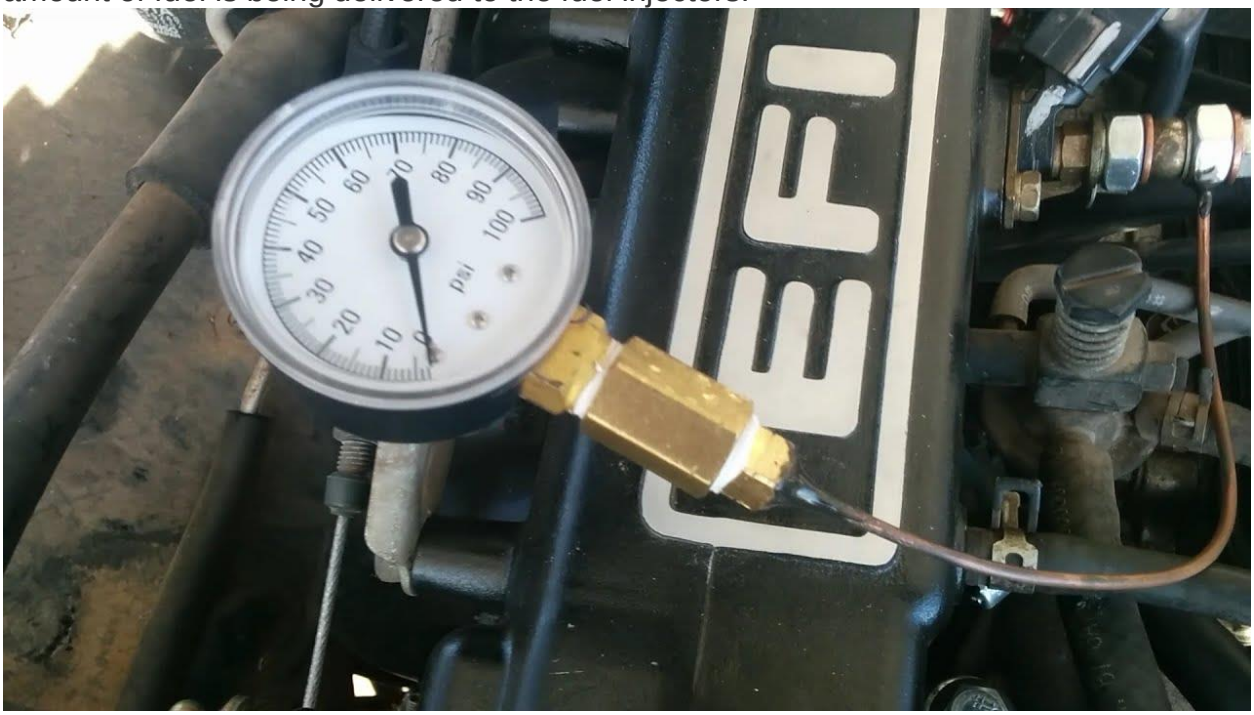

Fig 4.0 check the fuel pressure

Step 3: Use a flow-meter or glass measuring container

The most accurate way to test fuel delivery is by using a flow-meter. But while some repair facilities may have that, you may not. So here's a pretty reliable way to perform a timed fuel delivery test. Make sure to be careful and use an appropriate measuring container. Glass is a good choice because fuel can corrode or fog up plastic.

Collecting a diesel fuel sample is a critical step in the diagnostic process. Contaminated fuel can damage fuel system components and cause the vehicle to perform poorly. In the sequence of photos above, the specific gravity of a fuel sample is being measured.

Fig 4.1 glass measuring container

Step 4: Test

Starting up the car will signal the pump to run, so start the car and let it idle. You'll have to collect a fuel sample for five seconds with the pump running. The pump should deliver a specific amount of fuel within that time frame—check your manufacturer's specification to see if your pump is delivering the right amount and your system is working properly. You might have to convert milliliters per second to gallons per hour in order to figure that out.

4. Bosch Denso Delphi Simons Code Generating Common Rail Injector Tester

Common rail injector tester for testing common rail diesel fuel injectors, generating code for Bosch Denso Delphi common rail injector, small size, easy for transportation, remote controlling for software updating.

Description

Bosch Denso Delphi Simons Code Generating Common Rail Injector Tester Advantage:

- Coding Injectors for Bosch Denso Delphi Siemens common rail injectors.
- BIP function: checking the solenoid valve responding time.
- Common rail injector inductance test.

Technical parameter of the injector calibration machine:

- Output power: 2.6KW
- Rotation speed controlling: inverter
- Power supply: 220V 50/60HZ
- Fuel tank: 8 liters
- Fuel temperature controlling: 40±2℃
- Filtration: less than 5μm
- Machine size: 700×600×670 mm
- Weight: 110kg
- Flow sensor of the injector tester: imported flow sensor

Fig.4.2 Common rail injector test bench feature

Common rail injector test bench feature:

1. Industrial computer real-time control, Windows operating system, built-in display, touch screen operation.

2. Full-automatic operation, high precision, automatically setup test plans, multiple protection of the injector tester machine.

3. Real-time display of fuel injection and back-flow curve, automatic testing the fuel quantity of all working conditions, automatic generation of report after testing.

5. **Diesel injector test equipment function:**

1. equipped with bosch genuine cp3 pump, which can drive various solenoid valve common rail injectors and piezoelectric crdi injectors, testing the fuel quantity under different working conditions.

2. accurately distinguish the injectors ‘defaults, for example, missing cylinders, knock cylinders, or speed limiters when the injector working on the engine.

3. testing diesel fuel can be heating or cooling automatic

4. cleaning the common rail injectors by high pressure flushing.

5. the common rail injector tester has the short-circuit protection, ground protection, over pressure protection during the testing.

6. software advantage: intelligent algorithm is used on this injector tester machine, to automatically calibrate the fuel quantity of the new injector, and generate test plan after calibration.

7. automatic measurement of the common rail injectors under different working conditions, automatic analysis of measurement results, and generation of reports

8. user can customize parameters such as rail pressure, pulse width, and fuel injection time when using this diesel fuel injector tester.

9. data backup, system software and function upgrade by remote control.

10. frequency inverter equipped to achieve testing function under different speed conditions

11. testing data same as bosch, denso, delphi original data, and accuracy can reach the original level

12 the precision filter is used before fuel comes to flow sensor, can effectively keep the

13 sensor clean and ensor usage life.

Fig 4.3 JZ230 Common Rail Diesel Injector tester And Caterpillar HEUI Injector Tester

Fig4.4 Economic Model Common Rail Injector Tester

6. EFI Fuel Injector Testing and Cleaning.

1. WARM UP ENGINE: Allow the engine to warm up to normal operating temperature (THW is less than 1 volt).
2. While the engine is running disconnect the supply fuel line from the fuel tank, let the engine stop. This is to remove the fuel pressure in the fuel rail.
3. Turn the engine switch OFF.
4. Disconnect the fuel injector connector.
5. Disconnect fuel line from the fuel rail.
6. Disconnection pressure regulator hose.
7. Loosen and remove the bolts of the fuel rail.
8. Full the fuel rail slowly so that the injector O-ring will not be damage. If it is hard to remove spray with penetrating oil on the mounting port of the injector against the manifold runner.
9. Remove the fuel injector from the rail by removing the clipInjectors Connector

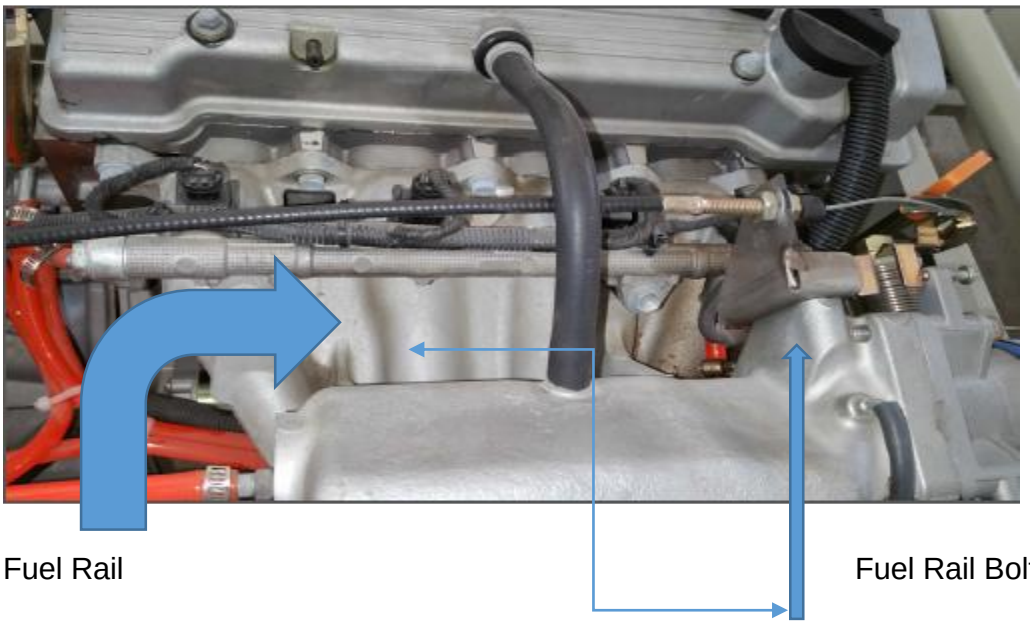

Fig.4.5.1fuel hose test indication

10. Fuel Injector Analyzer and Cleaner

1. Fuel Hose
2. Standard Nut
3. Turn Buckle
4. Tube Stand
5. Test Tube
6. Power Switch
7. Standard Feed Fuel Block
8. Injector Connector
9. Keypad
10. Gauge
11. Launder
12. Ultrasonic Timer

Keypads:

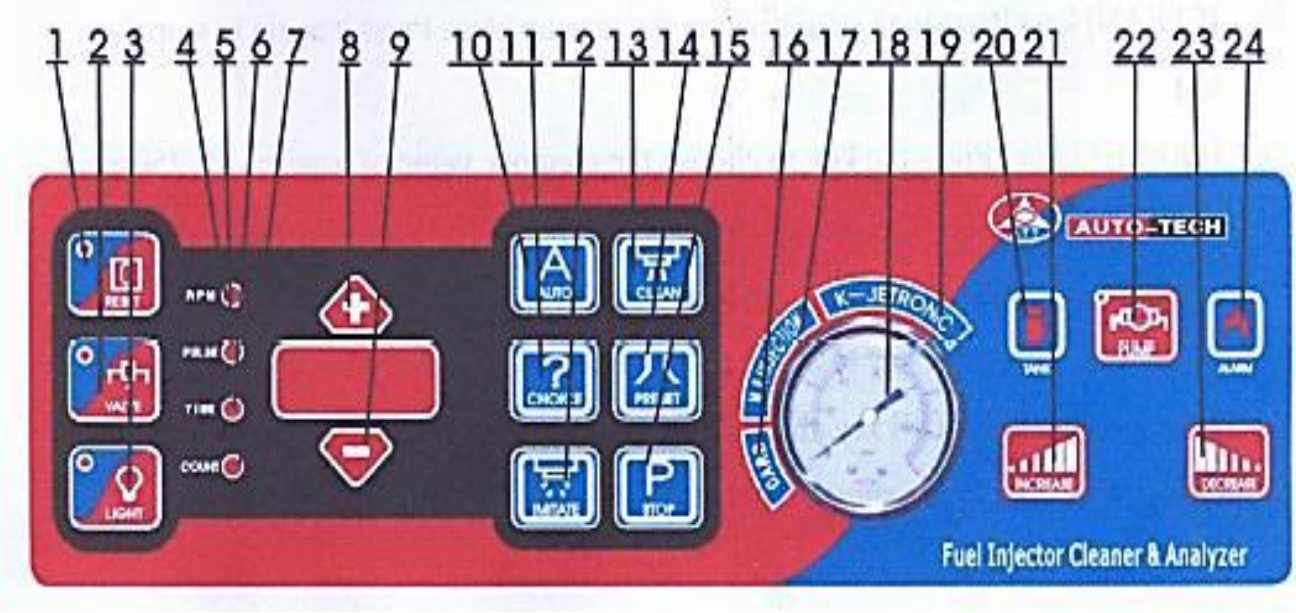

Fig.4.6 Fuel Injector Analyzer and Cleaner

Operation [reset] key: press the key, the unit will turn back to its initial setup. [Valve] key: press the key, the unit begins to back drain the liquid, and the valve indicator comes on.

Press it again, the pump stops and the indicator turns off. [Light] key: press the key, the backlight comes on.

Press it again, the backlight turns off. [Rpm] indicator: when the indicator comes on, the screen will display the frequency value.

[Pulse] indicator: when the indicator comes on, the screen will display the pulse width value. [Time] indicator:

when the indicator comes on, the screen will display the timed value. [Count] indicator: when the indicator comes on, the screen will display the injecting times.

[+] key: press the key to increase the value. [-] key: press the key to decrease the value. [Auto] key: press the key, the unit will auto conduct the test, cleaning and analysis (note: adjust the pressure to specific range before cleaning).

[Choice] key: press the key to display the in-order parameters: rpm, pulse, time and count. When the indicator comes on, the screen will display the corresponding value. for example, when the pulse indicator comes on and the screen displays 03.00, it means the pulse width is 3ms; when the rpm indicator comes on and the screen display 0750, it means the rpm is 750r/min. press [+] key to increase the value, and press [-] key to decrease the value. [Imitate] key: press the key, the unit will begin to conduct the memory program. Press [stop] key to stop during test.

And press [imitate] key again to continue the test. [Clean] key: press the key to perform the injecting test. Press it again to stop the test. [Preset] key: press the key to choose the memory value of low speed: 750rpm; medium speed value: 3200rpm; high speed: 5600rpm; the corresponding pulse width is 3ms, 12ms and 5.8ms.

The corresponding time is 320s, 37s, 32s. [Stop] key: press the key to stop the system running.

During the procedure of test, every time press [stop] key, the system will enter the next program. Carb: display the pressure of carburetor. M.p.

injection: display pressure of multi-points injection pressure gauge: display the fuel pressure of system. K-Getronics: display the pressure of single point and mechanical injection. [Tank]: it is a test fluid level indicator. When the red indicator comes on, it means the liquid level is very low and needs to charge. [increase] key: press the key to increase the value of the system pressure 22] [pump] key:

press the key, the system begins to provide test liquid, and the pump indicator comes on. Press it again, the pump stops and the indicator turns off when the pump is running but the unit System is not in work state, the pump will be protected then automatically stop running.

[Decrease] key: press the key to decrease the value of the system pressure. [Alarm] indicator: when the indicator come~ on, it means the climate and system temperature is over-heat, so stop the test at once.

Note: if keeping press [decrease] key for long time and at the same time you start the pump, pressure will be change to zero. In this case must press [increase] key and the gauge will display the current reading.

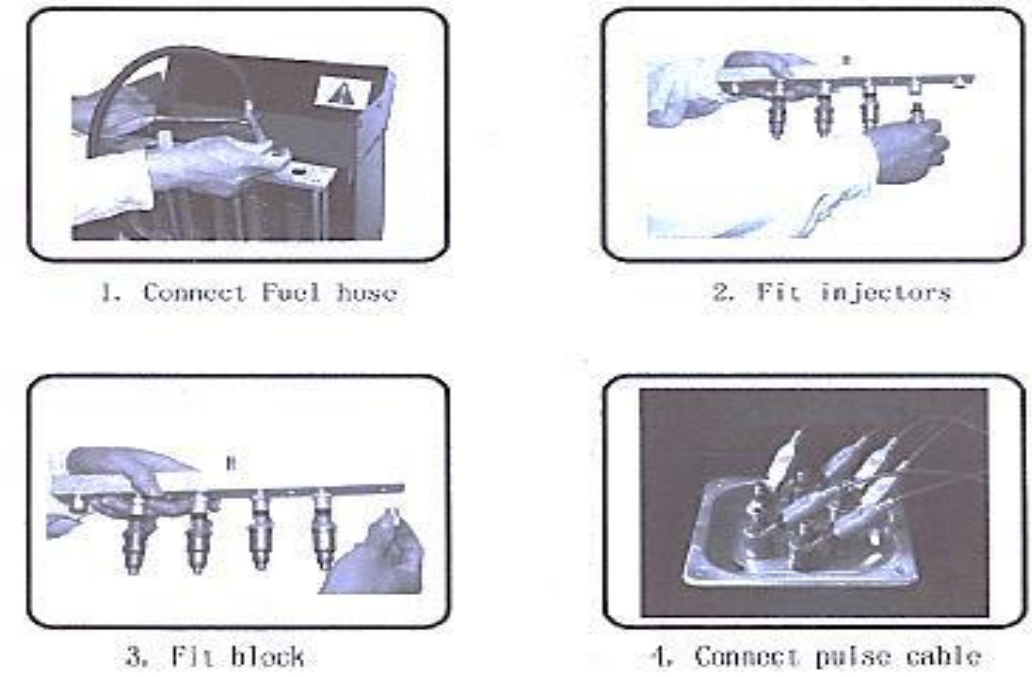

Fig.4.7 Injector Installation

11. **Automatic test and cleaning**

Before automatic test and cleaning, set the system pressure to the specified value of the serviced vehicle, and then press [auto] key, the unit will perform test and cleaning based on the following procedures. During the procedure of automatic test, if press [reset], the system will back to initial state.

12. **Automatic procedure with display**

(1) to auto detect the injecting volume, angles, atomization, uniformity and dribbling: keep injecting for 15 seconds to observe the injecting angles, injecting states, which turns the continuous injecting test and cleaning into reality. *(Time value will be decrease from 15 to 0)*

(2) Test mode at low speed includes

- following procedures guide you to conduct the injecting test:

- Injecting rpm: 650r/min; pulse width: 3ms; count: 4000.
- When the procedure is over, observe the injecting uniformity for 25 seconds, and replace it if the value is more than 9%.
- Keep the [valve] key open for 30 seconds. When the liquid return is over. Close the [valve] key.
- The routine detecting of injectors is complete. The system will automatically enter to the next max loading test.

(3) **Automatic detect max loading test:**

- following procedures guide you to conduct max loading test:
- *injecting rpm:* **2400r/min;**
- *Pulse width:* **12ms;** *count:* **2000.**
- When the procedure is over, observe the injecting uniformity for 25 seconds, and replace it if the value is more than 12%. Meanwhile observe the injecting state with timing gun.
- Keep the [valve] key open for 30 seconds. When the liquid return is over, dose the [valve] key. The routine detecting of injectors is complete. The system will automatically enter to the next test.

4) Test mode at high speed:

- Following procedures guide you to conduct the injecting test.
- *injecting rpm:* **3600r/min**
- *pulse width:* **5.8ms** *count:* **3000**
- During this procedure you can observe the states of high speed and liquid supply, also you can detect the injector's states.
- Keep the [valve] key open for 30 seconds. When the liquid return is over. Close the [valve] key, the system is complete (count display is 3000).

13. **Selective test and cleaning**

(1) Dribbling test

- First check the breakage and distortion of the a-ring of the injectors (replace it if damaged), select the corresponding connectors and fit them on the injectors. Put the injectors on the test stand, and then connect them well. Press [pump] key to start pump running. Set the pressure to the manufacturer specified value (10% higher is the best) by pressing [+] or [-] to observe the dribbling state. Replace the injector if it dribbles one more drop in 1 minute (or identify it according technical standard).

(2) Injecting angle and atomization states are:-

- Press [clean] key to start the injecting, and observe injecting angles and atomizing states.
- Injecting angles should be identical (or identify it according technical standard), and injecting well distributed (without jetting), otherwise replace the injectors.
- to observe it with flash (timing) gun:

- Connect the power cable of the timing gun to the socket on the control panel, set the rpm as 1500r/min, the pulse width as 12ms.
- Press [imitate] key, trigger the gunlock, and aim the gun at the test tubes to observe the injecting angles and atomizing states.

(3) Injecting volume

- close [valve] key (indicator turns off); press [clean] key, 15 seconds later the injecting volume should be up to 34-38ml (or test it according technical standard), otherwise replace the injectors.

(4) Test opened and closed pressure

- Observe the opening and closing pressure of injectors from the pressure gauge.

(5) Injecting uniformity

- Press [preset] key, the unit defaults low rpm as 650r/min, pulse width as 3ms, 1 count as 4000.
- Start pump running, and set the fuel pressure up to the specified value.
- Press [imitate] key to start the test.
- when count displays "0000", observe the injecting volume of each injector, the uniformity less than 10% in each test tube is good (or test it according technical standards), conduct ultrasonic clean or replace default injectors if the volume is more than 10%.

Self-Check -2	Written Test

Direction I: short answer items

Instruction: Give short answer for the following question on the space provided.

1. Write steps of injection uniformity.(3pts)

Note: **Satisfactory rating ≥ 3 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the answers.

Name: _____Date: _____score_____

Rating_____

Answer sheet

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Information Sheet 4- Verifying and indicating Results

4. Verifying and indicating Results

4.1. Electrical troubleshooting guide

The following test procedures win require the use of a millimeter and the Engine~ wiring diagram (in this manual). Also refer to the relay testing. Weser Erbekere commends that these tests be performed

PROBLEM	Couse	SOLUTION
EFI diesel fuel injection problem.	• -Fuel not rich • -Knock sensor circuit short or open • Coolant sensor circuit short or open • Man maturing defective	• -Clean the fuel hose or repair • -Connect, adjust and replace • Connect, adjust and replace • Over pressure happen
EFI engine over heat	Coolant sensor Open circuit and short circuit	Connect or adjust
Abnormal nose supply pump	Knock sensor problem	Rapier or replace
Pressure Tempesure sensor problem	Open circuit and short circuit	Connect or repair
Exhaust smoke	Oxygen sensor circuit problem	Connect , repair or replace

Table 4.0 Electrical troubleshooting guide

Self-Check -4	Written Test

Direction I: short answer items.

Instruction: Give short answer the following question. The answer provided in the next page.

1. What is the cause of engine over heat in EFI? (5pts)

2. What is the effect of injection supply pump? (5pts)

Note: **Satisfactory rating - 7and points** **Unsatisfactory - below 7and points**

Name: _____Date: _____

Score = _____

Rating: _____

Answer sheet

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5. carrying out Repair/Service of diesel and gasoline fuel system and its components

5.1. DIESEL ENGINE FUEL SYSTEM

Injection Pump: - A diesel engine injection pump is used to increase the pressure of the diesel fuel from very low values from the lift pump to the extremely high pressures needed for injection.

Demand on Modern Diesel Engine Development and there function

- Low fuel consumption
- Low pollutant emissions
- Quiet running engines
- Improved engine performance
-

Common rail diesel injection system

The Common Rail Diesel Injection System delivers a more controlled quantity of atomized fuel, which leads to better fuel economy; a reduction in exhaust emissions; and a significant decrease in engine noise during operation.

In the Common Rail system, an accumulator, or rail, is used to create a common reservoir of fuel under a consistent (constant) controlled pressure that is separate from the fuel injection points.

A high-pressure pump increases the fuel pressure in the accumulator up to 1,600 bars. The pressure is set by the engine control unit and is independent of the engine speed and quantity of fuel being injected into any of the cylinders.

The fuel is then transferred through rigid pipes to the fuel injectors, which inject the correct amount of fuel into the combustion chambers. Rail is a forged-steel tube. Length is between 280 and 600mm.

How does a CR system function?

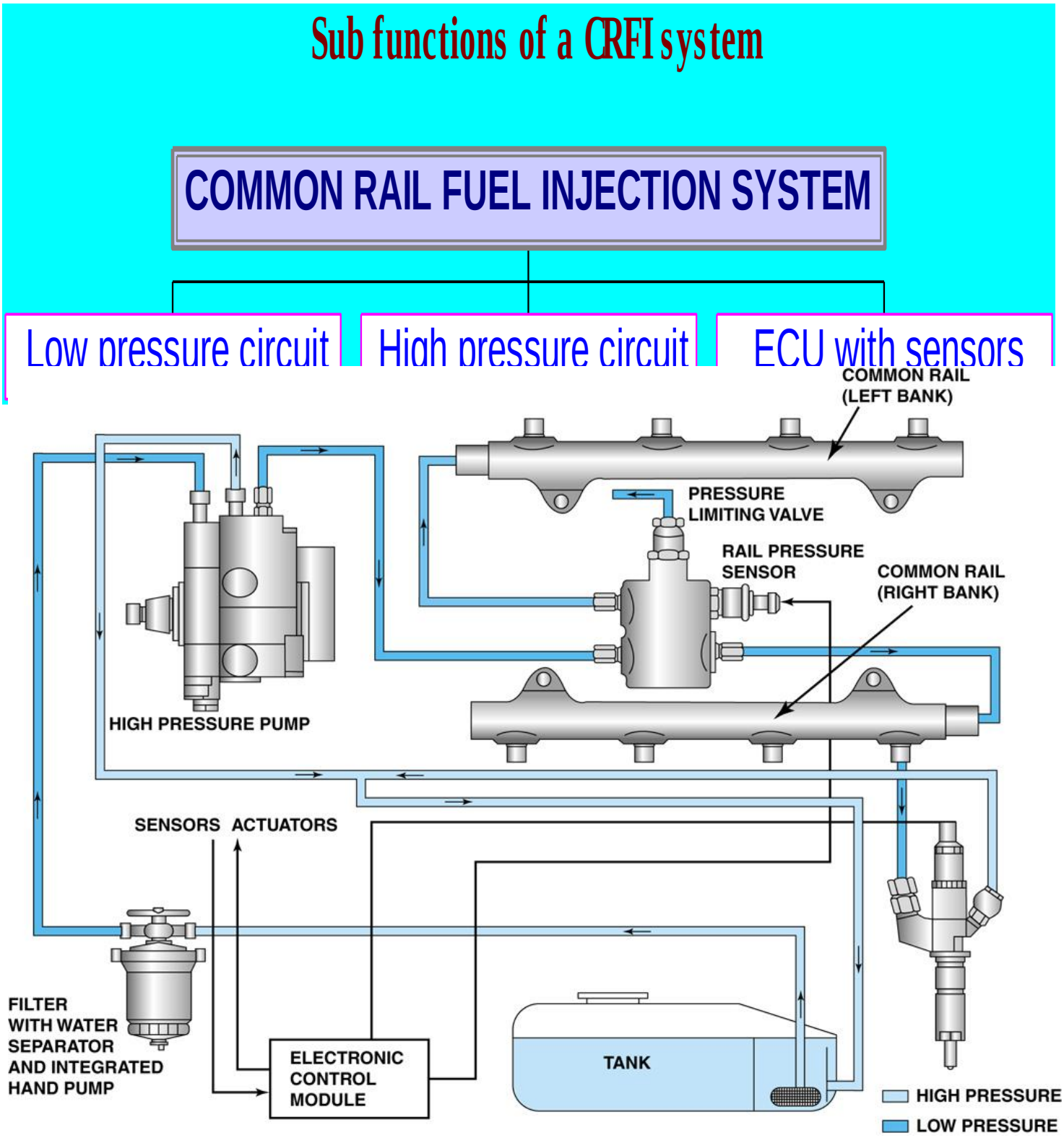

Fig 5.0 CR system function

Component of EFI DESILE FULE

1. cut-off solenoid
2. Accelerator pedal position (APP) sensor
3. Battery
4. Crankshaft position (CKP) sensor
5. Engine control module (ECM)
6. Engine coolant temperature (ECT) sensor
7. Exhaust gas recirculation (EGR) solenoid
8. Fuel cooler
9. Fuel filter
10. Fuel heater
11. Fuel injector
12. Fuel lift pump (electrical)
13. Fuel lift pump (mechanical)
14. Fuel lift pump relay
15. Fuel pressure control solenoid
16. Fuel pressure sensor
17. Fuel rail
18. Fuel tank
19. Fuel temperature sensor
20. Glow plug relay
21. Glow plug
22. Glow plug warning lamp
23. High-pressure fuel pump
24. Ignition switch
25. Intake air temperature (IAT) sensor
26. Malfunction indicator lamp (MIL)
27. Manifold absolute pressure (MAP) sensor
28. Mass air flow (MAF) sensor
29. Turbocharger (TC) waste gate regulating valve
30. Vehicle speed sensor (VSS)

5.1.1. The Common Rail Sub functions

Low –pressure circuit comprises of:

- Fuel tank, Pre-supply pump, Fuel filter, and the respective connection lines
- Low –pressure circuit
- The low –pressure circuit is responsible for transporting the fuel to the high –pressure circuit

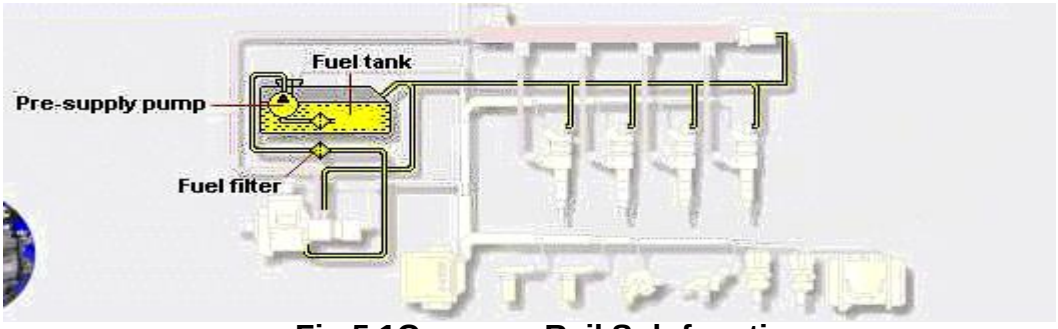

Fig.5.1Common Rail Sub functions

High –pressure circuit comprises:

- High – pressure pump with pressure – control valve
- The high – pressure accumulator (Rail)with the rail –pressure sensor
- Injectors, and
- The respective high – pressure connection lines.

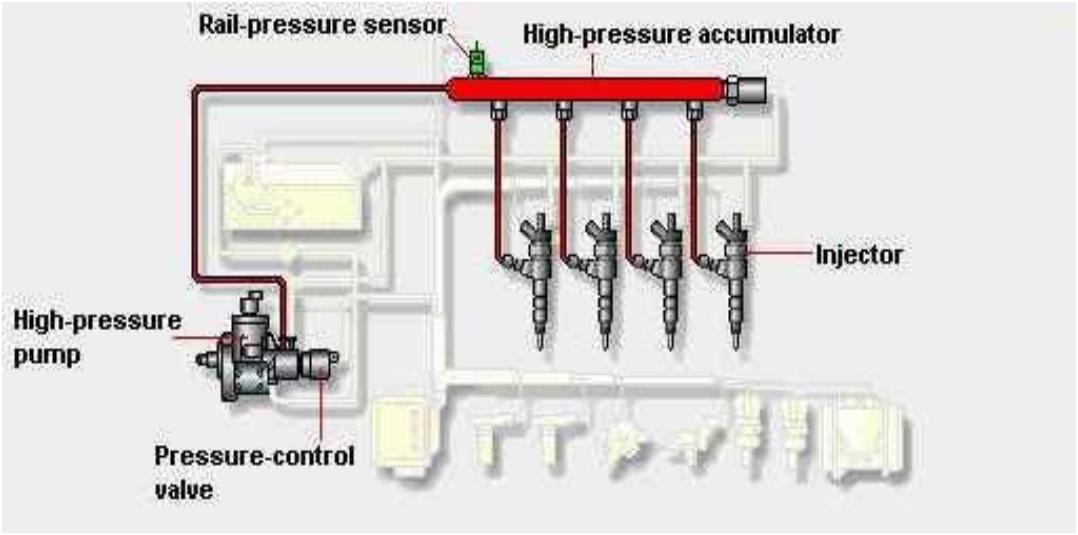

Fig.5.2 High –pressure circuit comprises

5.1.2. PRE SUPPLY PUMP FUNCTION

- Transports fuel from the fuel tank to the high pressure pump. An electric fuel pump is used for this purpose in the CRFIS. When the electric fuel pump is switched off, the supply of fuel is interrupted and the engine stops.

The type of electric fuel pump comprises

1. Electric Motor
2. Roller-Cell Pump
3. Non Return Valve

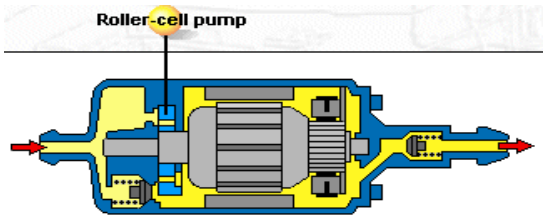

Fig.5.3 Roller-Cell Pum

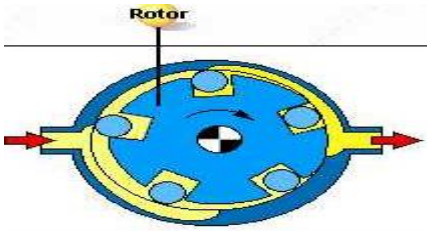

fig.5.4 rotor

Roller-Cell Pum opreration

- The roller cell is driven by an electric motor.
- Its rotor is mounted eccentrically and provided with slots in which movable rollers are free to travel.
- The rollers are forced against the base plate by rotation and by fuel pressure.
- The fuel is transported to the outlet openings on the pump's pressure side.

5.1.3. Gear type fuel pump operation

- The drive gear wheel is driven by the engine.
- Delivery quantity is directly proportional to engine speed.
- Shut off is by means of an electromagnet.

5.1.4. High- pressure pump operation

- The pump plunger moves downwards
- The inlet valve opens
- The fuel is drawn in to the pumping element chamber(suction stroke)
- At BDC, the inlet valve closes

5.2. ECU and sensors

The common rail ECU evaluates the signals from the following sensors. Crankshaft – speed sensor, Camshaft sensor, and Accelerator-pedal travel sensor

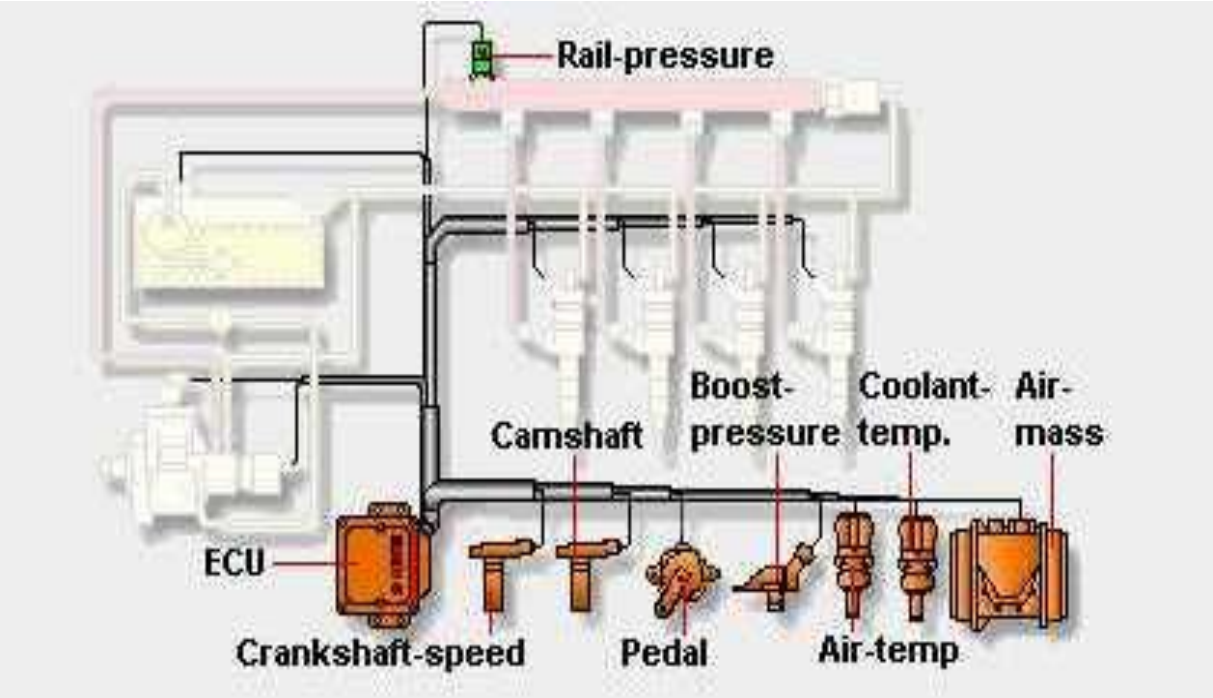

Fig.5.5 ECU and sensors

The common rail ECU evaluates the signals from the following sensors:

- Boost – pressure sensor,
- Air temperature sensor, Air
- Mass meter and Rail pressure sensor

5.2.1. Sensor Details

The sensors are responsible for measuring important physical quantities. The ECU calculates injected fuel quantity, start of injection, duration of injection, and rate of discharge curve, as well supervises the correct functioning of the injection system as a whole.

The sensors used in this electronic fuel injection system are airflow sensor, crankshaft position sensor, load sensor, exhaust temperature sensor. Some of the sensors require signal conditioning because of weak signal strength, noises, etc., Various signal conditioning boards are used for the crankshaft position sensor, speed sensor, and air flow sensor and are shown in Fig 6. Sensors are fitted at different places of the engine. Load sensor is fitted at the dynamometer to get the engine load condition.

5.2.1.1. Rail-pressure sensor (RDS)

- Measures the pressure in the rail
- inputs the information to the ECU
- RDS should provide extremely precise measured values.
- RDS is mounted directly on the rail.

5.2.1.2. Air Flow Sensor

In order to achieve optimum idle mileage control for an electronically controlled fuel injection system, accurate measurement of intake air is required. Air Flow Sensor (AFS) measures intake rate of air that is filtered by air cleaner, and one of the most important components of EMS (engine management system). Therefore, AFS shall have accurate response characteristic over a wide air rate range, immediate response characteristic against rapid change of air flow rate and easier processing of signals. AFS is fitted in the air drum of the experimental setup.

5.2.1.3. Crank Shaft Position Sensor

The crankshaft position sensor sends the information of the piston position to find the timing of the injection and it is fitted at the extreme end of the crank shaft.

The sensor consists of sensor part that includes magnets and soft iron core winded by coil and toothed wheel that is designed to rotate in linkage with the crankshaft.

Toothed wheel has 58 teeth and two tooth gaps that are used for identifying the cylinder position.

The revolution of toothed wheel makes the crank angle sensor to generate 58 signals. From which the exact timing at which the start of the delivery of fuel is arrived.

5.2.1.4. Speed Sensor

The Speed sensor is fitted at the coupling between the engine and the dynamometer. It is used to find the engine speed.

Speed sensor generates 4 pulse signals per a revolution of the output gear. Then ECM receives the pulse signal that will be used for idling speed adjustment.

Speed sensor finds whether the engine is at idling or running. When current flows it receives 0.5V, when the sensor does not operate and it receives a 12V signal, to detect engine speed.

5.2.1.5. Load Sensor

Load cell is attached to the dynamometer. Load cell calculates the mechanical load acting on a dynamometer. This value is given to the ECU to calculate the load acting on the engine through the dynamometer. Fuel injection quantity is fixed based on the engine load at the ECU.

5.2.1.6. Exhaust Gas Temperature Sensor

The exhaust gas temperature sensor is attached to exhaust manifold of the engine. The Exhaust gas temperature sensor uses a temperature sensitive semiconductor called a thermistor.

The sensor is typically connected as a varying resistance across a fixed reference voltage. As the temperature increases, the output voltage decreases.

5.2.1.7. Accelerator pedal position sensor

Some light truck diesel engines are equipped with an electronic throttle to control the amount of fuel injected into the engine. Because a diesel engine does not use a throttle in the air intake, the only way to control engine speed is by controlling the amount of fuel being injected into the cylinders.

Instead of a mechanical link from the accelerator pedal to the diesel injection pump, a throttle-by-wire system uses an accelerator pedal position sensor. To ensure safety, it consists of three separate sensors that change in voltage as the accelerator pedal is depressed.

Self-Check -5	Written Test

Direction I: short answer items.

Instruction: **give short answer the following question the answer provided in the next page.**

1. List demand on modern diesel engine development and there function.(5pts)
2. **What is the function of speed sensor? (5pts)**

Note: **Satisfactory rating - 8and points** **Unsatisfactory - below 8 and points**

Name_____ date_____ rating _____

Score_____

Answer sheet

1……

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2……

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5. Documenting results with evidence, supporting information

Documentation can be used as a key tool for legal defense. Good documentation by supervisors and managers can mean the difference between a company winning and losing an employment-related lawsuit.

For example, good documentation employee's pattern of poor performance and discipline can establish that the employee's firing wasn't related to discrimination based on race, sex, age, religion, disability, or national origin.

An employer may have a much more difficult time proving that without such documentation. "Can you afford not to take the time to document internal incidents and the rest of the investigation process?

If taking the time to record incidents and information means the difference between winning and losing a case in court, wouldn't it be easier to start documenting these matters now. The idea that you cannot be held liable simply because there's no written record of an incident isn't going to help you out.

Documentation can also benefit your business should an employee lodge a complaint after they have been removed from your company.

The longer it takes for an incident to be reported, the worse will be your recall of the events and reasoning behind decisions made, which could make your statements invalid.

Employees may come and go – as well as their feelings toward an employer – but the documents will always remain.

Documenting results with evidence record

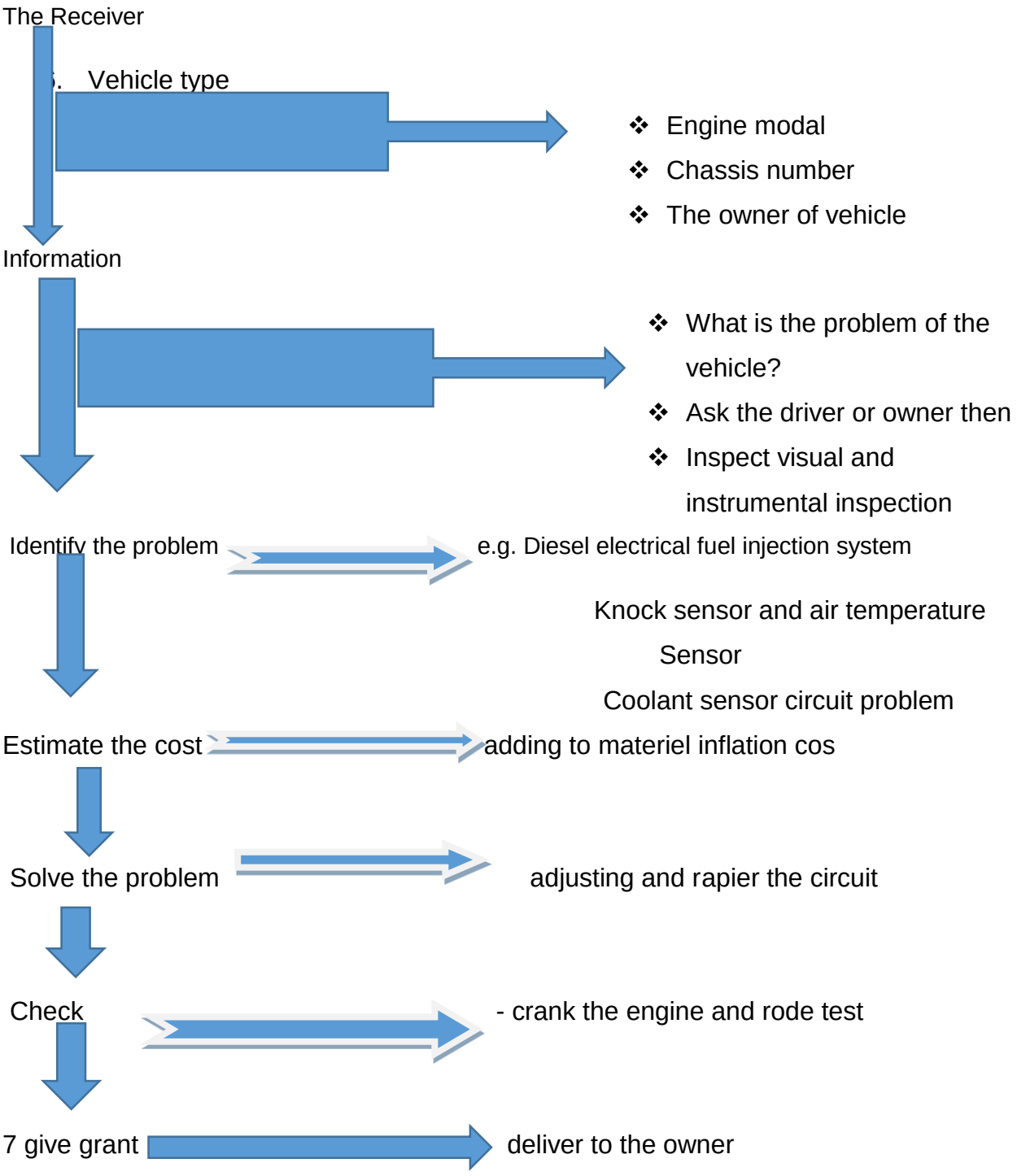

Chart 1**. Document results with evidence record**

Self-Check 5	Written Test

Direction I- short answer item

Instruction: Give short answer the following question and write the answer using the Answer sheet provided in the next page:

1. Write steps of service documentation? (10pts)

Note: **Satisfactory rating - 7and points** **Unsatisfactory - below 7and points**

Name: ----------Date: ----------score_____

Rating_____

Answer sheet for short items

1……

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Information Sheet 6- Forwarding Report to appropriate persons

6. Forwarding report to appropriate persons

The owner of Name _____

Vehicle type_____

Engine modal_____

Chassis number_____

Service or maintenance type_____

Cost payment_____

Garratt year_____

Self-Check -6	Written Test

Direction I: short answer items

Instruction: Give answer the following question. The answer provided in the next page.

1. How to prepare service report? (5%)

Note: **Satisfactory rating - 7and points** **Unsatisfactory - below 7and points**

Name_____ date_____

Score = _____

Rating: _____

Answer sheet

1……

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Operation Sheet 1 overhaul diesel EFI

Operation title: - Step of overhaul diesel EFI (electrical fuel injection)

1) Step. 1drain the fuel in reserve tank
2) Step.2 fuel circuit remove
3) Step3.Dismantling the fuel supply pump
4) Step 4 clean the body
5) Step5.disassambling fuel supply pump
6) Step6. Clean the part
7) Step 7.Inspection
8) Step 8. Identify the problem
9) Step9. Solve the problem
10) Step10.then assembling diesel EFI
11) Step11.check and in stole the vehicle

Operation Sheet-2 Remove the fuel injector

Operation I: EFI Fuel Injector Testing and Cleaning.

Step 1. Warm up engine: Allow the engine to warm up to normal operating temperature (THW is less than 1 volt).

Step 2. While the engine is running disconnect the supply fuel line from the fuel tank, let the engine stop. This is to remove the fuel pressure in the fuel rail.

Step 3. Turn the engine switch OFF.

Step 4. Disconnect the fuel injector connector.

Step 5. Disconnect fuel line from the fuel rail.

Step 6. Disconnection pressure regulator hose.

Step 7. Loosen and remove the bolts of the fuel rail.

Step 8. Full the fuel rail slowly so that the injector O-ring will not be damage. If it is hard to remove spray with penetrating oil on the mounting port of the injector against the manifold runner.

Step 9. Remove the fuel injector from the rail by removing the clip Injectors Connector

LAP test	Remove the fuel injector

Name----------date----------

Task1. Remove Injector and perform Testing and Cleaning

Operation Sheet-3	EFI Fuel Injector Testing and Cleaning step

Step 1: clean the service injectors and then wipe them with soft cloth. check the breakage and distortion of the O-ring of the injectors. In case of breakage or distortion, must replace them before use, thereby can avoid leakage.

Step 2: remove the serviced injectors from vehicle and mark them by sequence. measure the impedance value (resistance) of each injector using digital multi-meter, and the fuel injector cleaner & analyzer impedance difference of each nozzle should not be more than 1ω, or replace them.

Step 3: connect the power cable (2201l10v), turn on the power switch on the side of unit, and check all warning devices.

Step 4: check the minimum liquid level indicator, if the level is too low, it is necessary to charge test liquid for standard use.

Caution: *never mix detergent into test liquid, especially not to take detergent as test fluid to use, otherwise it will result in damage of pump and other components.*

Step 5: start test and cleaning as following procedure.

LAP Test	**Step of EFI (electrical fuel injection) Fuel Injector Testing and Cleaning.**

TASK1. Step of EFI (electrical fuel injection) Fuel Injector Testing and Cleaning.

Name_____ date_____

LAP test	Demonstrate

Task1. . Make properly overhaul diesel EFI (electrical fuel injection)?

Operation Sheet-4	knock sensor test

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Operation I; title knock sensor test step

Step1.Disconnect the negative terminal of the battery.
Step2. Use a DMM to perform continuity test**.**
Step3. Vc-E2 signal voltage test
Step4. PIM-E2 signal voltage
Step5. Vc-PIM signal voltage

LAP Test 1	Knock sensor voltage tests?

task1. Knock sensor voltage tests?

Operation Sheet-5	Techniques of report operation and document preparation

Operation I: Techniques of report operation and document preparation.

Steps 1 Receive and record information about the vehicle?

Step 2.Collect and organization Information about the problem of the vehicle?

Step 3.Make visual and instrumental vehicle Inspection?

Step 4. Identify the problem of the vehicle?

Step 5.estmat cost?

Step 6.solve the problem?

Step 7. Grant and deliver to owner?

LAP test	Demonstrate Make vehicle service report operation and document preparation

Name----------date----------

Task1. Make vehicle service report operation and document preparation?